Departamento de Sistemas Informáticos y Computación
Universitat Politècnica de València

Historial Académico, Docente e Investigador

Germán Moltó Martínez

Requisito para el Acceso al Cuerpo de Catedráticos de Universidad

Valencia, 11 de septiembre de 2022

Código de concurso, Plaza
082/22, 6708

Área de Conocimiento
Ciencia de la Computación e Inteligencia Artificial

Destino
Escuela Técnica Superior de Ingeniería Informática
Departamento de Sistemas Informáticos y Computación
Universitat Politècnica de València

Perfil
Infraestructuras de Cloud Público (ICP).
Estructuras de Datos y Algoritmos

Resolución
BOE nº 157 de 1 de julio de 2022
(resolución de 22 de junio de 2022)

Capítulo 1

Introducción

De conformidad con lo dispuesto en el artículo 62 de la Ley Orgánica 6/2001, de 21 de diciembre, de Universidades, modificada por Ley Orgánica 4/2007, de 12 de abril, y en el artículo 3 del Real Decreto 1313/2007, de 5 de octubre, por el que se regula el régimen de los concursos de acceso a cuerpos docentes universitarios y a tenor de lo establecido por los Estatutos de la Universitat Politècnica de València, aprobados por Decreto 182/2011, de 25 de noviembre de 2011 (DOCV 29/11/11), y dentro del marco normativo de estabilidad presupuestaria y sostenibilidad financiera y una vez obtenida la autorización de la Generalitat Valenciana para efectuar las convocatorias de la OEP, el Rectorado de la Universitat Politècnica de València, en ejercicio de las competencias atribuidas por la legislación vigente, resolvió convocar a concurso de acceso la plaza de código 6708, de acuerdo a la resolución de fecha 22 de junio de 2022, publicada en el Boletín Oficial del Estado número 157 del 1 de julio de 2022.

El procedimiento que rige los concursos debe permitir valorar, en todo caso, el historial académico, docente e investigador del candidato, su proyecto docente e investigador y, en su caso, el trabajo original de investigación, así como contrastar sus capacidades para la exposición y el debate ante la comisión en la correspondiente materia o especialidad en sesión pública.

Por ello, el presente documento incluye el Historial Académico, Docente e Investigador presentado por el candidato Germán Moltó Martínez, con DNI 52656437-F, a la mencionada plaza. Tras la introducción, el documento está estructurado como sigue.

El capítulo 2 incluye un resumen de la trayectoria del candidato, utilizando el formato empleado por la ANECA para la presentación de méritos en su programa ACADEMIA para la figura de Catedrático de Universidad, en el que se deben destacar las cuatro contribuciones más relevantes a juicio del candidato. También se presenta un resumen del historial docente y académico del candidato que permite tener una visión integradora de la trayectoria, mas allá de la mera recopilación individualizada de méritos.

El capítulo 3 incluye el Curriculum Vitae Normalizado (CVN), generado automáticamente a partir de la base de datos Senia de la Universitat Politècnica de València, que permite la recopilación y visualización de la producción científica de cada profesor.

El capítulo 4 incluye diferentes certificados generados automáticamente a partir de las bases de datos institucionales de la Universitat Politècnica de València, en los siguientes ámbitos:

- La sección 4.1 incluye el certificado de méritos de actividad docente o profesional para su presentación al programa ACADEMIA/PEP de la ANECA. Este certificado incluye: i) Puestos docentes ocupados; ii) Tesis doctorales dirigidas; iii) Dirección de PFCs/TFGs; iv) Dirección de Tesinas de Máster; v) Evaluaciones positivas de la actividad docente; vi) Resultados de encuestas de alumnado; vii) Proyectos de Innovación Docente.

- La sección 4.2 incluye el certificado de participación en proyectos de I+D financiados en convocatorias públicas así como la participación en contratos de I+D de especial relevancia con empresas y/o administraciones.

- La sección 4.3 incluye el certificado de prestaciones de servicio, es decir, las actividades realizadas de acuerdo con el artículo 83 de la LOU (Ley Orgánica de Universidades).

- La sección 4.4 incluye el certificado de autoría de activos de propiedad intelectual o industrial, así como los registros de software realizados.

Finalmente, el capítulo 5 incluye la justificación documental de aquellos méritos que se consideran más relevantes dentro de las siguientes categorías:

- Méritos de investigación, incluyendo las publicaciones muy relevantes y relevantes, de acuerdo a la definición de ANECA sobre las mismas, así como otras publicaciones con índices de calidad relativa y, finalmente, premios de investigación.

- Méritos de Comunidad Académica, incluyendo labor de editor y de revisor en revistas indexadas.

- Méritos de docencia, incluyendo la participación como ponente en congresos de innovación docente y la participación, como asistente, en cursos orientados a la formación docente universitaria.

Puesto que los certificados aportados están avalados por la información ya revisada situada en las bases de datos institucionales, se evita aportar los justificantes individuales de cada mérito para evitar incrementar de forma innecesaria el tamaño de este documento, pero están a disposición de cualquier miembro del tribunal que lo estime oportuno bajo petición previa. Sí que se ha optado por incluir la justificación documental de aquellos méritos que se consideran clave para una plaza de

Catedrático de Universidad, como es el caso de las publicaciones consideradas relevantes, de acuerdo a los criterios de acreditación del programa ACADEMIA de ANECA.

Índice general

Capítulo 2

Aspectos Destacados de la Trayectoria del Candidato

El candidato demuestra capacidad de captación de recursos de financiación en convocatorias regionales, nacionales y europeas para su transformación en publicaciones de alto impacto en revistas indexadas de calidad contrastada, así como en la concepción y producción de herramientas software de código abierto y sus correspondientes servicios que se usan actualmente en producción en plataformas de computación distribuida Europeas (EGI – European Grid Infrastructure)[1] en el contexto de la iniciativa de la Comisión Europea EOSC (European Open Science Cloud)[2]. Para evidenciar la anterior afirmación, destaco las siguientes cuatro contribuciones relevantes, así como su vinculación a los resultados de los correspondientes proyectos de investigación.

2.1. Cuatro Aportaciones de Investigación Más Relevantes

2.1.1. Contribución #1: Orchestrating Complex Application Architectures in Heterogeneous Clouds

M. Caballer, S. Zala, Á. López García, G. Moltó, P. Orviz Fernández, and M. Velten, "Orchestrating Complex Application Architectures in Heterogeneous Clouds," J. Grid Comput., vol. 16, no. 1, pp. 3–18, Mar. 2018, doi: https://dx.doi.org/10.1007/s10723-017-9418-y

---

Este artículo (JCR, Q1) es uno de los resultados del proyecto Europeo H2020 INDIGO-DataCloud

[1] European Grid Infrastructure: https://www.egi.eu

[2] European Open Science Cloud: https://ec.europa.eu/info/research-and-innovation/strategy/strategy-2020-2024/our-digital-future/open-science/european-open-science-cloud-eosc_en

(653549 - https://cordis.europa.eu/project/id/653549/es), un proyecto con un presupuesto de 11 M€ y 26 socios, en el que el candidato desempeñó el papel de Task Leader de la tarea T5.1 destinada a la creación de una arquitectura de tipo PaaS (Platform as a Service) para el soporte a comunidades de usuarios científicos para el despliegue de infraestructuras Cloud virtualizadas. Se integró la herramienta Infrastructure Manager (https://www.grycap.upv.es/im) en dicha arquitectura para el despliegue de arquitecturas complejas sobre infraestructuras Cloud heterogéneas.

El candidato desempeñó el rol de Product Owner del IM durante el proyecto. Esta herramienta es el resultado de la Tesis Doctoral de Miguel Caballer, co-dirigida por el candidato. En dicha contribución se describe el proceso de integración del soporte al estándar TOSCA (Topology Specification for Cloud Applications) y la capacidad de permitir desplegar infraestructuras en EGI Federated Cloud (https://www.egi.eu/federation/egi-federated-cloud/). Esto permitió integrar el IM como el orquestador por defecto para el despliegue de máquinas virtuales dentro de EGI, la infraestructura de computación distribuida más grande de Europa, y es el componente usado por la herramienta Federated Cloud AppDB VMOps Dashboard (https://wiki.egi.eu/wiki/Federated_Cloud_AppDB_VMOps_Dashboard) para el despliegue de máquinas virtuales. Como evidencia adicional de impacto, indicar que al haber alcanzado el nivel de madurez tecnológica TRL (Technology Readiness Level) 9, se ha integrado dicha herramienta en el EOSC Portal (https://marketplace.eosc-portal.eu/services/infrastructure-manager-im), el portal de servicios ofrecido dentro de la iniciativa de la Comisión Europea llamada European Open Science Cloud (EOSC). De hecho, el IM se utiliza como componente para acceso multi-Cloud dentro del proyecto Europeo H2020 EOSC-HUB (https://www.eosc-hub.eu/), 100 socios y 30M € de presupuesto, en el que el candidato actúa como Task Leader de la tarea T6.3 de procesamiento y orquestación.

2.1.2. Contribución #2: Self-managed cost-efficient virtual elastic clusters on hybrid Cloud infrastructures

A. Calatrava, E. Romero, G. Moltó, M. Caballer, and J. M. Alonso, "Self-managed cost-efficient virtual elastic clusters on hybrid Cloud infrastructures," Futur. Gener. Comput. Syst., vol. 61, pp. 13–25, Aug. 2016, doi: https://dx.doi.org/10.1016/j.future.2016.01.018

Este artículo (JCR, Q1) fue uno de los principales resultados del proyecto de Plan Nacional de I+D (RETOS) CLUVIEM (TIN2013-44390-R), donde el candidato fue Investigador Principal. Supone la consolidación de la herramienta de código abierto EC3 (Elastic Cloud Computing Cluster - https://www.grycap.upv.es/ec3), para el despliegue de clusters virtuales de propósito científico

sobre infraestructuras multi-Clouds. EC3 es una de las contribuciones de la Tesis Doctoral de Amanda Calatrava, dirigida por el candidato. Esta herramienta fue adoptada posteriormente en diferentes proyectos Europeos H2020 como INDIGO-DataCloud (grant agreement 653549), ATMOSPHERE (grant agreement 777154) y DEEP Hybrid-DataCloud (grant agreement 777435), donde fue utilizada para el despliegue de clusters virtuales complejos (ver, por ejemplo: https://deep-hybrid-datacloud.eu/2019/11/06/hybrid-virtual-elastic-clusters-across-clouds/). Tras conseguir el estado de madurez tecnológica TRL 9, EC3 se integró dentro del servicio Applications on Demand de EGI (https://www.egi.eu/services/applications-on-demand/), ofreciendo como servicio el portal de EC3 (https://servproject.i3m.upv.es/ec3-ltos/index.php, accesible con cuenta de EGI, aunque también se ofrece para el público general en https://servproject.i3m.upv.es/ec3/). Este servicio opera en el ámbito del Long Tail of Science (LToS) y permite a los científicos desplegarse sus propios clusters bajo demanda, configurados con las aplicaciones que necesitan para poder hacer un cálculo intensivo puntual y, una vez finalizado, eliminar el cluster. Todo ello sobre EGI Federated Cloud, la infraestructura Cloud federada europea. Como evidencias adicionales de impacto, comentar que EC3 está integrado con el EOSC Marketplace (https://marketplace.eosc-portal.eu/services/elastic-cloud-compute-cluster-ec3) y nuestro grupo de investigación soporta el servicio en producción. Finalmente, comentar que esta integración del servicio a nivel Europeo ha garantizado la obtención de financiación para el mantenimiento y evolución del servicio en el marco del proyecto H2020 EGI-ACE que comenzó en 2021.

2.1.3. Contribución #3: Serverless computing for container-based architectures

A. Pérez, G. Moltó, M. Caballer, and A. Calatrava, "Serverless computing for container-based architectures," Futur. Gener. Comput. Syst., vol. 83, pp. 50–59, Jun. 2018, doi: https://dx.doi.org/10.1016/j.future.2018.01.022

Este artículo (JCR, Q1) fue de uno de los resultados del proyecto BigCLOE (TIN2016-79951-R), liderado como Investigador Principal por el candidato, y el principal resultado de la Tesis Doctoral de Alfonso Pérez, dirigida por el candidato. En ella se describe la herramienta de código abierto SCAR (https://github.com/grycap/scar) que permite la ejecución de aplicaciones científicas sobre plataformas de serverless computing de tipo Funciones como Servicio (Functions as a Service), pudiendo disponer de aplicaciones altamente escalables que no requieren infraestructura pre-aprovisionada. Esta herramienta ha tenido una gran adopción por parte la comunidad, consta de 550 estrellas en GitHub, y ha sido adoptada para diferentes casos de uso, como por ejemplo la ejecución de modelos de Deep Learning sobre Amazon Web Services

(AWS), siendo utilizada en el proyecto Europeo H2020 DEEP Hybrid-DataCloud (ver https://deep-hybrid-datacloud.eu/2020/03/25/event-driven-execution-of-deep-open-catalog-modules-for-prediction-on-amazon-web-services/). SCAR es la única herramienta española listada en el catálogo de herramientas serverless de la Cloud Native Computing Foundation (https://landscape.cncf.io/format=serverless&selected=scar), propiciando una mayor visibilidad para la herramienta. Comentar que la línea de investigación en serverless computing iniciada con esta herramienta propició la creación de herramientas afines, como es el caso de OSCAR (https://github.com/grycap/oscar), que supone la adaptación a on-premises del modelo de computación ofrecido por SCAR y que, además de diferentes publicaciones, el candidato obtuvo la financiación necesaria a través del EGI Strategic and Innovation Fund (https://www.egi.eu/about/egi-council/egi-strategic-and-innovation-fund/) para tener un prototipo funcional integrado con EGI y se continuará su evolución en el proyecto H2020 AI-SPRINT que comenzó en 2021, así como en la Tesis Doctoral de Sebastián Risco Gallardo, dirigida por el candidato.

2.1.4. Contribución #4: Automatic memory-based vertical elasticity and oversubscription on cloud platforms

G. Moltó, M. Caballer, and C. de Alfonso, "Automatic memory-based vertical elasticity and oversubscription on cloud platforms," Futur. Gener. Comput. Syst., vol. 56, pp. 1–10, Mar. 2016, doi: https://dx.doi.org/10.1016/j.future.2015.10.002

Este artículo (JCR Q1) es uno de los resultados del proyecto de Plan Nacional de I+D (RETOS) CLUVIEM (TIN2013-44390-R), liderado como Investigador Principal por el candidato y en el que, como primer autor del mismo, fue responsable de la concepción de un sistema para la gestión automatizada de la elasticidad vertical en plataformas Cloud on-premises produciendo, gracias a la implementación realizada por los co-autores, la herramienta de código abierto CloudVAMP (https://www.grycap.upv.es/cloudvamp). Esta herramienta fue integrada dentro del ecosistema de OpenNebula (https://opennebula.io/), un gestor de plataformas Cloud on-premises ampliamente utilizado, mediante la gestión dinámica de la memoria asignada a las máquinas virtuales y monitorización automática para ir asignando / retirando memoria en función del consumo real de memoria de las aplicaciones ejecutadas en ella. La combinación de estas técnicas, unida a la migración en vivo de las máquinas virtuales para evitar sobresubscripción (cuando las máquinas virtuales demandan mayor memoria que la disponible en la máquina física donde se ejecutan), posibilitó una mayor consolidación del número de máquinas virtuales que pueden ejecutarse por nodo (ver la reseña

en el propio blog de OpenNebula: https://opennebula.io/automated-oversubscription-and-dynamic-memory-elasticity-for-opennebula/).

2.2. Aportaciones Docentes Más Relevantes

El candidato aporta 16 años de docencia universitaria a tiempo completo vinculada a la Universitat Politècnica de València (UPV), 13 de ellos con grado de doctor, comenzando en el curso 2004/2005 como Ayudante y acumulando más de 2268,35 horas hasta el curso 2021/2022 incluido, tal y como se refleja en el Certificado de Méritos para la presentación al programa ACADEMIA de la ANECA aportado.

La docencia reglada se ha centrado fundamentalmente en asignaturas de postgrado directamente relacionadas con el área de conocimiento de Ciencias de la Computación e Inteligencia Artificial, aunque también ha impartido asignaturas de Grado. El candidato es principalmente responsable de las asignaturas impartidas y la mayoría de ellas están estrechamente vinculadas con el ámbito de la investigación desarrollada (Cloud Computing y Big Data, principalmente). Imparte su docencia en diferentes Másteres, como es el caso del Máster Universitario en Gestión de la Información (MUGI)[3], el Máster Universitario en Computación en La Nube y de Altas Prestaciones (MUCNAP)[4], antiguamente conocido como Máster en Computación Paralela y Distribuida (MUCPD) y en el Master Universitario en Ciberseguridad y Ciberinteligencia (MUCC)[5]. Su docencia de grado se centra en el Grado en Informática y en el Grado en Ciencia de Datos, impartiendo asignaturas que abordan la computación en la nube desde diferentes perspectivas. También imparte docencia no reglada en el Máster en Big Data Analytics (MBDA)[6] desde el curso 2014/2015, en las que se abordan estrategias de computación distribuida para el procesado eficiente de datos en la nube.

Tal y como se observa en el Certificado de Méritos aportado, las encuestas oficiales del alumnado desde la primera fecha que hay registro (2006/2007) reflejan un valor promedio de 9,37 sobre 10, alcanzando un valor máximo de 9,9 sobre 10 en el curso 2019/2020. De hecho, el candidato aporta evaluaciones muy positivas de su actividad docente de acuerdo al Índice Actividad Docente (IAD), parámetro basado en el modelo del Programa DOCENTIA y que fue certificado por AVAP y ANECA con fecha 19/12/2012, obteniendo una moda (valor que más se repite) de EXCELENTE. El candidato recibió en 2009 un Premio a la Excelencia por parte de la Escuela Técnica Superior de Ingeniería Informática (ETSINF) de la Universitat Politècnica de València (UPV).

El candidato también aporta experiencia en la impartición de cursos online asíncronos (de tipo MOOC, pero de pago). Es el creador del Curso Online de Cloud Computing con Amazon Web Servi-

[3]MUGI: http://mugi.webs.upv.es
[4]MUCNAP: http://www.upv.es/titulaciones/MUCPD
[5]MUCC: https://www.upv.es/titulaciones/MUCC
[6]MBDA: http://bigdata.webs.upv.es/

ces (AWS)[7], que desde 2013 ha formado a más de 100 alumnos de más de 10 países en las tecnologías de Cloud Computing, obteniendo una valoración promedio en las encuestas oficiales del alumnado de 9,14 y generando unos ingresos superiores a 140K€. También realiza periódicamente actividades de formación a demanda para empresas y otras instituciones educativas en temas relacionados con Cloud Computing.

Su trayectoria docente va ligada a la formación continua y permanente. Destaca un Título de Especialista Universitario en Pedagogía Universitaria (EUPU)[8] correspondiente a 320 horas lectivas, un título de Experto Universitario en Formación Online (EUFOL)[9] correspondiente a 150 horas y una participación en el Programa de Iniciación a la Investigación Educativa (INED)[10] de 125 horas.

El candidato es el fundador y coordinador del Equipo de Innovación y Calidad Educativa (EICE) denominado MATI (Metodologías Activas y Tecnologías de la Información)[11] desde su creación en el año 2011. Ha participado en 10 Proyectos de Innovación y Mejora Educativa (PIME), liderando 3 de ellos, dando lugar a un total de 1 publicación en revista JCR y 14 publicaciones en congresos de innovación educativa tanto nacionales como internacionales, además de otras 14 publicaciones de idénticos foros de innovación educativa, como resultado de la colaboración con otros docentes no pertenecientes al MATI.

[7] CursoCloudAWS: https://www.grycap.upv.es/cursocloudaws
[8] EUPU: https://www.upv.es/contenidos/ICEP/info/781973normalc.html
[9] EUFOL: https://www.upv.es/contenidos/ICEP/info/868949normalc.html
[10] INED: http://www.upv.es/contenidos/ICEP/info/Modulos_C.pdf
[11] EICE: https://www.ice.upv.es/innovacion/eice-equipos-de-innovacion-y-calidad-educativa/

Capítulo 3

Curriculum Vitae Normalizado (CVN)

CURRÍCULUM VÍTAE NORMALIZADO

Germán Moltó Martínez

Generado desde: Universitat Politècnica de València

Fecha del documento: 23/06/2022

v 1.4.0

46b4c45697c5a37bb68fbb78676a8bf1

Germán Moltó Martínez

Apellidos:	**Moltó Martínez**
Nombre:	**Germán**
DNI:	**52656437F**
ResearcherID:	**C-6994-2008**
ScopusID:	**8953108200**
ORCID:	**0000-0002-8049-253X**
Fecha de nacimiento:	**06/01/1979**
Sexo:	**Hombre**
Teléfono fijo:	**(034) 963877000 - 73527**
Correo electrónico:	**gmolto@dsic.upv.es**

Situación profesional actual

Entidad empleadora: UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Tipo de entidad: Universidad

Departamento: D. Sistemas Informáticos y Computación, E.T.S.I. Informática

Categoría profesional: Profesor/a Titular de Universidad

Gestión docente (Sí/No): Si

Correo electrónico: gmolto@dsic.upv.es

Fecha de inicio: 04/04/2012

Modalidad de contrato: Funcionario/a

Régimen de dedicación: Tiempo completo

Cargos y actividades desempeñados con anterioridad

	Entidad empleadora	Categoría profesional	Fecha de inicio
1	Universitat Politècnica de València	Profesor/a Titular de Universidad	04/04/2012
2	Universitat Politècnica de València	Profesor/a Contratado/a Doctor	11/09/2009
3	Universitat Politècnica de València	Profesor/a Ayudante Doctor	10/06/2008
4	Universitat Politècnica de València	Ayudante	15/09/2006
5	Universitat Politècnica de València	Ayudante	04/03/2005

1 **Entidad empleadora:** Universitat Politècnica de València
Categoría profesional: Profesor/a Titular de Universidad
Fecha de inicio: 04/04/2012

2 **Entidad empleadora:** Universitat Politècnica de València
Categoría profesional: Profesor/a Contratado/a Doctor
Fecha de inicio: 11/09/2009
Duración: 2 años - 6 meses - 22 días

3 **Entidad empleadora:** Universitat Politècnica de València
Categoría profesional: Profesor/a Ayudante Doctor
Fecha de inicio: 10/06/2008 **Duración:** 1 año - 3 meses

4 **Entidad empleadora:** Universitat Politècnica de València
Categoría profesional: Ayudante
Fecha de inicio: 15/09/2006 **Duración:** 1 año - 8 meses - 24 días

5 **Entidad empleadora:** Universitat Politècnica de València
Categoría profesional: Ayudante
Fecha de inicio: 04/03/2005 **Duración:** 1 año - 6 meses - 10 días

Formación académica recibida

Titulación universitaria

Estudios de 1º y 2º ciclo, y antiguos ciclos (Licenciados, Diplomados, Ingenieros Superiores, Ingenieros Técnicos, Arquitectos)

Titulación universitaria: INGENIERO EN INFORMÁTICA
Nombre del título: INGENIERO EN INFORMÁTICA
Ciudad entidad titulación: España
Entidad de titulación: Universitat Politècnica de València
Tipo de entidad: Universidad
Fecha de titulación: 01/06/2002
Nota media del expediente: Notable

Doctorados

Programa de doctorado: DOCTOR EN INFORMÁTICA
Entidad de titulación: Universitat Politècnica de València
Tipo de entidad: Universidad
Ciudad entidad titulación: España
Fecha de titulación: 22/10/2007
Título de la tesis: Computación de altas prestaciones sobre entornos grid en aplicaciones biomédicas: simulación de la actividad eléctrica cardiaca y diseño de proteínas
Calificación obtenida: Sobresaliente Cum Laude

Cursos y seminarios recibidos de perfeccionamiento, innovación y mejora docente, nuevas tecnologías, etc., cuyo objetivo sea la mejora de la docencia

1 **Título del curso/seminario:** Cómo proporcionar un feedback de calidad
Entidad organizadora: ICE
Duración en horas: 10 horas
Fecha de finalización: 22/10/2021

2 **Título del curso/seminario:** Creación de vídeos con preguntas interactivas con Stream y Forms de Microsoft 365
Entidad organizadora: ICE
Duración en horas: 3 horas
Fecha de finalización: 27/09/2021

3 **Título del curso/seminario:** Cómo editar tus grabaciones de clases de TEAMS: propuestas para mejorar el resultado final de los vídeos
Entidad organizadora: ICE
Duración en horas: 2 horas
Fecha de finalización: 08/03/2021

4 **Título del curso/seminario:** Gamificación mediante recursos digitales en la enseñanza universitaria
Entidad organizadora: ICE
Duración en horas: 12 horas
Fecha de finalización: 24/02/2021

5 **Título del curso/seminario:** La enseñanza basada en retos
Entidad organizadora: ICE
Duración en horas: 2 horas
Fecha de finalización: 19/01/2021

6 **Título del curso/seminario:** Lo que saben nuestros entornos de aprendizaje sobre lo que hacen (o no) nuestros alumnos
Entidad organizadora: ICE
Duración en horas: 3 horas
Fecha de finalización: 20/02/2020

7 **Título del curso/seminario:** Comunicación asertiva
Entidad organizadora: ICE
Duración en horas: 4 horas
Fecha de finalización: 23/01/2020

8 **Título del curso/seminario:** Módulo de iniciación a la investigación educativa
Entidad organizadora: ICE
Duración en horas: 100 horas
Fecha de finalización: 23/01/2020

9 **Título del curso/seminario:** Lenguaje corporal y relaciones sociales: la comunicación no verbal
Entidad organizadora: ICE
Duración en horas: 6 horas
Fecha de finalización: 12/03/2019

10 **Título del curso/seminario:** Gestión académica asociada a la dirección de tesis doctorales en el nuevo marco normativo
Entidad organizadora: ICE
Duración en horas: 4 horas
Fecha de finalización: 21/02/2019

11 **Título del curso/seminario:** Jornada de aprendizaje orientado a proyectos
Entidad organizadora: ICE
Duración en horas: 6 horas
Fecha de finalización: 30/01/2019

12 **Título del curso/seminario:** TALLER PARA PROFESORES "AULA EMPRENDE"
Entidad organizadora: IDEAS UPV
Duración en horas: 8 horas
Fecha de finalización: 10/07/2018

13 **Título del curso/seminario:** JORNADA DE INNOVACIÓN DOCENTE DE LA ETSINF
Entidad organizadora: ICE
Duración en horas: 5 horas
Fecha de finalización: 03/07/2018

14 **Título del curso/seminario:** Creación de contenidos con la herramienta LESSONS
Entidad organizadora: ICE
Duración en horas: 4 horas
Fecha de finalización: 17/01/2018

15 **Título del curso/seminario:** Educación de la voz
Entidad organizadora: ICE
Duración en horas: 8 horas
Fecha de finalización: 17/01/2018

16 **Título del curso/seminario:** Elaboración de cuestionarios para la investigación educativa
Entidad organizadora: ICE
Duración en horas: 8 horas
Fecha de finalización: 18/05/2017

17 **Título del curso/seminario:** JORNADA DE INNOVACIÓN DOCENTE DE LA ETSINF
Entidad organizadora: ICE
Duración en horas: 4 horas
Fecha de finalización: 19/01/2017

18 **Título del curso/seminario:** Innovaciones y propuestas para la e-evaluación de competencias en la universidad
Entidad organizadora: ICE
Duración en horas: 8 horas
Fecha de finalización: 10/03/2016

19 **Título del curso/seminario:** Competencia transversal. Instrumental específica
Entidad organizadora: ICE
Duración en horas: 4 horas
Fecha de finalización: 27/01/2016

20 **Título del curso/seminario:** Ser amables con nosotros mismos: la autocompasión como fuente de autocuidado para afrontar el sufrimiento y disfrutar de la vida
Entidad organizadora: ICE
Duración en horas: 8 horas
Fecha de finalización: 15/01/2016

21 **Título del curso/seminario:** REALIZACION DE EXAMENES A TRAVES DE PLATAFORMAS EDUCATIVAS: POLIFORMAT - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 10 horas
Fecha de finalización: 15/07/2015

22 **Título del curso/seminario:** RECURSOS TECNOLOGICOS DE APOYO AL APRENDIZAJE OFERTADOS POR LA UPV - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 10 horas
Fecha de finalización: 17/07/2014

23 **Título del curso/seminario:** JORNADAS DE INNOVACIÓN Y DOCENCIA EN RED
Entidad organizadora: ICE
Duración en horas: 10 horas
Fecha de finalización: 16/07/2014

24 **Título del curso/seminario:** PLATAFORMAS DE TRABAJO COLABORATIVO - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 10 horas
Fecha de finalización: 24/06/2014

25 **Título del curso/seminario:** PROGRAMACION DE ASIGNATURAS SEMIPRESENCIALES Y ON LINE - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 10 horas
Fecha de finalización: 12/06/2014

26 **Título del curso/seminario:** BUSQUEDA Y GESTION DE INFORMACION ON LINE - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 15 horas
Fecha de finalización: 29/05/2014

27 **Título del curso/seminario:** LOS BLOGS AL SERVICIO DE LA DOCENCIA - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 5 horas
Fecha de finalización: 27/05/2014

28 **Título del curso/seminario:** LA TUTORIA Y EL SEGUIMIENTO DEL TRABAJO DEL ALUMNO - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 10 horas
Fecha de finalización: 29/04/2014

29 **Título del curso/seminario:** INNOVACIONES Y PROPUESTAS PARA LA E-EVALUACION DE COMPETENCIAS EN LA UNIVERSIDAD - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 10 horas
Fecha de finalización: 08/04/2014

30 **Título del curso/seminario:** REALIZACION DE TAREAS A TRAVES DE PLATAFORMAS EDUCATIVAS: POLIFORMAT - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 10 horas
Fecha de finalización: 10/03/2014

31 **Título del curso/seminario:** PEDAGOGIA UNIVERSITARIA Y E-LEARNING - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 10 horas
Fecha de finalización: 18/02/2014

32 **Título del curso/seminario:** PLATAFORMAS EDUCATIVAS COMO APOYO A LA ENSEÑANZA - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 10 horas
Fecha de finalización: 10/02/2014

33 **Título del curso/seminario:** ELABORACION DE RECURSOS MULTIMEDIA PARA LA DOCENCIA: PUBLICACIONES DOCENTES CON LA PLANTILLA LATEX DE LA UPV - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 10 horas
Fecha de finalización: 06/02/2014

34 **Título del curso/seminario:** AULA 2.0. LAS TIC COMO ELEMENTO DINAMIZADOR DE LA INTERACTIVIDAD - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 5 horas
Fecha de finalización: 31/01/2014

35 **Título del curso/seminario:** Tus publicaciones en Senia accesibles en RiuNet
Entidad organizadora: ICE
Duración en horas: 4 horas
Fecha de finalización: 21/05/2013

36 **Título del curso/seminario:** CONFERENCIA-COLOQUIO: "Mirando al futuro en la docencia de la UPV"
Entidad organizadora: ICE
Duración en horas: 2 horas
Fecha de finalización: 21/01/2013

37 **Título del curso/seminario:** Meditación (Mindfulness)
Entidad organizadora: ICE
Duración en horas: 12 horas
Fecha de finalización: 17/01/2013

38 **Título del curso/seminario:** V JORNADA DE INNOVACIÓN DOCENTE DE LA ETSINF
Entidad organizadora: ICE
Duración en horas: 4 horas
Fecha de finalización: 13/12/2012

39 **Título del curso/seminario:** CURSO EN PREVENCIÓN DE RIESGOS LABORALES EN LA ACTIVIDAD DOCENTE EN EL AULA O LABORATORIO INFORMÁTICO
Entidad organizadora: ICE
Duración en horas: 15 horas
Fecha de finalización: 19/10/2012

40 **Título del curso/seminario:** JORNADAS DE INNOVACIÓN EDUCATIVA 2012
Entidad organizadora: ICE
Duración en horas: 16 horas
Fecha de finalización: 13/07/2012

41 **Título del curso/seminario:** Habilidades para la vida: mejorando la competencia emocional y relacional
Entidad organizadora: ICE
Duración en horas: 12 horas
Fecha de finalización: 29/06/2012

42 **Título del curso/seminario:** Seducir con la palabra y triunfar en las reuniones
Entidad organizadora: ICE
Duración en horas: 12 horas
Fecha de finalización: 12/06/2012

43 **Título del curso/seminario:** El uso de las rúbricas para mejorar los criterios de calidad en la evaluación
Entidad organizadora: ICE
Duración en horas: 8 horas
Fecha de finalización: 07/06/2012

44 **Título del curso/seminario:** La participación del alumnado en la evaluación en la enseñanza universitaria: autoevaluación, evaluación entre iguales y evaluación compartida
Entidad organizadora: ICE
Duración en horas: 8 horas
Fecha de finalización: 20/04/2012

45 **Título del curso/seminario:** El grupo como espacio de aprendizaje
Entidad organizadora: ICE
Duración en horas: 8 horas
Fecha de finalización: 02/02/2012

46 **Título del curso/seminario:** Elaboración del proyecto de investigación
Entidad organizadora: ICE
Duración en horas: 5 horas
Fecha de finalización: 26/01/2012

47 **Título del curso/seminario:** ECOSISTEMAS DE APRENDIZAJE: RETOS DE LA EDUCACIÓN DE INGENIERÍA/CIENCIAS EN EL SIGLO XXI
Entidad organizadora: ICE
Duración en horas: 6 horas
Fecha de finalización: 24/01/2012

48 **Título del curso/seminario:** IV JORNADA DE INNOVACIÓN DOCENTE DE LA ETSINF
Entidad organizadora: ICE
Duración en horas: 4 horas
Fecha de finalización: 24/11/2011

49 **Título del curso/seminario:** EL PENSAMIENTO ESTADÍSTICO EN LA INVESTIGACIÓN
Entidad organizadora: ICE
Duración en horas: 5 horas
Fecha de finalización: 03/06/2011

50 **Título del curso/seminario:** FINANCIACIÓN PÚBLICA
Entidad organizadora: ICE
Duración en horas: 10 horas
Fecha de finalización: 08/02/2011

51 **Título del curso/seminario:** EL SISTEMA DE I+D+I
Entidad organizadora: ICE
Duración en horas: 5 horas
Fecha de finalización: 21/01/2011

52 **Título del curso/seminario:** Tablets-PC + Tinta digital. Una oportunidad para dinamizar las aulas
Entidad organizadora: ICE
Duración en horas: 4 horas
Fecha de finalización: 29/04/2010

53 **Título del curso/seminario:** METODOLOGÍA PARTICIPATIVA EN LA UNIVERSIDAD
Entidad organizadora: ICE
Duración en horas: 7 horas
Fecha de finalización: 15/07/2009

54 **Título del curso/seminario:** EL PLAN DOCENCIA EN RED DE LA UPV: OBJETOS Y MÓDULOS DE APRENDIZAJE Y ASIGNATURAS OCW
Entidad organizadora: ICE
Duración en horas: 5 horas
Fecha de finalización: 14/07/2009

55 **Título del curso/seminario:** JORNADAS DE INTERCAMBIO DE EXPERIENCIAS SOBRE METODOLOGÍAS ACTIVAS PARA LA FORMACIÓN EN COMPETENCIAS
Entidad organizadora: ICE
Duración en horas: 4 horas
Fecha de finalización: 08/07/2009

56 **Título del curso/seminario:** CÓMO CALCULAR EL TIEMPO DE TRABAJO DEL ESTUDIANTE: LOS ECTS
Entidad organizadora: ICE
Duración en horas: 4 horas
Fecha de finalización: 06/07/2009

57 **Título del curso/seminario:** EXPERIENCIAS INNOVADORAS EN POLIFORMAT
Entidad organizadora: ICE
Duración en horas: 5 horas
Fecha de finalización: 11/07/2008

58 **Título del curso/seminario:** DISEÑO DE PROYECTOS - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 5 horas
Fecha de finalización: 30/06/2008

59 **Título del curso/seminario:** EVALUACION DE LOS APRENDIZAJES - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 15 horas
Fecha de finalización: 30/06/2008

60 **Título del curso/seminario:** HABILIDADES DOCENTES PARA LA COMUNICACION EDUCATIVA - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 20 horas
Fecha de finalización: 30/06/2008

61 **Título del curso/seminario:** HERRAMIENTAS PARA EL EJERCICIO DE LA FUNCION DOCENTE - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 10 horas
Fecha de finalización: 30/06/2008

62 **Título del curso/seminario:** INNOVACION Y MEJORA DE LA ENSEÑANZA - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 10 horas
Fecha de finalización: 30/06/2008

63 **Título del curso/seminario:** LA ACCION TUTORIAL EN EL CONTEXTO UNIVERSITARIO - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 8 horas
Fecha de finalización: 30/06/2008

64 **Título del curso/seminario:** LA PROFESION DE PROFESOR DE UNIVERSIDAD - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 5 horas
Fecha de finalización: 30/06/2008

65 **Título del curso/seminario:** LA UNIVERSIDAD COMO ESCENARIO DE LA FORMACION - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 5 horas
Fecha de finalización: 30/06/2008

66 **Título del curso/seminario:** LAS TECNOLOGIAS DE LA INFORMACION Y LA COMUNICACION - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 10 horas
Fecha de finalización: 30/06/2008

67 **Título del curso/seminario:** MEJORA DE LA TAREA DOCENTE - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 7 horas
Fecha de finalización: 30/06/2008

68 **Título del curso/seminario:** PANORAMICA GENERAL DE LOS METODOS DE APRENDIZAJE-ENSEÑANZA EN LA UNIVERSIDAD - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 15 horas

Fecha de finalización: 30/06/2008

69 **Título del curso/seminario:** PLANIFICACION DE LA ENSEÑANZA DESDE LA PERSPECTIVA DEL ECTS - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 15 horas
Fecha de finalización: 30/06/2008

70 **Título del curso/seminario:** TEORIA DEL APRENDIZAJE EN LA UNIVERSIDAD - (FORMACIÓN PEDAGÓGICA Y TECNOLÓGICA UNIVERSITARIA)
Entidad organizadora: ICE
Duración en horas: 15 horas
Fecha de finalización: 30/06/2008

71 **Título del curso/seminario:** COACHING PARA DOCENTES: EL DESARROLLO DE HABILIDADES EN EL AULA
Entidad organizadora: ICE
Duración en horas: 12 horas
Fecha de finalización: 25/01/2007

72 **Título del curso/seminario:** Los contratos de aprendizaje como elemento favorecedor de la autonomía del alumno
Entidad organizadora: ICE
Duración en horas: 14 horas
Fecha de finalización: 02/06/2006

73 **Título del curso/seminario:** Uso eficaz del tiempo: cómo alcanzar el éxito sin estrés
Entidad organizadora: ICE
Duración en horas: 8 horas
Fecha de finalización: 09/02/2006

74 **Título del curso/seminario:** Argumentación oral en situaciones del ámbito universitario (B)
Entidad organizadora: ICE
Duración en horas: 8 horas
Fecha de finalización: 25/01/2006

75 **Título del curso/seminario:** Estilos de aprendizaje y estrategias de enseñanza
Entidad organizadora: ICE
Duración en horas: 12 horas
Fecha de finalización: 05/07/2005

76 **Título del curso/seminario:** El portafolio docente
Entidad organizadora: ICE
Duración en horas: 8 horas
Fecha de finalización: 30/06/2005

77 **Título del curso/seminario:** Cognitive thinking tools for the classroom and for collaborative work
Entidad organizadora: ICE
Duración en horas: 8 horas
Fecha de finalización: 20/05/2005

78 **Título del curso/seminario:** EXPERTO UNIVERSITARIO EN FORMACIÓN ONLINE
Entidad organizadora: ICE
Duración en horas: 243 horas

79 **Título del curso/seminario:** ESPECIALISTA UNIVERSITARIO EN PEDAGOGÍA UNIVERSITARIA
Entidad organizadora: ICE
Duración en horas: 325 horas

Conocimiento de idiomas

Idioma	Comprensión auditiva	Comprensión de lectura	Interacción oral	Expresión oral	Expresión escrita
Español					
Inglés					
Catalán					

Actividad docente

Formación académica impartida

1 **Tipo de docencia:** Docencia no oficial
Nombre de la asignatura/curso: Arquitecturas de Aplicaciones con Amazon Web Services
Fecha de finalización: 24/05/2022 **Tipo de horas/créditos ECTS:** Horas
Nº de horas/créditos ECTS: 8
Entidad de realización: GESTIÓN Y DESARROLLO DEL CONOCIMIENTO, S.L.U.

2 **Tipo de docencia:** Docencia no oficial
Nombre de la asignatura/curso: Arquitecturas de Aplicaciones Seguras en AWS
Fecha de finalización: 28/03/2020 **Tipo de horas/créditos ECTS:** Horas
Nº de horas/créditos ECTS: 24
Entidad de realización: ILearn Innovaciones Formativas

3 **Tipo de docencia:** Docencia no oficial
Nombre de la asignatura/curso: Arquitectura de Aplicaciones AWS
Fecha de finalización: 22/11/2019 **Tipo de horas/créditos ECTS:** Horas
Nº de horas/créditos ECTS: 24
Entidad de realización: GESDECO

4 **Tipo de docencia:** Docencia no oficial
Nombre de la asignatura/curso: Arquitectura de Aplicaciones en AWS
Fecha de finalización: 14/11/2018 **Tipo de horas/créditos ECTS:** Horas
Nº de horas/créditos ECTS: 20
Entidad de realización: Colegio Oficial de Ingenieros Informáticos de la Comunitat Valenciana (COIICV)

5 **Tipo de docencia:** Docencia no oficial
Nombre de la asignatura/curso: Arquitectura de Aplicaciones en AWS
Fecha de finalización: 06/04/2017 **Tipo de horas/créditos ECTS:** Horas

Nº de horas/créditos ECTS: 24
Entidad de realización: Spain Business School, S.L.

6 **Tipo de docencia:** Docencia no oficial
Nombre de la asignatura/curso: Taller de Polireunión
Fecha de finalización: 24/03/2011 **Tipo de horas/créditos ECTS:** Horas
Nº de horas/créditos ECTS: 2
Entidad de realización: ICE

7 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Desarrollo y despliegue seguro
Titulación universitaria: Máster Universitario en Ciberseguridad y Ciberinteligencia
Curso que se imparte: 2022
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 3
Entidad de realización: Universitat Politècnica de València

8 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Estrategias y herramientas de computación big data en la nube (CBD)
Titulación universitaria: Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing
Curso que se imparte: 2022
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 2
Entidad de realización: Universitat Politècnica de València

9 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Infraestructura para el procesamiento de datos
Curso que se imparte: 2022
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 1,89
Entidad de realización: Universitat Politècnica de València

10 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Infraestructuras de cloud público (ICP)
Titulación universitaria: Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing
Curso que se imparte: 2022
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 4
Entidad de realización: Universitat Politècnica de València

11 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Lenguajes y entornos de programación paralela
Curso que se imparte: 2022
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 2,25
Entidad de realización: Universitat Politècnica de València

12 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Desarrollo y despliegue seguro
Titulación universitaria: Máster Universitario en Ciberseguridad y Ciberinteligencia
Curso que se imparte: 2021
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 3
Entidad de realización: Universitat Politècnica de València

13 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Estrategias y herramientas de computación big data en la nube (CBD)
Titulación universitaria: Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing
Curso que se imparte: 2021
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 2
Entidad de realización: Universitat Politècnica de València

14 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Infraestructura para el procesamiento de datos
Titulación universitaria: Grado en Ciencia de Datos
Curso que se imparte: 2021
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 2,64
Entidad de realización: Universitat Politècnica de València

15 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Infraestructuras de cloud público (ICP)
Titulación universitaria: Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing
Curso que se imparte: 2021
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 4
Entidad de realización: Universitat Politècnica de València

16 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Ingeniería Cloud: Despliegue y Operación de Servicios
Curso que se imparte: 2021
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 10
Entidad de realización: Universidad de Sevilla

17 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Lenguajes y entornos de programación paralela
Titulación universitaria: Grado en Ingeniería Informática
Curso que se imparte: 2021
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 3
Entidad de realización: Universitat Politècnica de València

18 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Desarrollo y despliegue seguro
Titulación universitaria: Máster Universitario en Ciberseguridad y Ciberinteligencia
Curso que se imparte: 2020
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 3
Entidad de realización: Universitat Politècnica de València

19 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Estrategias y herramientas de computación big data en la nube (CBD)
Titulación universitaria: Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing
Curso que se imparte: 2020
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 2
Entidad de realización: Universitat Politècnica de València

20 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Infraestructura para el procesamiento de datos
Titulación universitaria: Grado en Ciencia de Datos
Curso que se imparte: 2020
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 2,64
Entidad de realización: Universitat Politècnica de València

21 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Infraestructuras de cloud público (ICP)
Titulación universitaria: Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing
Curso que se imparte: 2020
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 4
Entidad de realización: Universitat Politècnica de València

22 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Ingeniería Cloud: Despliegue y Operación de Servicios
Curso que se imparte: 2020
Tipo de horas/créditos ECTS: Horas
Nº de horas/créditos ECTS: 10
Entidad de realización: Universidad de Sevilla

23 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Lenguajes y entornos de programación paralela
Titulación universitaria: Grado en Ingeniería Informática; Máster Universitario en Ingeniería Industrial
Curso que se imparte: 2020
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 1,5
Entidad de realización: Universitat Politècnica de València

24 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Servicios en la nube
Titulación universitaria: Grado en Ingeniería de Tecnologías y Servicios de Telecomunicación; Máster Universitario en Gestión de la Información
Curso que se imparte: 2020
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 4,5
Entidad de realización: Universitat Politècnica de València

25 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Infraestructuras de cloud público (ICP)
Titulación universitaria: Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing
Curso que se imparte: 2019
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 4
Entidad de realización: Universitat Politècnica de València

26 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Ingeniería Cloud: Despliegue y Operación de Servicios
Curso que se imparte: 2019
Tipo de horas/créditos ECTS: Horas
Nº de horas/créditos ECTS: 10
Entidad de realización: Universidad de Sevilla

27 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Lenguajes y entornos de programación paralela
Titulación universitaria: Grado en Ingeniería Informática
Curso que se imparte: 2019
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 3
Entidad de realización: Universitat Politècnica de València

28 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Servicios en la nube
Titulación universitaria: Máster Universitario en Gestión de la Información; Máster Universitario en Ingeniería Informática
Curso que se imparte: 2019
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 4,5
Entidad de realización: Universitat Politècnica de València

29 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Estrategias y herramientas de computación big data en la nube (CBD)
Titulación universitaria: Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing
Curso que se imparte: 2018
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 2
Entidad de realización: Universitat Politècnica de València

30 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Infraestructuras de cloud público (ICP)
Titulación universitaria: Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing
Curso que se imparte: 2018
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 4
Entidad de realización: Universitat Politècnica de València

31 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Servicios en la nube
Titulación universitaria: Máster Universitario en Gestión de la Información; Máster Universitario en Ingeniería Informática
Curso que se imparte: 2018
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 4,5
Entidad de realización: Universitat Politècnica de València

32 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: DESPLIEGUE Y CONFIGURACIÓN AUTOMATIZADA MEDIANTE DEVOPS (DCA)
Titulación universitaria: Máster Universitario en Computación Paralela y Distribuida; Programa de Doctorado en Informática
Curso que se imparte: 2017
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 2
Entidad de realización: Universitat Politècnica de València

33 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: ESTRATEGIAS Y HERRAMIENTAS DE COMPUTACIÓN BIG DATA EN LA NUBE (CBD)
Titulación universitaria: Máster Universitario en Computación Paralela y Distribuida; Programa de Doctorado en Informática
Curso que se imparte: 2017
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 2
Entidad de realización: Universitat Politècnica de València

34 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: INFRAESTRUCTURAS DE CLOUD PÚBLICO (ICP)
Titulación universitaria: Máster Universitario en Computación Paralela y Distribuida; Programa de Doctorado en Informática
Curso que se imparte: 2017
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 3
Entidad de realización: Universitat Politècnica de València

35 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: PLATAFORMAS DE GESTIÓN DE CONTENEDORES (PGC)
Titulación universitaria: Máster Universitario en Computación Paralela y Distribuida; Programa de Doctorado en Informática
Curso que se imparte: 2017

Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 1,8
Entidad de realización: Universitat Politècnica de València

36 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Servicios en la nube
Titulación universitaria: Máster Universitario en Gestión de la Información; Máster Universitario en Ingeniería de Sistemas Electrónicos; Máster Universitario en Ingeniería de Telecomunicación
Curso que se imparte: 2017
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 4,5
Entidad de realización: Universitat Politècnica de València

37 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: ESTRATEGIAS Y HERRAMIENTAS DE COMPUTACIÓN BIG DATA EN LA NUBE (CBD)
Titulación universitaria: Máster Universitario en Computación Paralela y Distribuida
Curso que se imparte: 2016
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 2
Entidad de realización: Universitat Politècnica de València

38 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: INFRAESTRUCTURAS DE CLOUD PÚBLICO (ICP)
Titulación universitaria: Máster Universitario en Computación Paralela y Distribuida
Curso que se imparte: 2016
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 3
Entidad de realización: Universitat Politècnica de València

39 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Programación
Titulación universitaria: Grado en Ingeniería Informática
Curso que se imparte: 2016
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 1,65
Entidad de realización: Universitat Politècnica de València

40 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Servicios en la nube
Titulación universitaria: Máster Universitario en Gestión de la Información; Máster Universitario en Ingeniería Informática
Curso que se imparte: 2016
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 3,5
Entidad de realización: Universitat Politècnica de València

41 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: ESTRATEGIAS Y HERRAMIENTAS DE COMPUTACIÓN BIG DATA EN LA NUBE (CBD)

Titulación universitaria: Máster Universitario en Computación Paralela y Distribuida; Programa de Doctorado en Informática
Curso que se imparte: 2015
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 0,5
Entidad de realización: Universitat Politècnica de València

42 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: INFRAESTRUCTURAS DE CLOUD PÚBLICO (ICP)
Titulación universitaria: Máster Universitario en Computación Paralela y Distribuida; Programa de Doctorado en Informática
Curso que se imparte: 2015
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 3
Entidad de realización: Universitat Politècnica de València

43 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Programación
Titulación universitaria: Grado en Ingeniería Informática
Curso que se imparte: 2015
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 4,95
Entidad de realización: Universitat Politècnica de València

44 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Servicios en la nube
Titulación universitaria: Máster Universitario en Gestión de la Información; Máster Universitario en Ingeniería Informática
Curso que se imparte: 2015
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 3
Entidad de realización: Universitat Politècnica de València

45 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: ESTRATEGIAS Y HERRAMIENTAS DE COMPUTACIÓN BIG DATA EN LA NUBE (CBD)
Titulación universitaria: Máster Universitario en Computación Paralela y Distribuida
Curso que se imparte: 2014
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 0,5
Entidad de realización: Universitat Politècnica de València

46 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: INFRAESTRUCTURAS DE CLOUD PÚBLICO (ICP)
Titulación universitaria: Máster Universitario en Computación Paralela y Distribuida
Curso que se imparte: 2014
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 3
Entidad de realización: Universitat Politècnica de València

47 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Introducción a la informática y a la programación
Titulación universitaria: Grado en Ingeniería Informática
Curso que se imparte: 2014
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 4,95
Entidad de realización: Universitat Politècnica de València

48 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Programación
Titulación universitaria: Grado en Ingeniería Informática
Curso que se imparte: 2014
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 4,95
Entidad de realización: Universitat Politècnica de València

49 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Servicios en la nube
Titulación universitaria: Grado en Ingeniería Informática; Máster Universitario en Gestión de la Información; Máster Universitario en Ingeniería de Computadores
Curso que se imparte: 2014
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 1,5
Entidad de realización: Universitat Politècnica de València

50 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: ESTRATEGIAS Y HERRAMIENTAS DE COMPUTACIÓN BIG DATA EN LA NUBE (CBD)
Titulación universitaria: Máster Universitario en Computación Paralela y Distribuida
Curso que se imparte: 2013
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 2
Entidad de realización: Universitat Politècnica de València

51 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: INFRAESTRUCTURAS DE CLOUD PÚBLICO (ICP)
Titulación universitaria: Máster Universitario en Computación Paralela y Distribuida
Curso que se imparte: 2013
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 3
Entidad de realización: Universitat Politècnica de València

52 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Introducción a la informática y a la programación
Titulación universitaria: Grado en Ingeniería Informática
Curso que se imparte: 2013
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 4,95
Entidad de realización: Universitat Politècnica de València

53 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Programación
Titulación universitaria: Grado en Ingeniería Geomática y Topografía; Grado en Ingeniería Informática
Curso que se imparte: 2013
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 4,95
Entidad de realización: Universitat Politècnica de València

54 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: APLICACIONES AVANZADAS DE GRID
Titulación universitaria: Máster Universitario en Computación Paralela y Distribuida
Curso que se imparte: 2012
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 0,08
Entidad de realización: Universitat Politècnica de València

55 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: CONCEPTOS DE LA COMPUTACIÓN EN GRID
Titulación universitaria: Máster Universitario en Computación Paralela y Distribuida
Curso que se imparte: 2012
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 1,1
Entidad de realización: Universitat Politècnica de València

56 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Introducción a la informática y a la programación
Titulación universitaria: Grado en Ingeniería Informática
Curso que se imparte: 2012
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 6,6
Entidad de realización: Universitat Politècnica de València

57 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Programación
Titulación universitaria: Grado en Ingeniería Informática
Curso que se imparte: 2012
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 4,95
Entidad de realización: Universitat Politècnica de València

58 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: CONCEPTOS DE LA COMPUTACIÓN EN GRID
Titulación universitaria: Máster Universitario en Computación Paralela y Distribuida
Curso que se imparte: 2011
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 0,6
Entidad de realización: Universitat Politècnica de València

59 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Introducción a la informática y a la programación
Titulación universitaria: Grado en Ingeniería Informática

Curso que se imparte: 2011
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 8,25
Entidad de realización: Universitat Politècnica de València

60 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Programación
Titulación universitaria: Grado en Ingeniería Informática
Curso que se imparte: 2011
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 9,08
Entidad de realización: Universitat Politècnica de València

61 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: ESTRUCTURA DE DATOS Y ALGORITMOS
Titulación universitaria: I. Informático; Ingeniero Técnico en Informática de Gestión; I.T. Informática de Gestión; I.T. Informática de Sistemas
Curso que se imparte: 2010
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 15
Entidad de realización: Universitat Politècnica de València

62 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Introducción a la informática y a la programación
Titulación universitaria: Grado en Ingeniería Informática
Curso que se imparte: 2010
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 5,02
Entidad de realización: Universitat Politècnica de València

63 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: ESTRUCTURA DE DATOS Y ALGORITMOS
Curso que se imparte: 2009
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 21
Entidad de realización: Universitat Politècnica de València

64 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: ESTRUCTURA DE DATOS Y ALGORITMOS
Curso que se imparte: 2008
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 18
Entidad de realización: Universitat Politècnica de València

65 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: ESTRUCTURA DE DATOS Y ALGORITMOS
Curso que se imparte: 2007
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 10,98
Entidad de realización: Universitat Politècnica de València

66 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: ESTRUCTURA DE DATOS Y ALGORITMOS
Curso que se imparte: 2006
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 10,89
Entidad de realización: Universitat Politècnica de València

67 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Computación Numérica
Curso que se imparte: 2005
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 4

68 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: ESTRUCTURA DE DATOS Y ALGORITMOS
Curso que se imparte: 2005
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 11
Entidad de realización: Universitat Politècnica de València

69 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: Estructuras de Datos y Algoritmos
Curso que se imparte: 2005
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 1,5

70 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: COMPUTACIÓN NUMÉRICA
Curso que se imparte: 2004
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 4
Entidad de realización: Universitat Politècnica de València

71 **Tipo de docencia:** Docencia oficial
Nombre de la asignatura/curso: ESTRUCTURA DE DATOS Y ALGORITMOS
Curso que se imparte: 2004
Tipo de horas/créditos ECTS: Créditos
Nº de horas/créditos ECTS: 1,5
Entidad de realización: Universitat Politècnica de València

Dirección de tesis doctorales y/o proyectos fin de carrera

1 **Título del trabajo:** Plataformes avançades en el Núvol per a la reproductibilitat d'experiments computacionals
Tipo de proyecto: Tesis Doctoral
Entidad de realización: Universitat Politècnica de València
Alumno/a: Giménez Alventosa, Vicent
Calificación obtenida: SOBRESALIENTE
Fecha de defensa: 03/06/2022
Mención de calidad: Si

2 **Título del trabajo:** Computación Serverless basada en GPUs en AWS
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , CONTRERAS RUIZ, MANUEL RAMON
Calificación obtenida: 9.0
Fecha de defensa: 13/12/2021

3 **Título del trabajo:** Entorno con integración continua para aplicaciones web desarrolladas con AngularJS
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , FUSTER JUST, FRANCISCO
Calificación obtenida: 6.0
Fecha de defensa: 20/07/2021

4 **Título del trabajo:** Gestión de Servicios de Amazon Web Services Mediante Alexa
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , AGULLO VALLS, ADRIAN
Calificación obtenida: 7.0
Fecha de defensa: 09/07/2021

5 **Título del trabajo:** Aplicación Web para Composición de Workflows Serverless
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , SOLER MARCO, DAVID
Calificación obtenida: 8.5
Fecha de defensa: 21/04/2021

6 **Título del trabajo:** Aplicación web para venta de entradas de cine en AWS
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , LLORCA PEDROS, CRISTIAN
Calificación obtenida: 7.0
Fecha de defensa: 29/03/2021

7 **Título del trabajo:** Recopilación Automatizada de Analíticas de Aprendizaje Mediante Herramientas Informáticas
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , HERRERO CABO, CARLOS
Calificación obtenida: 6.0
Fecha de defensa: 11/01/2021

8 **Título del trabajo:** Serverless Computing Strategies on Cloud Platforms
Tipo de proyecto: Tesis Doctoral
Entidad de realización: Universitat Politècnica de València
Alumno/a: Naranjo Delgado, Diana María
Calificación obtenida: SOBRESALIENTE (cum laude)
Fecha de defensa: 07/01/2021
Mención de calidad: Si

9 **Título del trabajo:** Un programa de fidelización de clientes que utiliza Blockchain
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , ALGHAMDI, OSAMA ABDULRAHMAN A
Calificación obtenida: 8.0
Fecha de defensa: 22/12/2020

10 **Título del trabajo:** Plataforma Serverless de Procesado de Datos Abiertos
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , ORTIZ AMAYA, JESUS
Calificación obtenida: 9.0
Fecha de defensa: 24/09/2020

11 **Título del trabajo:** Arquitecturas y Modelos Económicos de Aplicaciones Serverless
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , PETROSYAN, LUIZA
Calificación obtenida: 8.5
Fecha de defensa: 24/09/2020

12 **Título del trabajo:** Diseño de una Infraestructura Informática de Virtualización
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , VILA CASTELLO, ADRIAN
Calificación obtenida: 7.5
Fecha de defensa: 16/09/2020

13 **Título del trabajo:** Análisis de Herramientas Software para el Ciclo de Vida de un Proyecto de Big Data
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , MATA LLORCA, MANUEL
Calificación obtenida: 8.5
Fecha de defensa: 24/07/2020

14 **Título del trabajo:** Sistema Serverless de Monitorización de Recursos para Plataformas de Cloud Público
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , REQUENA CASARES, CRISTINA
Calificación obtenida: 9.0
Fecha de defensa: 24/07/2020

15 **Título del trabajo:** Optimización de arquitecturas distribuidas para el procesado de datos masivos
Tipo de proyecto: Tesis Doctoral
Entidad de realización: Universitat Politècnica de València
Alumno/a: Herrera Hernández, José
Calificación obtenida: SOBRESALIENTE (cum laude)
Fecha de defensa: 17/07/2020
Mención de calidad: Si

16 **Título del trabajo:** Advanced Elastic Platforms for High Throughput Computing on Container-based and Serverless Infrastructures
Tipo de proyecto: Tesis Doctoral
Entidad de realización: Universitat Politècnica de València
Alumno/a: Pérez González, Alfonso María
Calificación obtenida: SOBRESALIENTE (cum laude)
Fecha de defensa: 15/05/2020
Mención de calidad: Si

17 **Título del trabajo:** Algoritmos predictivos basados en el aprendizaje para plataformas integradas y distribuidas en el estudio de las ondas cerebrales.
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , GARCIA JIMENEZ, ALBERTO
Calificación obtenida: 9.5
Fecha de defensa: 23/09/2019

18 **Título del trabajo:** Val&Go: Aplicación de Movilidad Urbana para Valencia
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , GALLARDO MOSTEO, PABLO
Calificación obtenida: 9.5
Fecha de defensa: 19/09/2019

19 **Título del trabajo:** Ejecución Monetizada de Workflows de Algoritmos Privados en Plataformas Serverless Públicas
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , MENDEZ MADRIGAL, ADOLFO
Calificación obtenida: 10.0
Fecha de defensa: 25/07/2019

20 **Título del trabajo:** Plataforma Serverless Híbrida de Procesado de Datos
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , RISCO GALLARDO, SEBASTIAN
Calificación obtenida: 10.0
Fecha de defensa: 18/07/2019

21 **Título del trabajo:** Implementación de un chatbot mediante una arquitectura serverless
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , SOLE FONTE, MARC
Calificación obtenida: 10.0
Fecha de defensa: 09/07/2019

22 **Título del trabajo:** Evaluación del escalamiento de un sistema en la nube con cargas realistas y ajuste del umbral de escalamiento
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , CERVIERI CARRAU, VALENTIN VICENTE

Calificación obtenida: 6.0
Fecha de defensa: 23/05/2019

23 **Título del trabajo:** Interfaz para la Ejecución de Aplicaciones sobre Plataformas Serverless
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , PEIRO CASTELLO, JORDI
Calificación obtenida: 8.5
Fecha de defensa: 27/09/2018

24 **Título del trabajo:** Entrenamiento Escalable de Modelos de Deep Learning sobre Infraestructuras Cloud
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , JORGE CANO, JAVIER
Calificación obtenida: 10.0
Fecha de defensa: 27/09/2018

25 **Título del trabajo:** Plataforma Serverless de Ejecución de Trabajos
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , ORDOÑEZ OSORTO, DORIAN ADOLFO
Calificación obtenida: 9.0
Fecha de defensa: 27/09/2018

26 **Título del trabajo:** Portal Web de Analíticas de Uso para Cuentas Compartidas en AWS
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , PRIETO FONTCUBERTA, JOSE RAMON
Calificación obtenida: 10.0
Fecha de defensa: 12/07/2018

27 **Título del trabajo:** Despliegue y Monitorización de un cluster Mesos
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , LOPEZ HUGUET, SERGIO
Calificación obtenida: 9.5
Fecha de defensa: 28/07/2017

28 **Título del trabajo:** Desarrollo de una Interfaz REST para una Herramienta de Despliegue de Clusters Virtuales en la Nube
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , TELLO BENEYTO, ABEL
Calificación obtenida: 6.0
Fecha de defensa: 17/01/2017

29 **Título del trabajo:** Plataforma en la Nube para la Gestión y Evaluación de Portafolios Académicos
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , MIRANDA VASQUEZ, FRANZ ROBERT
Calificación obtenida: 9.0

Fecha de defensa: 14/12/2016

30 **Título del trabajo:** Gestión Eficiente de Arquitecturas Basadas en Microservicios
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , CRUZ HERRERA, PABLO ROBERTO
Calificación obtenida: 6.5
Fecha de defensa: 14/12/2016

31 **Título del trabajo:** High Performance Scientific Computing over Hybrid Cloud Platforms
Tipo de proyecto: Tesis Doctoral
Entidad de realización: Universitat Politècnica de València
Alumno/a: Calatrava Arroyo, Amanda
Calificación obtenida: SOBRESALIENTE (cum laude)
Fecha de defensa: 11/11/2016
Mención de calidad: Si

32 **Título del trabajo:** Elasticidad Horizontal Reactiva basada en Contenedores
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , GONZALEZ SEGURA, CESAR
Calificación obtenida: 8.5
Fecha de defensa: 30/09/2016

33 **Título del trabajo:** Gestión Elástica de Clusters de Contenedores
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , YATSYK GAVRYLYAK, YURIY
Calificación obtenida: 8.5
Fecha de defensa: 30/09/2016

34 **Título del trabajo:** Rivence: Aplicación móvil de servicios al ciudadano
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , QUINZA PEREZ, CARLOS
Calificación obtenida: 8.0
Fecha de defensa: 14/07/2016

35 **Título del trabajo:** Efficient and elastic management of computing infrastructures
Tipo de proyecto: Tesis Doctoral
Entidad de realización: Universitat Politècnica de València
Alumno/a: Alfonso Laguna, Carlos de
Calificación obtenida: SOBRESALIENTE (cum laude)
Fecha de defensa: 23/10/2015
Mención de calidad: Si

36 **Título del trabajo:** DESARROLLO DE UNA APLICACIÓN WEB PARA GESTIONAR LOS ARCHIVOS DE DROPBOX ENTRE VARIOS USUARIOS
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , GUAN, CHENG CHENG

Calificación obtenida: 8.0
Fecha de defensa: 30/09/2015

37 **Título del trabajo:** ANÁLISIS DE FACTORES DE DIAGNÓSTICO EN INFORMES RADIOLÓGICOS DEL PROCESO CLÍNICO DIAGNÓSTICO DE CÁNCER DE MAMA MEDIANTE MAPREDUCE
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , LOOR MASPONS, LUIS ENRIQUE
Calificación obtenida: 8.0
Fecha de defensa: 28/09/2015

38 **Título del trabajo:** Desarrollo de una aplicación web modular autogestionable
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , PERIS PEREZ, SERGIO
Calificación obtenida: 8.5
Fecha de defensa: 10/09/2015

39 **Título del trabajo:** Desarrollo de una aplicación para gestión de productos farmacéuticos
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , FARINOS MOLINA, JAVIER
Calificación obtenida: 7.0
Fecha de defensa: 16/07/2015

40 **Título del trabajo:** ESTUDIO DE APLICABILIDAD DE TÉCNICAS DE BIG DATA EN EL STREAMING MULTIMEDIA PARA LA DETECCIÓN DE EVENTOS
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , HERRERA HERNANDEZ, JOSE
Calificación obtenida: 9.3
Fecha de defensa: 25/02/2015

41 **Título del trabajo:** Gestión de infraestructuras virtuales configuradas dinámicamente
Tipo de proyecto: Tesis Doctoral
Entidad de realización: Universitat Politècnica de València
Alumno/a: Caballer Fernández, Miguel
Calificación obtenida: SOBRESALIENTE (cum laude)
Fecha de defensa: 25/04/2014
Mención de calidad: Si

42 **Título del trabajo:** DESARROLLO DE UNA APLICACIÓN WEB ORIENTADA A FACILITAR SERVICIOS DOMÉSTICOS-AYUDA2.ES
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , PUCHADES MARTINEZ, JOSE
Calificación obtenida: 9.0
Fecha de defensa: 25/04/2014

43 **Título del trabajo:** SLA-Driven Cloud Computing Domain Representation and Management
Tipo de proyecto: Tesis Doctoral
Entidad de realización: Universitat Politècnica de València
Alumno/a: García García, Andrés
Calificación obtenida: SOBRESALIENTE
Fecha de defensa: 07/03/2014
Mención de calidad: Si

44 **Título del trabajo:** Sistema de iluminación animada en un cubo de LEDS
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , SANCHEZ CHAMORRO, JEFFERSON DAVID
Calificación obtenida: 8.0
Fecha de defensa: 06/02/2014

45 **Título del trabajo:** Sistema de iluminación animada en un cubo de LEDS
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , MORA MORCILLO, ANDRES
Calificación obtenida: 8.0
Fecha de defensa: 06/02/2014

46 **Título del trabajo:** AGRILUK 2.0 EL BUSCADOR DE LA AGRICULTURA
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , MANRIQUE DOMINGO, DANIEL
Calificación obtenida: 9.0
Fecha de defensa: 30/09/2013

47 **Título del trabajo:** Agriluk 2.0 el buscador de la agricultura
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , BLAZQUEZ CALDERON, ADRIAN
Calificación obtenida: 9.0
Fecha de defensa: 30/09/2013

48 **Título del trabajo:** VMCA: UN SISTEMA PARA LA CONSOLIDACIÓN DE RECURSOS EN PLATAFORMAS DE VIRTUALIZACIÓN
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , ALFONSO LAGUNA, CARLOS DE
Calificación obtenida: 10.0
Fecha de defensa: 24/07/2013

49 **Título del trabajo:** DISEÑO E IMPLEMENTACIÓN CON TECNOLOGÍAS JSF Y JPA DE UNA WEB PARA UN GRUPO DE INVESTIGACIÓN EN BIOTECNOLOGÍA
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , GARCIA-MIGUEL PEREZ-LUENGO, CARLOS
Calificación obtenida: 9.0
Fecha de defensa: 13/06/2013

50 **Título del trabajo:** PUBLICACIÓN DE ESCRITORIOS Y APLICACIONES EN REMOTO EN UN ENTORNO DE VIRTUALIZACIÓN
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , SANMARTIN GALIPIENSO, GONZALO AGUSTIN
Calificación obtenida: 9.0
Fecha de defensa: 02/05/2013

51 **Título del trabajo:** Migración de un Catálogo y Repositorio de Imágenes de Maquinas Virtuales a Java/Hibernate
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , GARCIA VILLALOBOS, ANGEL LUIS
Calificación obtenida: 8.0
Fecha de defensa: 26/09/2012

52 **Título del trabajo:** CREACIÓN DE UNA INTERFAZ DE COMUNICACIÓN ENTRE DOS SISTEMAS PARA LA GESTIÓN DE LA PRODUCCIÓN DE VEHÍCULOS
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , HOYO MORENO, ROQUE
Calificación obtenida: 9.0
Fecha de defensa: 26/07/2012

53 **Título del trabajo:** DEVELOPMENT OF AN UNIVERSAL COMPUTER CONFIGURATION APPLICATION
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , CASERO RAMIREZ, HUGO
Calificación obtenida: 9.0
Fecha de defensa: 25/07/2012

54 **Título del trabajo:** USO DE INFRAESTRUCTURAS HÍBRIDAS GRID Y CLOUD PARA LA COMPUTACIÓN CIENTÍFICA
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , CALATRAVA ARROYO, AMANDA
Calificación obtenida: 9.0
Fecha de defensa: 28/02/2012

55 **Título del trabajo:** SISTEMA DE INFORMACIÓN PARA MEJORAR LAS COLABORACIONES DINÁMICAS EN EL GRID
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València
Alumno/a: , TORRES SERRANO, ERIK
Calificación obtenida: 9.0
Fecha de defensa: 28/02/2012

56 **Título del trabajo:** ARQUITECTURA PARA UN SISTEMA DE FICHEROS DISTRIBUIDO ORIENTADO AL ÁMBITO DE LAS APLICACIONES GRID Y CLOUD
Tipo de proyecto: Trabajo Fin de Máster
Entidad de realización: Universitat Politècnica de València

Alumno/a: , CARRION BURGUETE, JOSE VICENTE
Calificación obtenida: 9.0
Fecha de defensa: 14/07/2011

57 **Título del trabajo:** INTEGRACIÓN DE COMPONENTES EN SISTEMAS DE INFORMACIÓN HOSPITALARIOS
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , CUENCA BENITEZ, FRANCISCO JOSE
Calificación obtenida: 8.0
Fecha de defensa: 28/06/2011

58 **Título del trabajo:** "GRID BASED CFD OPTIMIZATION"
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , CHAPMAN, NICHOLAI
Calificación obtenida: 9.0
Fecha de defensa: 22/10/2010

59 **Título del trabajo:** ABSTRACCIÓN EN EL ACCESO A LA INFORMACIÓN DE EQUIPOS MÉDICOS MEDIANTE ANALIZADORES LÉXICOS Y SINTÁCTICOS Y ENCAPSULADORES DE PROTOCOLOS
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , MINUESA CUENCA, VICTOR MIGUEL
Calificación obtenida: 8.0
Fecha de defensa: 06/10/2010

60 **Título del trabajo:** DESARROLLO DE INTERFACES DE ALTO NIVEL PARA LA INTERACCION CON GESTORES DE MAQUINAS VIRTUALES EN INFRAESTRUCTURAS TIPO CLOUD
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , CALATRAVA ARROYO, AMANDA
Calificación obtenida: 9.0
Fecha de defensa: 07/09/2010

61 **Título del trabajo:** HERRAMIENTAS Y PROCEDIMIENTOS PARA LA ADMINISTRACION DE UN CLUSTER DE ALTAS PRESTACIONES
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , CARRION BURGUETE, JOSE VICENTE
Calificación obtenida: 9.0
Fecha de defensa: 31/05/2010

62 **Título del trabajo:** DESARROLLO DE UNA APLICACIÓN GRÁFICA PARA LA GENERACIÓN AUTOMÁTICA DE FICHEROS PARAMÉTRICOS XML EN PROBLEMAS DE SIMULACIÓN DE LA ACTIVIDAD ELÉCTRICA CARDIACA.
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , TOLEDO CATALAN, ADRIANA
Calificación obtenida: 7.0
Fecha de defensa: 23/06/2005

63 **Título del trabajo:** IMPLEMENTACIÓN DE UN SISTEMA PARA GESTIONAR LA EJECUCIÓN DE SIMULACIONES DE TEJIDOS CARDIACOS EN ENTORNOS GRID
Tipo de proyecto: Trabajo Fin de Grado
Entidad de realización: Universitat Politècnica de València
Alumno/a: , SANTANDREU BENAVENT, MARIA MANUELA
Calificación obtenida: 8.0
Fecha de defensa: 15/06/2005

Tutorías académicas de estudiantes

1 **Nombre del programa:** Tutor Prácticas en Empresa
Nº de alumnos/as tutelados/as: 3

2 **Nombre del programa:** Tutor Prácticas en Empresa
Nº de alumnos/as tutelados/as: 3

3 **Nombre del programa:** Tutor Prácticas en Empresa
Nº de alumnos/as tutelados/as: 8

4 **Nombre del programa:** Tutor Prácticas en Empresa
Nº de alumnos/as tutelados/as: 22

5 **Nombre del programa:** Tutor Prácticas en Empresa (Erasmus)
Nº de alumnos/as tutelados/as: 1

6 **Nombre del programa:** Tutor Prácticas en Empresa
Nº de alumnos/as tutelados/as: 36

7 **Nombre del programa:** Tutor Prácticas en Empresa (Erasmus)
Nº de alumnos/as tutelados/as: 1

8 **Nombre del programa:** Tutor Prácticas en Empresa
Nº de alumnos/as tutelados/as: 34

9 **Nombre del programa:** Tutor Prácticas en Empresa
Nº de alumnos/as tutelados/as: 8

10 **Nombre del programa:** Tutor Prácticas en Empresa
Nº de alumnos/as tutelados/as: 2

11 **Nombre del programa:** Tutor Prácticas en Empresa
Nº de alumnos/as tutelados/as: 2

12 **Nombre del programa:** Tutor Prácticas en Empresa
Nº de alumnos/as tutelados/as: 1

Publicaciones docentes o de carácter pedagógico, libros, artículos, etc.

1 Natividad Prieto Saez; Assumpció Casanova Faus; Francisco Marqués Hernández; María Luisa Llorens Agost; Isabel Remedios Galiano Ronda; Jon Ander Gómez Adrian; Jorge González Mollá; Carlos Herrero Cuco; Carlos David Martínez Hinarejos; Germán Moltó Martínez; Francisco Javier Piris Ruano. EMPEZAR A PROGRAMAR USANDO JAVA. Universitat Politècnica de València, 2012. ISBN 9788483639030
Tipo de soporte: Libro

2 José Damián Segrelles Quilis; Nuria Castilla Cabanes; Alicia Martínez Antón; Carla Sentieri Omarrementeria; Germán Moltó Martínez; José Francisco Monserrat Del Río. Proyecto A04. Entornos Virtuales Computacionales para la Evaluación de Competencias Transversales en la Nube. Innovación en la educación superior. PIMEs en la ETSID 2016/2017. A04, pp. 1 - 16. Escuela Técnica Superior en la Ingeniería del Diseño, 2017. ISBN 978-84-17003-51-7
Tipo de soporte: Capítulos de libros

3 Germán Moltó Martínez. Vídeo-ejercicios didácticos para el aprendizaje de la programación. Novática. pp. 28 - 33. 2013. ISSN 0211-2124
Tipo de soporte: Artículo/s

Participación en proyectos de innovación docente

1 **Título del proyecto:** Estrategias y Herramientas de Analíticas del Aprendizaje para la Formación Multidisciplinar en Competencias Transversales (PIME/19-20/166)
Fecha de inicio-fin: 01/09/2020 - 31/08/2021

2 **Título del proyecto:** Comunidades de Aprendizaje como servicios en la nube para el desarrollo y evaluación automática de Competencias Transversales y Objetivos Formativos específicos (PIME/18-19/79)
Fecha de inicio-fin: 01/09/2020 - 31/08/2021

3 **Título del proyecto:** Metodologías activas y TICs (MATI)
Fecha de inicio-fin: 01/09/2020 - 31/08/2021

4 **Título del proyecto:** Estrategias y Herramientas de Analíticas del Aprendizaje para la Formación Multidisciplinar en Competencias Transversales (PIME/19-20/166)
Fecha de inicio-fin: 01/09/2019 - 31/08/2020

5 **Título del proyecto:** Comunidades de Aprendizaje como servicios en la nube para el desarrollo y evaluación automática de Competencias Transversales y Objetivos Formativos específicos (PIME/18-19/79)
Fecha de inicio-fin: 01/09/2019 - 31/08/2020

6 **Título del proyecto:** Metodologías activas y TICs (MATI)
Fecha de inicio-fin: 01/09/2019 - 31/08/2020

7 **Título del proyecto:** Comunidades de Aprendizaje como servicios en la nube para el desarrollo y evaluación automática de Competencias Transversales y Objetivos Formativos específicos (B79/18)
Fecha de inicio-fin: 01/09/2018 - 31/08/2019

8 **Título del proyecto:** Metodologías activas y TICs (MATI)
Fecha de inicio-fin: 01/09/2018 - 31/08/2019

9 **Título del proyecto:** Entornos Virtuales Computacionales para la Evaluación de Competencias Transversales en la Nube (A04-17/16)
Fecha de inicio-fin: 01/09/2017 - 31/08/2018

10 **Título del proyecto:** Experiencias Multi-Disciplinares de Integracio¿n de Aula Inversa para el Desarrollo de Competencias Transversales (A08-17/16)
Fecha de inicio-fin: 01/09/2017 - 31/08/2018

11 **Título del proyecto:** Metodologías activas y TICs (MATI)
Fecha de inicio-fin: 01/09/2017 - 31/08/2018

12 **Título del proyecto:** Entornos Virtuales Computacionales para la Evaluación de Competencias Transversales en la Nube (A04/16)
Fecha de inicio-fin: 01/09/2016 - 31/08/2017

13 **Título del proyecto:** Experiencias Multi-Disciplinares de Integracio?n de Aula Inversa para el Desarrollo de Competencias Transversales (A08/16)
Fecha de inicio-fin: 01/09/2016 - 31/08/2017

14 **Título del proyecto:** Metodologías activas y TICs (MATI)
Fecha de inicio-fin: 01/09/2016 - 31/08/2017

15 **Título del proyecto:** Análisis y Evaluación de Impacto del Cloud Computing en la Gestión de Entornos Virtuales Computacionales en la Enseñanza (A14-16/15)
Fecha de inicio-fin: 01/09/2015 - 31/08/2016

16 **Título del proyecto:** Diseño de experiencias y creación de materiales para la implantación del Flipped Classroom (A17-16/15)
Fecha de inicio-fin: 01/09/2015 - 31/08/2016

17 **Título del proyecto:** Metodologías activas y TICs (MATI)
Fecha de inicio-fin: 01/09/2015 - 31/08/2016

18 **Título del proyecto:** Análisis y Evaluación de Impacto del Cloud Computing en la Gestión de Entornos Virtuales Computacionales en la Enseñanza (A14/14)
Fecha de inicio-fin: 01/09/2014 - 31/08/2015

19 **Título del proyecto:** Diseño de experiencias y creación de materiales para la implantación del Flipped Classroom (A17/14)
Fecha de inicio-fin: 01/09/2014 - 31/08/2015

20 **Título del proyecto:** Metodologías activas y TICs (MATI)
Fecha de inicio-fin: 01/09/2014 - 31/08/2015

21 **Título del proyecto:** Metodologías activas y TICs (MATI)
Fecha de inicio-fin: 01/09/2013 - 31/08/2014

22 **Título del proyecto:** Southwestern Europe Regional Contest (SWERC) 2013 (PIEX/35)
Fecha de inicio-fin: 01/09/2013 - 31/08/2014

23 **Título del proyecto:** Uso de Entornos Virtualizados basados en Cloud para la Realización de Prácticas Docentes (A16/13)
Fecha de inicio-fin: 01/09/2013 - 31/08/2014

24 **Título del proyecto:** Creación y distribución de vídeo-conceptos multidisciplinares para el fomento del aprendizaje autónomo (A05/12)
Fecha de inicio-fin: 01/09/2012 - 31/08/2013

25 **Título del proyecto:** Metodologías activas y TICs (MATI)
Fecha de inicio-fin: 01/09/2012 - 31/08/2013

26 **Título del proyecto:** Southwestern Europe Regional Contest (SWERC) 2013 (PIEX/35)
Fecha de inicio-fin: 01/09/2012 - 31/08/2013

27 **Título del proyecto:** Elaboración de materiales de Autoaprendizaje, Autoevaluación y Evaluación en las asignaturas IIP y PRG en el Grado de Informática (B20/11)
Fecha de inicio-fin: 01/09/2011 - 31/08/2012

28 **Título del proyecto:** Metodologías activas y TICs (MATI)
Fecha de inicio-fin: 01/09/2011 - 31/08/2012

29 **Título del proyecto:** Utilización de Vídeos Didácticos para la Mejora de los Procesos de Aprendizaje Autónomo Basados en la Resolución de Ejercicios (A04/11)
Fecha de inicio-fin: 01/09/2011 - 31/08/2012

30 **Título del proyecto:** Aprendizaje virtual síncrono mediante entornos colaborativos en un contexto multidisciplinar (A001/10)
Fecha de inicio-fin: 01/09/2010 - 31/08/2011

31 **Título del proyecto:** Metodologías activas y TICs (MATI)
Fecha de inicio-fin: 01/09/2010 - 31/08/2011

32 **Título del proyecto:** Grupo de Innovación docente (EICE)

33 **Título del proyecto:** Grupo de Innovación docente (PACE)

34 **Título del proyecto:** Grupo de Innovación Docente (EICE)

35 **Título del proyecto:** Participación en Proyectos de Innovación Docente (PACE)

36 **Título del proyecto:** Grupo de Innovación Docente UPV

Participación en congresos con ponencias orientadas a la formación docente

1 **Nombre del evento:** VII Congreso Nacional de Innovación Educativa y Docencia en Red (IN-RED 2021)
Ciudad de celebración: Online,
Fecha de presentación: 15/07/2021
Experiencias de Analíticas de Aprendizaje para el Seguimiento de Competencias Transversales. pp. null - null. Servicio de Publicaciones Universitat Politècnica de València, ISSN 978-84-9048-638-2

2 **Nombre del evento:** XXV Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2019)
Ciudad de celebración: Murcia, España,
Fecha de presentación: 05/06/2019
Herramienta web para el seguimiento automatizado de actividades educativas prácticas en la nube. pp. 175 - 182. Asociación de Enseñantes Universitarios de la Informática (AENUI),

3 **Nombre del evento:** 10th International Conference on Education and New Learning Technologies (EDULEARN 2018)
Ciudad de celebración: Palma de Mallorca, España,
Fecha de presentación: 04/07/2018
IMPROVING ACTIVITIES TO DEVELOP SOFT SKILLS USING FLIPPED TEACHING IN HIGHER EDUCATION. pp. 6820 - 6825. IATED, ISSN 978-84-09-02709-5

4 **Nombre del evento:** Jornada de Innovación Docente JIDINF 2018
Ciudad de celebración: Valencia, Spain,
Fecha de presentación: 03/07/2018
Herramienta de Análisis de Registros de Uso para Actividades Educativas en la Nube. pp. 0 - 0. Escola Tècnica Superior d☐Enginyeria Informàtica, ISSN 978-84-09-05709-2

5 **Nombre del evento:** 5th International Conference on Innovation, Documentation and Teaching Technologies (INNODOCT 2017)
Ciudad de celebración: Valencia, Spain,
Fecha de presentación: 27/10/2017
A Flipped Learning Approach to Develop Soft Skills in Multidisciplinary Higher Education. pp. 295 - 305. Editorial Universitat Politècnica de València, ISSN 978-84-9048-612-2

6 **Nombre del evento:** IV Congreso Internacional sobre Aprendizaje, Innovación y Competitividad (CINAIC 2017)
Ciudad de celebración: Zaragoza,
Fecha de presentación: 06/10/2017
Portafolios Docentes de Programación en la Nube para la Evaluación de Competencias. pp. 57 - 62. Servicio de Publicaciones Universidad de Zaragoza, ISSN 978-84-16723-41-6

7 **Nombre del evento:** XXIII Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2017)
Ciudad de celebración: Cáceres, España,
Fecha de presentación: 07/07/2017

Grid as a Service: Herramienta para el despliegue y gestión de un Grid en la nube para actividades educativas. pp. 191 - 197. Editores: Alberto Gómez Mancha, Roberto Rodríguez Echeverría, ISSN 978-84-697-4077-4

8 **Nombre del evento:** Congreso Nacional de Innovación Educativa y Docencia en Red = Congrés Nacional d'Innovació Educativa i Docència en Xarxa (IN-RED 2016)
Ciudad de celebración: Valencia, España,
Fecha de presentación: 08/07/2016
Aula Inversa: una Oportunidad para el Desarrollo de Competencias Transversales. pp. 0 - 0. Editorial Universitat Politècnica de València, ISSN 978-84-9048-541-5

9 **Nombre del evento:** XXII Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2016)
Ciudad de celebración: Almería, España,
Fecha de presentación: 08/07/2016
Panel web de gestión automatizada para actividades educativas no presenciales. pp. 311 - 318. Editorial Universidad de Almería, ISSN 978-84-16642-30-4

10 **Nombre del evento:** III Congreso Internacional sobre Aprendizaje, Innovación y Competitividad (CINAIC 2015)
Ciudad de celebración: Madrid,
Fecha de presentación: 16/10/2015
Aula Inversa en estudios tecnológicos. pp. 329 - 334. Fundación General de La Universidad Poltécnica de Madrid, ISSN 978-84-608-2907-2

11 **Nombre del evento:** XXIII Congreso Universitario de Innovación Educativa en las Enseñanzas Técnicas (CUIEET 2015)
Ciudad de celebración: Valencia,
Fecha de presentación: 17/07/2015
Experiencias de Cloud Computing en la Gestión de Entornos Virtuales Computacionales en la Enseñanza. pp. 1197 - 1210. Escuela Técnica Superior de Ingeniería del Diseño, ISSN 978-84-606-5611-1

12 **Nombre del evento:** XXI Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2015)
Ciudad de celebración: Andorra La Vella,
Fecha de presentación: 10/07/2015
Recopilación Automatizada de Evidencias de la Realización de Actividades Educativas en el Cloud. pp. 97 - 104. Xavier Canaleta, August Climent y Lluís Vicent, ISSN 978-99920-70-10-9

13 **Nombre del evento:** Congreso Nacional de Innovación Educativa y Docencia en Red = Congrés Nacional d'Innovació Educativa i Docència en Xarxa (IN-RED 2015)
Ciudad de celebración: Valencia, España,
Fecha de presentación: 01/07/2015
Comité científico/editor INRED 2015. pp. 0 - 0. Editorial Universitat Politècnica de València, ISSN 978-84-9048-396-1

14 **Nombre del evento:** 14th International Conference on Information Technology Based Higher Education and Training (ITHET 2015)
Ciudad de celebración: Lisbon, Portugal,
Fecha de presentación: 13/06/2015
On the Introduction of Flipped Teaching Across Multi-Disciplinary Fields. pp. 1 - 4. IEEE, ISSN 978-1-4799-1756-3

15 **Nombre del evento:** XXII Congreso Universitario de Innovación Educativa en las Enseñanzas Técnicas (CUIEET 2014). Vol. 1
Ciudad de celebración: Almadén, Spain,
Fecha de presentación: 19/09/2014

Creación de entornos virtuales para fomentar el trabajo en grupo y la racionalización de recursos. pp. 1 - 13. Universidad de Castilla la Mancha, ISSN 978-84-9044-107-7

16 **Nombre del evento:** Jornadas de Innovación Educativa y Docencia en Red (IN-RED 2014)
Ciudad de celebración: Valencia, España,
Fecha de presentación: 16/07/2014
Experiencias Tecnológicas de Soporte al Blended Learning en un Contexto Multidisciplinar. pp. 54 - 68. Editorial Universitat Politècnica de València, ISSN 9788490482711

17 **Nombre del evento:** Jornadas de Innovación Educativa y Docencia en Red (IN-RED 2014)
Ciudad de celebración: Valencia, España,
Fecha de presentación: 16/07/2014
Gestión de Infraestructuras Virtuales Docentes en Asignaturas con Requisitos Computacionales. pp. 151 - 165. Editorial Universitat Politècnica de València, ISSN 9788490482711

18 **Nombre del evento:** Jornadas de Innovación Educativa y Docencia en Red (IN-RED 2014)
Ciudad de celebración: Valencia, España,
Fecha de presentación: 16/07/2014
Gestión Eficiente de Cursos Online: La Experiencia de @CursoCloudAWS en la UPV. pp. 166 - 180. Editorial Universitat Politècnica de València, ISSN 9788490482711

19 **Nombre del evento:** XX Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2014)
Ciudad de celebración: Oviedo, Spain,
Fecha de presentación: 11/07/2014
Gestión de recursos computacionales en el Cloud para actividades educativas. pp. 99 - 106. Universidad de Oviedo, ISSN 978-84-697-0774-6

20 **Nombre del evento:** XIX Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2013)
Ciudad de celebración: Castellón de la Plana, España,
Fecha de presentación: 12/07/2013
Competiciones de programación. Estímulo y salida laboral para los alumnos. pp. 161 - 166. Publicacions de la Universitat Jaume I, ISSN 978-84-695-8051-6

21 **Nombre del evento:** XIX Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2013)
Ciudad de celebración: Castellón de la Plana, España,
Fecha de presentación: 12/07/2013
Entorno virtualizado de aprendizaje para facilitar el desarrollo de destrezas de programación. pp. 327 - 334. Publicacions de la Universitat Jaume I, ISSN 978-84-695-8051-6

22 **Nombre del evento:** Jornadas Red Estatal de Docencia Universitaria (RED-U 2013). Las competencias en la Formación Superior: El caso de las ingenierías
Ciudad de celebración: Madrid,
Fecha de presentación: 01/02/2013
Las Vídeo-Lecciones como Herramienta para la Adquisición Autónoma de Competencias Específicas en la Ingeniería. pp. 1 - 2.

23 **Nombre del evento:** V Jornada de Innovación Docente JIDINF'12
Ciudad de celebración: Valencia, España,
Fecha de presentación: 31/01/2013
La experiencia de organizar una competición de programación en la ETSINF. pp. 1 - 1. Universidad Politécnica de Valencia, ISSN 978-84-9048-030-4

24 **Nombre del evento:** V Jornada de Innovación Docente JIDINF'12
Ciudad de celebración: Valencia, España,
Fecha de presentación: 31/01/2013
Vídeo-Ejercicios para el Auto-Aprendizaje en Asignaturas de Programación. pp. 1 - 1. Universidad Politécnica de Valencia, ISSN 978-84-9048-030-4

25 **Nombre del evento:** Jornadas de Innovación Educativa 2012
Ciudad de celebración: Valencia,
Fecha de presentación: 13/07/2012
Integración de las Herramientas Poli[ReunióN] y Politube en la Práctica Docente en la UPV. pp. 197 - 201. Universidad Politécnica de Valencia, ISSN 978-84-8363-926-9

26 **Nombre del evento:** XVIII Jornadas de Enseñanza Universitaria de la Informática: JENUI 2012
Ciudad de celebración: Ciudad Real,
Fecha de presentación: 13/07/2012
Producción y Uso de Vídeo-Ejercicios Didácticos en Asignaturas de Programación. pp. 255 - 262. Comité de organización de las XVIII Jornadas de Enseñanza Universitaria de la Informática, ISSN 978-84-615-7157-4

27 **Nombre del evento:** VII Congreso Internacional Docencia Universitaria e Innovación (CIDUI 2012)
Ciudad de celebración: Barcelona,
Fecha de presentación: 06/07/2012
Experiencias en el uso de vídeo-ejercicios en la docencia Universitaria. pp. 1 - 21. ISSN 978-84-695-4073-2

28 **Nombre del evento:** IV JORNADA DE INNOVACIÓN DOCENTE (JIDINF'11)
Ciudad de celebración: ETS Ingeniería Informática,
Fecha de presentación: 25/11/2011
Los Vídeo-Ejercicios Didácticos como Herramienta para el Fomento del Aprendizaje Autónomo. pp. 1 - 1. UNIVERSIDAD POLITÉCNICA DE VALENCIA, ISSN 978-84-8363-820-0

29 **Nombre del evento:** Jornada de Innovación Docente ICE-UPV 2011
Ciudad de celebración: Valencia, España,
Fecha de presentación: 15/07/2011
Experiencias de Uso de la Herramienta de Aprendizaje Virtual Síncrono Poli[ReunióN]. pp. 1 - 4. ISSN 978-84-8363-763-0

30 **Nombre del evento:** XVII Jornadas de Enseñanza Universitaria de la Informática: JENUI 2011
Ciudad de celebración: Sevilla,
Fecha de presentación: 05/07/2011
Uso de Metodologías Activas en la Implantación de IIP en el Grado de Informática en la UPV. pp. 53 - 60. ISSN 978-84-694-5156-4

31 **Nombre del evento:** International Conference on Education and New Learning Technologies (EDULEARN 2011)
Ciudad de celebración: Barcelona, España,
Fecha de presentación: 04/07/2011
Leveraging Distance Learning Of Engineering Skills Through Video Exercises. pp. 864 - 871. International Association of Technology, Education and Development (IATED), ISSN 978-84-615-0441-1

32 **Nombre del evento:** II Congreso Internacional de Docencia Universitaria (CIDU 2011)
Ciudad de celebración: Vigo, España,
Fecha de presentación: 30/06/2011
La guía didáctica como eje central en la implantación de metodologías activas. pp. 227 - 232. UNIVERSIDAD DE VIGO,

33 **Nombre del evento:** 1st International Conference on The future of Education
Ciudad de celebración: Florencia, Italia,
Fecha de presentación: 17/06/2011
Multidisciplinary Experiences at University Degrees in the Use of Synchronous E-learning. pp. 121 - 127. Simonelli Editore University Press, ISSN 978-88-7647-648-8

34 **Nombre del evento:** 1st International Conference on The future of Education
Ciudad de celebración: Florencia, Italia,
Fecha de presentación: 17/06/2011
Multidisciplinary experiences at univesity degrees in the use of synchronous e-learning. pp. 121 - 127. Simonelli Editore University Press, ISSN 978-88-7647-648-8

35 **Nombre del evento:** III International conference UNIVEST 2011. The Self-Regulation of Learning
Ciudad de celebración: Girona, España,
Fecha de presentación: 16/06/2011
La Tutoría Virtual para la Autogestión del Aprendizaje en las Enseñanzas Técnicas. pp. 1 - 13. UNIVERSITAT DE GIRONA, ISSN 9788484583547

36 **Nombre del evento:** III JIDINF-Jornada de Innovación Docente ETS Ingeniería Informática
Ciudad de celebración: Valencia (España),
Fecha de presentación: 04/10/2010
Aprendizaje Virtual Síncrono Mediante Entornos Colaborativos en un Contexto Multidisciplinar. pp. 1 - 9. UPV, ISSN 978-84-693-5005-8

37 **Nombre del evento:** I Jornadas de innovación
Ciudad de celebración: Valencia, España,
Fecha de presentación: 01/12/2009
Uso de Herramientas TIC para la Mejora de la Interacción Profesor-Alumno, la Evaluación Continua y el Aprendizaje Autónomo. pp. 1 - 9. Universidad Politecnica Valencia, ISSN 978-84-8363-510-0

38 **Nombre del evento:** XVI Congreso Universitario de Innovación Educativa en las Enseñanzas Técnicas (CUIEET)
Ciudad de celebración: Cádiz, España,
Fecha de presentación: 23/09/2008
Experiencias de motivación a los alumnos de enseñanza universitaria técnica y artística. pp. 173 - 173. Universidad de Cádiz, ISSN 978-84-608-0803-9

39 **Nombre del evento:** International Technology, Education and Development Conference (INTED 2007)
Ciudad de celebración: Valencia, España,
Fecha de presentación: 01/03/2007
A Virtual Simulation-Oriented Framework to Evaluate Metascheduling Policies in Computational Grids. pp. 1 - 9. International Association of Technology, Education and Development (IATED), ISSN 97884-611-4517-1

Premios de innovación docente recibidos

1 **Nombre del premio:** Premio a la Excelencia Docente
Fecha de concesión: 2021

2 **Nombre del premio:** Premio a la Excelencia (ETSINF)
Fecha de concesión: 2009

Otras actividades/méritos no incluidos en la relación anterior

1 **Descripción de la actividad:** Complejidad Temporal Asintótica para Métodos Recursivos
Fecha de finalización: 31/12/2010

2 **Descripción de la actividad:** Estructuras de Datos Lineales: Pila, Cola y Lista con Punto de Interés
Fecha de finalización: 31/12/2010

3 **Descripción de la actividad:** Genericidad en el Lenguaje de Programación Java
Fecha de finalización: 31/12/2010

4 **Descripción de la actividad:** Gestión de Excepciones en Java
Fecha de finalización: 31/12/2010

5 **Descripción de la actividad:** Listas Enlazadas Genéricas en Java
Fecha de finalización: 31/12/2010

6 **Descripción de la actividad:** El Árbol Binario de Búsqueda
Fecha de finalización: 01/10/2009

7 **Descripción de la actividad:** El Montículo Binario
Fecha de finalización: 01/10/2009

8 **Descripción de la actividad:** La Tabla Hash
Fecha de finalización: 01/10/2009

9 **Descripción de la actividad:** Arrays Multidimensionales en Java

10 **Descripción de la actividad:** Arrays (unidimensionales) en Java

11 **Descripción de la actividad:** Estructuras de Iteración (Bucles) en Java

12 **Descripción de la actividad:** Traza de Búsqueda Recursiva en un Montículo Binario Minimal

13 **Descripción de la actividad:** Traza de Inserción Recursiva en un Arbol Binario de Búsqueda

14 **Descripción de la actividad:** Traza de Recorrido PostOrden en un Árbol Binario de Búsqueda

15 **Descripción de la actividad:** Traza del Cálculo Recursivo de la Talla de una Pila

Experiencia científica y tecnológica

Grupos/equipos de investigación, desarrollo o innovación

Nombre del grupo: Instituto de Instrumentación para Imagen Molecular

Actividad científica o tecnológica

Proyectos de I+D+i financiados en convocatorias competitivas de Administraciones o entidades públicas y privadas

1 **Nombre del proyecto:** AN INTERDISCIPLINARY DIGITAL TWIN ENGINE FOR SCIENCE (101058386)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Ignacio Blanquer Espert
Nº de investigadores/as: 2
Entidad/es financiadora/s:
COMISION DE LAS COMUNIDADES EUROPEA

Fecha de inicio: 01/09/2022 **Duración:** 2 años - 11 meses - 30 días
Cuantía total: 318.250 €

2 **Nombre del proyecto:** ARTIFICIAL INTELLIGENCE FOR THE EUROPEAN OPEN SCIENCE CLOUD (101058593)
Grado de contribución: Investigador/a
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Germán Moltó Martínez
Nº de investigadores/as: 2
Entidad/es financiadora/s:

COMISION DE LAS COMUNIDADES EUROPEA

Fecha de inicio: 01/09/2022 **Duración:** 2 años - 11 meses - 30 días
Cuantía total: 503.500 €

3 **Nombre del proyecto:** IMAGING DATA AND SERVICES FOR AQUATIC SCIENCE (101058625)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Ignacio Blanquer Espert
Nº de investigadores/as: 2
Entidad/es financiadora/s:
COMISION DE LAS COMUNIDADES EUROPEA

Fecha de inicio: 01/09/2022 **Duración:** 2 años - 11 meses - 30 días
Cuantía total: 77.937,5 €

4 **Nombre del proyecto:** COMPUTACION ABIERTA SIN SERVIDOR PARA LA ADOPCION DE INNOVACION RAPIDA EN RECURSOS SEGUROS PREPARADOS PARA LA EMPRESA (PDC2021-120844-I00)
Grado de contribución: Investigador/a
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Germán Moltó Martínez; Ignacio Blanquer Espert
Nº de investigadores/as: 9
Entidad/es financiadora/s:
AGENCIA ESTATAL DE INVESTIGACION

Fecha de inicio: 01/12/2021 **Duración:** 1 año - 11 meses - 29 días
Cuantía total: 143.750 €

5 **Nombre del proyecto:** COMPUTACION CIENTIFICA SERVERLESS A TRAVES DEL HIBRIDO CONTINUO CLOUD (PID2020-113126RB-I00)
Grado de contribución: Investigador/a
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Germán Moltó Martínez; Ignacio Blanquer Espert
Nº de investigadores/as: 9
Entidad/es financiadora/s:
AGENCIA ESTATAL DE INVESTIGACION

Fecha de inicio: 01/09/2021 **Duración:** 3 años - 11 meses - 30 días
Cuantía total: 145.321 €

6 **Nombre del proyecto:** ARTIFICIAL INTELLIGENCE IN SECURE PRIVACY-PRESERVING COMPUTING CONTINUUM (101016577)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Ignacio Blanquer Espert
Nº de investigadores/as: 7
Entidad/es financiadora/s:
COMISION DE LAS COMUNIDADES EUROPEA

Fecha de inicio: 01/01/2021 **Duración:** 2 años - 11 meses - 30 días
Cuantía total: 502.000 €

7 **Nombre del proyecto:** EGI ADVANCED COMPUTING FOR EOSC (101017567)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Ignacio Blanquer Espert

Nº de investigadores/as: 2
Entidad/es financiadora/s:
COMISION DE LAS COMUNIDADES EUROPEA

Fecha de inicio: 01/01/2021 **Duración:** 2 años - 5 meses - 29 días
Cuantía total: 95.813 €

8 **Nombre del proyecto:** EUROPEAN OPEN SCIENCE CLOUD - EXPANDING CAPACITIES BY BUILDING CAPABILITIES (857647)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Ignacio Blanquer Espert
Nº de investigadores/as: 4
Entidad/es financiadora/s:
COMISION DE LAS COMUNIDADES EUROPEA

Fecha de inicio: 01/09/2019 **Duración:** 3 años - 1 mes - 30 días
Cuantía total: 323.500 €

9 **Nombre del proyecto:** Elastic Kubernetes as a Service in EGI Federated Cloud
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Ignacio Blanquer Espert
Nº de investigadores/as: 5
Entidad/es financiadora/s:
STICHTING EGI

Fecha de inicio: 22/03/2019 **Duración:** 5 meses - 30 días
Cuantía total: 30.478,8 €

10 **Nombre del proyecto:** Elastic Serverless Platform for High Throughput Computing Scientific Application
Grado de contribución: Investigador/a
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Germán Moltó Martínez
Nº de investigadores/as: 5
Entidad/es financiadora/s:
STICHTING EGI

Fecha de inicio: 13/03/2019 **Duración:** 5 meses - 30 días
Cuantía total: 15.000 €

11 **Nombre del proyecto:** PLATAFORMA COLABORATIVA EN LA NUBE PARA EL DESARROLLO Y EVALUACION DE COMPETENCIAS EN LAS ENSEÑANZAS STEM (AICO/2019/313)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): José Damián Segrelles Quilis
Nº de investigadores/as: 11
Entidad/es financiadora/s:
GENERALITAT VALENCIANA

Fecha de inicio: 01/01/2019 **Duración:** 2 años - 2 meses - 30 días
Cuantía total: 40.000 €

12 **Nombre del proyecto:** Ejecución de aplicaciones sobre plataformas on-premises elásticas de funciones como servicio (FaaS) (SP20180068)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Miguel Caballer Fernández

Nº de investigadores/as: 7
Entidad/es financiadora/s:
UNIVERSIDAD POLITECNICA DE VALENCIA

Fecha de inicio: 01/01/2019 **Duración:** 11 meses - 30 días
Cuantía total: 5.000 €

13 **Nombre del proyecto:** AYUDA PREDOCTORAL GVA-GIMENEZ ALVENTOSA (ACIF/2018/148)
Grado de contribución: Investigador/a
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Germán Moltó Martínez
Nº de investigadores/as: 2
Entidad/es financiadora/s:
GENERALITAT VALENCIANA

Fecha de inicio: 01/09/2018 **Duración:** 3 años - 3 meses - 8 días
Cuantía total: 72.743,07 €

14 **Nombre del proyecto:** INTEGRATING AND MANAGING SERVICES FOR THE EUROPEAN OPEN SCIENCE CLOUD (777536)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Ignacio Blanquer Espert
Nº de investigadores/as: 7
Entidad/es financiadora/s:
COMISION DE LAS COMUNIDADES EUROPEA

Fecha de inicio: 01/01/2018 **Duración:** 3 años - 2 meses - 30 días
Cuantía total: 239.937,5 €

15 **Nombre del proyecto:** PLATAFORMA DE COMPUTACION INTENSIVA MEDIANTE ACELERADORES GRAFICOS (GPUS) PARA SU APLICACION EN MEDICINA PERSONALIZADA (IDIFEDER/2018/032)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Ignacio Blanquer Espert
Nº de investigadores/as: 22
Entidad/es financiadora/s:
GENERALITAT VALENCIANA

Fecha de inicio: 01/01/2018 **Duración:** 1 año - 11 meses - 30 días
Cuantía total: 318.111,4 €

16 **Nombre del proyecto:** DESIGNING AND ENABLING E-INFRASTRUCTURES FOR INTENSIVE PROCESSING IN A HYBRID DATACLOUD (777435)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Ignacio Blanquer Espert
Nº de investigadores/as: 8
Entidad/es financiadora/s:
COMISION DE LAS COMUNIDADES EUROPEA

Fecha de inicio: 01/11/2017 **Duración:** 2 años - 5 meses - 29 días
Cuantía total: 240.954,48 €

17 **Nombre del proyecto:** ADAPTIVE, TRUSTWORTHY, MANAGEABLE, ORCHESTRATED, SECURE, PRIVACY-ASSURING, HYBRID ECOSYSTEM FOR RESILIENT CLOUD COMPUTING (777154)
Entidad de realización: Universitat Politècnica de València

Nombres investigadores principales (IP, Co-IP,...): Ignacio Blanquer Espert
Nº de investigadores/as: 6
Entidad/es financiadora/s:
COMISION DE LAS COMUNIDADES EUROPEA

Fecha de inicio: 01/11/2017 **Duración:** 1 año - 11 meses - 30 días
Cuantía total: 283.085,6 €

18 **Nombre del proyecto:** ATMOSPHERE. ADAPTIVE, TRUSTWORTHY, MANAGEABLE, ORCHESTRATED, SECURE PRIVACY-ASSURING HYBRID, ECOSYSTEM FOR RESILIENT CLOUD COMPUTING (APE/2017/009)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Ignacio Blanquer Espert
Nº de investigadores/as: 5
Entidad/es financiadora/s:
GENERALITAT VALENCIANA

Fecha de inicio: 01/01/2017 **Duración:** 11 meses - 30 días
Cuantía total: 8.900 €

19 **Nombre del proyecto:** COLLABORATIVE CLOUD PLATFORM FOR CONTINUOUS INTEGRATION OF QUANTITATIVE IMAGING BIOMARKERS THROUGH THE SMART SPECIALISATION. (APE/2017/033)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): José Damián Segrelles Quilis
Nº de investigadores/as: 5
Entidad/es financiadora/s:
GENERALITAT VALENCIANA

Fecha de inicio: 01/01/2017 **Duración:** 11 meses - 30 días
Cuantía total: 8.950 €

20 **Nombre del proyecto:** COMPUTACION BIG DATA Y DE ALTAS PRESTACIONES SOBRE MULTI-CLOUDS ELASTICOS (TIN2016-79951-R)
Grado de contribución: Investigador/a
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Germán Moltó Martínez; Ignacio Blanquer Espert
Nº de investigadores/as: 9
Entidad/es financiadora/s:
AGENCIA ESTATAL DE INVESTIGACION

Fecha de inicio: 30/12/2016 **Duración:** 3 años - 11 meses - 30 días
Cuantía total: 110.594 €

21 **Nombre del proyecto:** EUROPE-BRAZIL COLLABORATION ON BIG DATA SCIENTIFIC RESEARCH THROUGH CLOUD-CENTRIC APPLICATIONS (690116)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Ignacio Blanquer Espert
Nº de investigadores/as: 9
Entidad/es financiadora/s:
COMISION DE LAS COMUNIDADES EUROPEA

Fecha de inicio: 01/01/2016 **Duración:** 1 año - 11 meses - 30 días
Cuantía total: 285.018 €

22 **Nombre del proyecto:** ADVANCED CLOUD INFRASTRUCTURE FOR BIG DATA APPLICATIONS IN EUROPE-BRAZIL (APE/2016/012)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Ignacio Blanquer Espert
Nº de investigadores/as: 5
Entidad/es financiadora/s:
GENERALITAT VALENCIANA

Fecha de inicio: 01/01/2016 **Duración:** 11 meses - 30 días
Cuantía total: 6.000 €

23 **Nombre del proyecto:** Engaging the EGI Community towards an Open Science Commons EGI-Engage (654142)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Ignacio Blanquer Espert
Nº de investigadores/as: 4
Entidad/es financiadora/s:
COMISION DE LAS COMUNIDADES EUROPEA

Fecha de inicio: 01/07/2015 **Duración:** 2 años - 1 mes - 30 días
Cuantía total: 90.147,25 €

24 **Nombre del proyecto:** INtegrating Distributed data Infrastructures for Global ExplOitation. INDIGO-DataCloud (653549)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Ignacio Blanquer Espert
Nº de investigadores/as: 12
Entidad/es financiadora/s:
COMISION DE LAS COMUNIDADES EUROPEA

Fecha de inicio: 01/04/2015 **Duración:** 2 años - 5 meses - 29 días
Cuantía total: 457.570,47 €

25 **Nombre del proyecto:** CLUSTERS VIRTUALES ELASTICOS Y MIGRABLES SOBRE INFRAESTRUCTURAS CLOUD HIBRIDAS (TIN2013-44390-R-AR)
Grado de contribución: Investigador/a
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Germán Moltó Martínez; Ignacio Blanquer Espert
Nº de investigadores/as: 8
Entidad/es financiadora/s:
MINISTERIO DE ECONOMIA Y EMPRESA

Fecha de inicio: 01/01/2014 **Duración:** 2 años - 11 meses - 30 días
Cuantía total: 79.876,94 €

26 **Nombre del proyecto:** EU-Brazil Cloud infrastructure Connecting federated resources for Scientific Advancement (614048)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Ignacio Blanquer Espert
Nº de investigadores/as: 4
Entidad/es financiadora/s:
COMISION DE LAS COMUNIDADES EUROPEA

Fecha de inicio: 01/10/2013 **Duración:** 2 años - 3 meses - 30 días

Cuantía total: 245.589 €

27 **Nombre del proyecto:** AYUDA PARA LA CONTRATACION DE PERSONAL EN FORMACION DE CARACTER PREDOCTORAL PROGRAMA VALI+D-CALATRAVA ARROYO, AMANDA (ACIF/2013/003)
Grado de contribución: Investigador/a
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Germán Moltó Martínez
Nº de investigadores/as: 2
Entidad/es financiadora/s:
GENERALITAT VALENCIANA

Fecha de inicio: 01/06/2013 **Duración:** 3 años
Cuantía total: 66.577,3 €

28 **Nombre del proyecto:** SERVICIOS AVANZADOS PARA EL DESPLIEGUE Y CONTEXTUALIZACION DE APLICACIONES VIRTUALIZADAS PARA DAR SOPORTE A MODELOS DE PROGRAMACION EN ENTORNOS CLC. (ACOMP/2013/127)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Vicente Hernández García
Nº de investigadores/as: 10
Entidad/es financiadora/s:
GENERALITAT VALENCIANA

Fecha de inicio: 01/01/2013 **Duración:** 10 meses - 29 días
Cuantía total: 10.043,04 €

29 **Nombre del proyecto:** GESTION ELASTICA Y EFICIENTE DE ENTORNOS CLOUD PARA LA EJECUCION DE APLICACIONES CIENTIFICAS (GV/2012/076)
Grado de contribución: Investigador/a
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Germán Moltó Martínez
Nº de investigadores/as: 8
Entidad/es financiadora/s:
GENERALITAT VALENCIANA; GENERALITAT VALENCIANA

Fecha de inicio: 01/01/2012 **Duración:** 1 año - 10 meses - 29 días
Cuantía total: 6.000 €

30 **Nombre del proyecto:** DISEÑO DE COMPONENTES CLOUD FACILITADORES DE DESPLIEGUE Y LA ALTA DISPONIBILIDAD DE SERVICIOS TRENCADIS, PARA COMPARTIR IMAGENES MEDICAS DICOM E INFORMES ASOCIADOS DICOM-SR. (2024)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): José Damián Segrelles Quilis
Nº de investigadores/as: 5
Entidad/es financiadora/s:
UNIVERSIDAD POLITECNICA DE VALENCIA

Fecha de inicio: 01/12/2011 **Duración:** 2 años
Cuantía total: 9.000 €

31 **Nombre del proyecto:** TEA (TECNOLOGIAS E-LEARNING ACCESIBLES) (2791)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Félix Buendía García
Nº de investigadores/as: 7

Entidad/es financiadora/s:
UNIVERSIDAD POLITECNICA DE VALENCIA

Fecha de inicio: 01/12/2011 **Duración:** 1 año - 29 días
Cuantía total: 6.000 €

32 **Nombre del proyecto:** SERVICIOS AVANZADOS PARA EL DESPLIEGUE Y CONTEXTUALIZACION DE APLICACIONES VIRTUALIZADAS PARA DAR SOPORTE A MODELOS DE PROGRAMACION EN ENTORNOS CLOUD (TIN2010-17804)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Vicente Hernández García
Nº de investigadores/as: 16
Entidad/es financiadora/s:
MINISTERIO DE ECONOMIA Y EMPRESA

Fecha de inicio: 01/01/2011 **Duración:** 3 años
Cuantía total: 252.890 €

33 **Nombre del proyecto:** INTEGRACION DE UN MOTOR DE BUSQUEDA TIPO BLAST A UNA APLICACION DE ANALISIS DE VARIACIONES DE SECUENCIAS GENOMICAS (PAID-05-09-4301)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Oscar Pastor López
Nº de investigadores/as: 14
Entidad/es financiadora/s:
UNIVERSIDAD POLITECNICA DE VALENCIA

Fecha de inicio: 15/12/2009 **Duración:** 1 año
Cuantía total: 12.000 €

34 **Nombre del proyecto:** EJECUCION ESCALABLE DE APLICACIONES CIENTIFICAS EN INFRAESTRUCTURAS VIRTUALIZADAS MULTICAPA MEDIANTE TECNOLOGIAS GRID Y CLOUD (PAID-06-09-2810)
Grado de contribución: Investigador/a
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Germán Moltó Martínez
Nº de investigadores/as: 6
Entidad/es financiadora/s:
UNIVERSIDAD POLITECNICA DE VALENCIA

Fecha de inicio: 01/12/2009 **Duración:** 2 años
Cuantía total: 12.000 €

35 **Nombre del proyecto:** COMPONENTES DE NUEVA GENERACION PARA LA EXPORTACION EFICIENTE DE INFRAESTRUCTURAS GRID EN E CIENCIA (TIN2006-12890)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Vicente Hernández García
Nº de investigadores/as: 18
Entidad/es financiadora/s:
MINISTERIO DE EDUCACION

Fecha de inicio: 01/04/2009 **Duración:** 2 años - 6 meses
Cuantía total: 435.600 €

36 **Nombre del proyecto:** COMPONENTES DE NUEVA GENERACION PARA LA EXPLOTACION EFICIENTE DE INFRAESTRUCTURAS GRID EN ECIENCIA (ACOMP/2009/052)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Vicente Hernández García
Nº de investigadores/as: 15
Entidad/es financiadora/s:
GENERALITAT VALENCIANA

Fecha de inicio: 01/01/2009 **Duración:** 1 año
Cuantía total: 7.000 €

37 **Nombre del proyecto:** ORGANIZACION Y PUESTA EN MARCHA DE LA RED DE E-CIENCIA EN ESPAÑA (CAC-2007-52)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Vicente Hernández García
Nº de investigadores/as: 78
Entidad/es financiadora/s:
MINISTERIO DE EDUCACION

Fecha de inicio: 01/10/2007 **Duración:** 3 años
Cuantía total: 473.830 €

38 **Nombre del proyecto:** PREPARACION DE PROPUESTA IDEALS (INTEGRATED DATA ANALYSIS ENVIRONMENT FOR ADVANCED LIFE SCIENCES) (TIN2007-30808-E)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Vicente Hernández García
Nº de investigadores/as: 6
Entidad/es financiadora/s:
MINISTERIO DE EDUCACION

Fecha de inicio: 01/07/2007 **Duración:** 5 meses - 30 días
Cuantía total: 3.000 €

39 **Nombre del proyecto:** MODELOS TEÓRICOS Y COMPUTACIÓN AVANZADA EN EL ESTUDIO DE SEÑALES BIOELÉCTRICAS EN CÉLULAS Y TEJIDOS. IMPLICACIONES EN EL ANÁLISIS DE ARRITMIAS CARDÍACAS, ELECTROESTIMULACIÓN Y ABLACIÓN POR RADIOFR.... (TEC2005-04199)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): José María Ferrero De Loma-Osorio
Nº de investigadores/as: 13
Entidad/es financiadora/s:
MINISTERIO DE EDUCACION

Fecha de inicio: 31/12/2005 **Duración:** 3 años
Cuantía total: 191.114,2 €

40 **Nombre del proyecto:** IMAGEN MEDICAL MOLECULAR Y MULTIMODALIDAD: PORTAL GRID DE POSTPROCESO DE IMAGENES (PI052716)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Vicente Hernández García
Nº de investigadores/as: 8
Entidad/es financiadora/s:
INSTITUTO DE SALUD CARLOS III

Fecha de inicio: 30/12/2005 **Duración:** 1 año

Cuantía total: 14.875 €

41 **Nombre del proyecto:** PROYECTO DE CREACION DEL METACENTRO DE APLICACIONES DE LA SUPERCOMPUTACION Y LAS TECNOLOGIAS GRID DE LA COMUNIDAD VALENCIANA (IIARC0/2004/74)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Vicente Hernández García
Nº de investigadores/as: 8
Entidad/es financiadora/s:
GENERALITAT VALENCIANA

Fecha de inicio: 01/01/2004 **Duración:** 2 años
Cuantía total: 25.032,36 €

42 **Nombre del proyecto:** SUBPROYECTO COMPUTACION AVANZADA EN LA MODELIZACION, SIMULACION Y VISUALIZACION DE ARRITMIAS VENTRICULARES (PPI-05-01 6023-2)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Vicente Hernández García
Nº de investigadores/as: 4
Entidad/es financiadora/s:
UNIVERSIDAD POLITECNICA DE VALENCIA

Fecha de inicio: 20/06/2002 **Duración:** 1 año - 3 meses
Cuantía total: 0 €

43 **Nombre del proyecto:** COMPUTACION AVANZADA EN LA MODELIZACION DE LA ACTIVIDAD ELECTRICA CARDIACA. SIMULACION Y VISUALIZACION DE LAS ALTERACIONES PRODUCIDAS EN ARRITMIAS VENTRICULARES POR LA ACCION DE FARMACOS ANTIARRITMICOS Y LA APLICACION DE CAMPOS ELECTRICOS (TIC2001-2686)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Francisco Javier Saiz Rodríguez
Nº de investigadores/as: 11
Entidad/es financiadora/s:
MINISTERIO DE CIENCIA Y TECNOLOGIA

Fecha de inicio: 28/12/2001 **Duración:** 3 años
Cuantía total: 80.144,97 €

Contratos, convenios o proyectos de I+D+i no competitivos con Administraciones o entidades públicas o privadas

1 **Nombre del proyecto:** APOYO TÉCNICO EN EL DESARROLLO DEL PROYECTO CDPS (CLOUD DATA PROCESSING SERVICE)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Ignacio Blanquer Espert
Nº de investigadores/as: 3
Entidad/es financiadora/s:
INDRA SISTEMAS, S.A.

Fecha de inicio: 14/12/2020 **Duración:** 1 año - 2 meses - 30 días
Cuantía total: 37.370 €

2 **Nombre del proyecto:** PRESTACIONES DE SERVICIO DE GERMAN MOLTO MARTINEZ
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Germán Moltó Martínez
Nº de investigadores/as: 1
Entidad/es financiadora/s:
SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA; ALCANZIA ENERGIA, S.L.; ASOCIACION ESPAÑOLA DE NORMALIZACION

Fecha de inicio: 28/10/2010 **Duración:** 6 años - 2 meses - 2 días
Cuantía total: 19.115,65 €

3 **Nombre del proyecto:** INFRAESTRUCTURA TECNOLOGICA Y METODOLOGICA DE SOPORTE PARA UN CORE BANCARIO (CENIT 2006)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Vicente Hernández García
Nº de investigadores/as: 9
Entidad/es financiadora/s:
GRID SYSTEMS S.A.

Fecha de inicio: 17/01/2006 **Duración:** 4 años
Cuantía total: 400.000 €

4 **Nombre del proyecto:** INVESTIGACION Y DESARROLLO DE UNA TECNOLOGIA DE IMAGEN ANOTOMO-FUNCIONAL BASADA EN LA EMISION DE POSITRONES Y RAYOS-X PARA SU APLICACION EN INVESTIGACION PRE-CLINICA (CENIT 2006)
Entidad de realización: Universitat Politècnica de València
Nombres investigadores principales (IP, Co-IP,...): Vicente Hernández García
Nº de investigadores/as: 8
Entidad/es financiadora/s:
SUINSA, MEDICAL SYSTEMS

Fecha de inicio: 12/01/2006 **Duración:** 4 años
Cuantía total: 415.000 €

Resultados

Propiedad industrial e intelectual

Título propiedad industrial registrada: R-17353-2015 -Infrastructure Manager (IM)
Tipo de propiedad industrial: Propiedad Intelectual (copyright)
Inventores/autores/obtentores: Ignacio Blanquer Espert; Germán Moltó Martínez; Miguel Caballer Fernández; Carlos De Alfonso Laguna
Nº de solicitud: R-17353-2015
Fecha de registro: 20/05/2015
Patente española: Si **Patente UE:** No
Patente internacional no UE: No

Actividades científicas y tecnológicas

Producción científica

Publicaciones, documentos científicos y técnicos

1 José Damián Segrelles Quilis; Germán Moltó Martínez; Ignacio Blanquer Espert. A Cloud framework for Problem-Based Learning on Grid Computing. Journal of Parallel and Distributed Computing. 155, pp. 24 - 37. 2021. ISSN 0743-7315. DOI: 10.1016/j.jpdc.2021.04.012
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

2 Shalini Sharma Goel; Anubhav Goel; Mohit Kumar; Germán Moltó Martínez. A review of Internet of Things: qualifying technologies and boundless horizon. Journal of Reliable Intelligent Environments. 7, pp. 23 - 33. 2021. ISSN 2199-4668. DOI: 10.1007/s40860-020-00127-w
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

3 Diana María Naranjo Delgado; Sebastián Risco Gallardo; Germán Moltó Martínez; Ignacio Blanquer Espert. A serverless gateway for event-driven machine learning inference in multiple clouds. Concurrency and Computation: Practice and Experience (Online). pp. 1 - 17. 2021. ISSN 1532-0634. DOI: 10.1002/cpe.6728
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

4 Miguel Caballer Fernández; Marica Antonacci; Zden#283k ☐ustr; Michele Perniola; Germán Moltó Martínez. Deployment of Elastic Virtual Hybrid Clusters Across Cloud Sites. Journal of Grid Computing. 19, pp. 1 - 16. 2021. ISSN 1570-7873. DOI: 10.1007/s10723-021-09543-5
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

5 Sebastián Risco Gallardo; Germán Moltó Martínez. GPU-Enabled Serverless Workflows for Efficient Multimedia Processing. Applied Sciences. 11, pp. 1 - 17. 2021. ISSN 2076-3417. DOI: 10.3390/app11041438
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

6 Sebastián Risco Gallardo; Germán Moltó Martínez; Diana María Naranjo Delgado; Ignacio Blanquer Espert. Serverless Workflows for Containerised Applications in the Cloud Continuum. Journal of Grid Computing. 19, pp. 1 - 18. 2021. ISSN 1570-7873. DOI: 10.1007/s10723-021-09570-2
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

7 Vicent Giménez Alventosa; Germán Moltó Martínez; José Damián Segrelles Quilis. TaScaaS: A Multi-Tenant Serverless Task Scheduler and Load Balancer as a Service. IEEE Access. 9, pp. 125215 - 125228. 2021. ISSN 2169-3536. DOI: 10.1109/ACCESS.2021.3109972
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

8 Álvaro López Garcia; Jesus Marco de Lucas; Marica Antonacci; Wolfgang zu Castell; Mário David; Marcus Hardt; Lara Lloret Iglesias; Germán Moltó Martínez; Marcin Plociennik; Viet Tran; ANDREI STEFAN ALIC; Miguel Caballer Fernández; Isabel Campos Plasencia; Alessandro Costantini; Stefan Dlugolinsky. A Cloud-Based Framework for Machine Learning Workloads and Applications. IEEE Access. 8, pp. 18681 - 18692. 2020. ISSN 2169-3536. DOI: 10.1109/ACCESS.2020.2964386
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

9 Diana María Naranjo Delgado; Sebastián Risco Gallardo; Carlos De Alfonso Laguna; Alfonso María Pérez González; Ignacio Blanquer Espert; Germán Moltó Martínez. Accelerated serverless computing based on GPU virtualization. Journal of Parallel and Distributed Computing. 139, pp. 32 - 42. 2020. ISSN 0743-7315. DOI: 10.1016/j.jpdc.2020.01.004
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

10 Vicent Giménez Alventosa; José Damián Segrelles Quilis; Germán Moltó Martínez; Mar Roca Sogorb. APRICOT: Advanced Platform for Reproducible Infrastructures in the Cloud via Open Tools. Methods of Information in Medicine. 59, pp. e33 - e45. 2020. ISSN 0026-1270. DOI: 10.1055/s-0040-1712460
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

11 Germán Moltó Martínez; Diana María Naranjo Delgado; José Damián Segrelles Quilis. Insights from Learning Analytics for Hands-On Cloud Computing Labs in AWS. Applied Sciences. 10, pp. 1 - 13. 2020. ISSN 2076-3417. DOI: 10.3390/app10249148
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

12 JOSE HERRERA HERNANDEZ; Germán Moltó Martínez. Toward Bio-Inspired Auto-Scaling Algorithms: An Elasticity Approach for Container Orchestration Platforms. IEEE Access. 8, pp. 52139 - 52150. 2020. ISSN 2169-3536. DOI: 10.1109/ACCESS.2020.2980852
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

13 Vicent Giménez Alventosa; Germán Moltó Martínez; Miguel Caballer Fernández. A framework and a performance assessment for serverless MapReduce on AWS Lambda. Future Generation Computer Systems. 97, pp. 259 - 274. 2019. ISSN 0167-739X. DOI: 10.1016/j.future.2019.02.057
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

14 Sergio López Huguet; Alfonso María Pérez González; Amanda Calatrava Arroyo; Carlos De Alfonso Laguna; Miguel Caballer Fernández; Germán Moltó Martínez; Ignacio Blanquer Espert. A Self-managed Mesos Cluster for Data Analytics with QoS Guarantees. Future Generation Computer Systems. 96, pp. 449 - 461. 2019. ISSN 0167-739X. DOI: 10.1016/j.future.2019.02.047
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

15 Diana María Naranjo Delgado; José Ramón Prieto Fontcuberta; Germán Moltó Martínez; Amanda Calatrava Arroyo. A Visual Dashboard to Track Learning Analytics for Educational Cloud Computing. Sensors. 19, pp. 1 - 15. 2019. ISSN 1424-8220. DOI: 10.3390/s19132952
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

16 Carlos De Alfonso Laguna; Miguel Caballer Fernández; Amanda Calatrava Arroyo; Germán Moltó Martínez; Ignacio Blanquer Espert. Multi-elastic Datacenters: Auto-scaled Virtual Clusters on Energy-Aware Physical Infrastructures. Journal of Grid Computing. 17, pp. 191 - 204. 2019. ISSN 1570-7873. DOI: 10.1007/s10723-018-9449-z
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

17 Davide Salomoni; Isabel Campos Plasencia; Luciano Gaido; Jesus Marco de Lucas; Peter Solagna; Jorge Gomes; Ludek Matyska; Patrick Fuhrmann; Marcus Hardt; Giacinto Donvito; Lukasz Dutka; Marcin Plociennik; Roberto Barbera; Ignacio Blanquer Espert; Andrea Ceccanti; Eva Cetinic; Mário David; Cristina Duma; Álvaro López Garcia; Germán Moltó Martínez. INDIGO-DataCloud: a Platform to Facilitate Seamless Access to E-Infrastructures. Journal of Grid Computing. 16, pp. 381 - 408. 2018. ISSN 1570-7873. DOI: 10.1007/s10723-018-9453-3
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

18 Miguel Caballer Fernández; Sahdev Zala; Álvaro López Garcia; Germán Moltó Martínez; Pablo Orviz; Mathieu Velten. Orchestrating Complex Application Architectures in Heterogeneous Clouds. Journal of Grid Computing. 16, pp. 3 - 18. 2018. ISSN 1570-7873. DOI: 10.1007/s10723-017-9418-y

Tipo de producción: Artículo científico **Tipo de soporte:** Revista

19 Alfonso María Pérez González; Germán Moltó Martínez; Miguel Caballer Fernández; Amanda Calatrava Arroyo. Serverless computing for container-based architectures. Future Generation Computer Systems. 83, pp. 50 - 59. 2018. ISSN 0167-739X. DOI: 10.1016/j.future.2018.01.022
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

20 Carlos De Alfonso Laguna; Amanda Calatrava Arroyo; Germán Moltó Martínez. Container-based Virtual Elastic Clusters. Journal of Systems and Software. 127, pp. 1 - 11. 2017. ISSN 0164-1212. DOI: 10.1016/j.jss.2017.01.007
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

21 Miguel Caballer Fernández; Giacinto Donvito; Germán Moltó Martínez; Ricardo Rocha; Mathieu Velten. TOSCA-based orchestration of complex clusters at the IaaS level. Journal of Physics: Conference Series (Online). 898, pp. 1 - 8. 2017. ISSN 1742-6596. DOI: 10.1088/1742-6596/898/8/082036
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

22 José Damián Segrelles Quilis; Alicia Martínez Antón; Nuria Castilla Cabanes; Germán Moltó Martínez. Virtualized Computational Environments on the cloud to foster group skills through PBL: A case study in architecture. Computers & Education. 108, pp. 131 - 144. 2017. ISSN 0360-1315. DOI: http://dx.doi.org/10.1016/j.compedu.2017.02.001
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

23 Germán Moltó Martínez; Miguel Caballer Fernández; Carlos De Alfonso Laguna. Automatic memory-based vertical elasticity and oversubscription on cloud platforms. Future Generation Computer Systems. 56, pp. 1 - 10. 2016. ISSN 0167-739X. DOI: 10.1016/j.future.2015.10.002
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

24 Amanda Calatrava Arroyo; Eloy Romero Alcalde; Germán Moltó Martínez; Miguel Caballer Fernández; José Miguel Alonso Abalos. Self-managed Cost-efficient Virtual Elastic Clusters on Hybrid Cloud Infrastructures. Future Generation Computer Systems. 61, pp. 13 - 25. 2016. ISSN 0167-739X. DOI: 10.1016/j.future.2016.01.018
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

25 Ana María Fita Fernández; José Francisco Monserrat Del Río; Germán Moltó Martínez; Eva María Mestre i Mestre; Adrián Rodríguez Burruezo. Use of synchronous e-learning at university degrees. Computer Applications in Engineering Education. 24, pp. 982 - 993. 2016. ISSN 1061-3773. DOI: 10.1002/cae.21773
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

26 Miguel Caballer Fernández; José Damián Segrelles Quilis; Germán Moltó Martínez; Ignacio Blanquer Espert. A platform to deploy customized scientific virtual infrastructures on the cloud. Concurrency and Computation: Practice and Experience. 27, pp. 4318 - 4329. 2015. ISSN 1532-0626. DOI: 10.1002/cpe.3518
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

27 Miguel Caballer Fernández; Ignacio Blanquer Espert; Germán Moltó Martínez; Carlos De Alfonso Laguna. Dynamic Management of Virtual Infrastructures. Journal of Grid Computing. 13, pp. 53 - 70. 2015. ISSN 1570-7873. DOI: 10.1007/s10723-014-9296-5
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

28 Miguel Caballer Fernández; Carlos De Alfonso Laguna; Germán Moltó Martínez; Eloy Romero Alcalde; Ignacio Blanquer Espert; Andrés García García. CodeCloud: A platform to enable execution of programming models on the Clouds. Journal of Systems and Software. 93, pp. 187 - 198. 2014. ISSN 0164-1212. DOI: 10.1016/j.jss.2014.02.005
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

29 FRANCISCO RODRIGO ARTEAGA SIERRA; Carles Milián Enrique; ALBERT FERRANDO COGOLLOS; Germán Moltó Martínez; Ismael Torres Gómez; Miguel Torres Cisneros. Supercontinuum optimization for dual-soliton based light sources using genetic algorithms in a grid platform. Optics Express. 22, pp. 23686 - 23693. 2014. ISSN 1094-4087. DOI: 10.1364/OE.22.023686
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

30 Germán Moltó Martínez; Amanda Calatrava Arroyo; Vicente Hernández García. A Service-Oriented Architecture for Scientific Computing on Cloud Infrastructures. Lecture Notes in Computer Science. 7851, pp. 163 - 176. 2013. ISSN 0302-9743. DOI: 10.1007/978-3-642-38718-0_18
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

31 Germán Moltó Martínez; Carlos De Alfonso Laguna; Miguel Caballer Fernández; Fernando Alvarruiz Bermejo. An economic and energy-aware analysis of the viability of outsourcing cluster computing to a cloud. Future Generation Computer Systems. 29, pp. 704 - 712. 2013. ISSN 0167-739X. DOI: 10.1016/j.future.2012.08.014
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

32 Germán Moltó Martínez; Miguel Caballer Fernández; Carlos De Alfonso Laguna; Fernando Alvarruiz Bermejo. EC3: Elastic Cloud Computing Cluster. Journal of Computer and System Sciences. 79, pp. 1341 - 1351. 2013. ISSN 0022-0000. DOI: http://dx.doi.org/10.1016/j.jcss.2013.06.005
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

33 Ignacio Blanquer Espert; Vicente Hernández García; Erik Torres Serrano; Germán Moltó Martínez; José Damián Segrelles Quilis. A replicated information system to enable dynamic collaborations in the Grid. Concurrency and Computation: Practice and Experience. 24, pp. 1668 - 1683. 2012. ISSN 1532-0626. DOI: 10.1002/cpe.1915
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

34 Karen Eliana Cardona Urrego; Beatriz Ana Trenor Gomis; Germán Moltó Martínez; Miguel Andrés Martínez Iranzo; José María Ferrero De Loma-Osorio; Francisco Javier Saiz Rodríguez. Exploring the role of pH in modulating the effects of lidocaine in virtual ischemic tissue. AJP Heart and Circulatory Physiology. 299, pp. 1615 - 1624. 2010. ISSN 0363-6135. DOI: 10.1152/ajpheart.00425.2
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

35 Germán Moltó Martínez; Vicente Hernández García; José Miguel Alonso Abalos. Automatic Replication of WSRF-based Grid Services via Operation Providers. Future Generation Computer Systems. 25, pp. 876 - 883. 2009. ISSN 0167-739X. DOI: 10.1016/j.future.2009.03.004
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

36 Germán Moltó Martínez; MARIA SUAREZ; PABLO TORTOSA; José Miguel Alonso Abalos; Vicente Hernández García; ALFONSO JARAMILLO ROSALES. Protein Design Based on Parallel Dimensional Reduction. Journal of Chemical Information and Modeling. 49, pp. 1261 - 1271. 2009. ISSN 1549-9596. DOI: 10.1021/ci8004594
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

37 José Miguel Alonso Abalos; José María Ferrero De Loma-Osorio; Vicente Hernández García; Germán Moltó Martínez; Francisco Javier Saiz Rodríguez; Beatriz Ana Trenor Gomis. A Grid Computing-based Approach for the Acceleration of Simulations in Cardiology. IEEE Transactions on Information Technology in Biomedicine. 12, pp. 138 - 144. 2008. ISSN 1089-7771. DOI: 10.1109/TITB.2007.907982
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

38 José Miguel Alonso Abalos; Vicente Hernández García; Germán Moltó Martínez. A High-Throughput Application for the Dynamic Analysis of Structures on a Grid Environment. Advances in Engineering Software. 39, pp. 839 - 848. 2008. ISSN 0965-9978. DOI: 10.1016/j.advengsoft.2007.05.005
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

39 Germán Moltó Martínez; Vicente Hernández García; José Miguel Alonso Abalos. A Service-Oriented WSRF-based Architecture for Metascheduling on Computational Grids. Future Generation Computer Systems. 24, pp. 317 - 328. 2008. ISSN 0167-739X. DOI: 10.1016/j.future.2007.05.001
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

40 José Antonio Gómez Tejedor; Germán Moltó Martínez; Carlos Alberto Barros Vidaurre. An Online Virtual Laboratory of Electricity. International Journal of Distance Education Technologies. 6, pp. 21 - 34. 2008. ISSN 1539-3100. DOI: 10.4018/jdet.2008040102
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

41 Beatriz Ana Trenor Gomis; Lucia Romero Pérez; José María Ferrero De Loma-Osorio; Francisco Javier Saiz Rodríguez; Germán Moltó Martínez; José Miguel Alonso Abalos. Vulnerability to Reentry in a Regionally Ischemic Tissue: A Simulation Study. Annals of Biomedical Engineering. 35, pp. 1756 - 1770. 2007. ISSN 0090-6964
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

42 José Miguel Alonso Abalos; Vicente Hernández García; ROBERTO LÓPEZ HERRERO; Germán Moltó Martínez. A Service Oriented System for on Demand Dynamic Structural Analysis over Computational Grids. Lecture Notes in Computer Science. 4395, pp. 13 - 26. 2007. ISSN 0302-9743
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

43 José Miguel Alonso Abalos; Fernando Alvarruiz Bermejo; José Mª Desantes Fernández; LEONOR HERNÁNDEZ LÓPEZ; Vicente Hernández García; Germán Moltó Martínez. Combining Neural Networks and Genetic Algorithms to Predict and Reduce Diesel Engine Emissions. IEEE Transactions on Evolutionary Computation. 11, pp. 46 - 55. 2007. ISSN 1089-778X
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

44 José Miguel Alonso Abalos; Vicente Hernández García; Germán Moltó Martínez. GMarte: Grid Middleware to Abstract Remote Task Execution. Concurrency and Computation: Practice and Experience. 18, pp. 2021 - 2036. 2006. ISSN 1532-0626
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

45 José Miguel Alonso Abalos; José María Ferrero De Loma-Osorio; Vicente Hernández García; Germán Moltó Martínez; Marta María Monserrat Del Río; Francisco Javier Saiz Rodríguez. Three-Dimensional Cardiac Electrical Activity Simulation on Cluster and Grid Platforms. Lecture Notes in Computer Science. 3402, pp. 219 - 232. 2005. ISSN 0302-9743
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

46 José Miguel Alonso Abalos; Vicente Hernández García; Germán Moltó Martínez. Enabling High Level Access to Grid Computing Services.Ercim News. 59, pp. 42 - 43. 2004. ISSN 0926-4981
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

47 José Miguel Alonso Abalos; Vicente Hernández García; Germán Moltó Martínez. Globus-Based Grid Computing Simulations of Action Potential Propagation on Cardiac Tissues. Lecture Notes in Computer Science. 3149, pp. 444 - 451. 2004. ISSN 0302-9743
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

48 José Miguel Alonso Abalos; Vicente Hernández García; Germán Moltó Martínez. Grid Computing Based Simulations of the Electrical Activity of the Heart. Lecture Notes in Computer Science. 3036, pp. 482 - 485. 2004. ISSN 0302-9743
Tipo de producción: Artículo científico **Tipo de soporte:** Revista

49 Clara López; Germán Moltó Martínez. Herramienta de Análisis para el Estudio de la Ortografía Preventiva. INVESTIGACIÓN EN LA ENSEÑANZA DE LAS LENGUAS Y LAS LITERATURAS. 7, pp. 97 - 110. Universitat Politècnica de València, 2016. ISBN 978-84-9048-441-8
Tipo de producción: Capítulo de libro **Tipo de soporte:** Libro

50 José Antonio Gómez Tejedor; Germán Moltó Martínez. Online Learning of Electrical Circuits through a Virtual Laboratory. Technologies Shaping Instruction and Distance Education: New Studies and Utilizations. 7, pp. 94 - 107. Mahbubur Rahman Syed, IGI Global, 2009. ISBN 978-1-60566-934-2
Tipo de producción: Capítulo de libro **Tipo de soporte:** Libro

51 José Antonio Gómez Tejedor; Germán Moltó Martínez. Online Learning of Electrical Circuits through a Virtual Laboratory. Technologies Shaping Instruction and Distance Education: New Studies and Utilizations. 7, pp. 94 - 107. Mahbubur Rahman Syed, IGI Global, 2009. ISBN 978-1-60566-935-9
Tipo de producción: Capítulo de libro **Tipo de soporte:** Libro

Trabajos presentados en congresos nacionales o internacionales

1 **Título del trabajo:** Deployment Service for Scalable Distributed Deep Learning Training on Multiple Clouds
Nombre del congreso: 11th International Conference on Cloud Computing and Services Science (CLOSER 2021)
Ciudad de celebración: Online,
Fecha de celebración: 30/04/2021
Javier Jorge Cano; Germán Moltó Martínez; José Damián Segrelles Quilis; João Pedro Fontes; Miguel Angel Guevara. "Proceedings of the 11th International Conference on Cloud Computing and Services Science (CLOSER 2021)". pp. 135 - 142. SciTePress, ISSN 978-989-758-510-4

2 **Título del trabajo:** A Serverless Gateway for the Execution of Open Machine Learning Models on AWS
Nombre del congreso: Gateways 2020
Ciudad de celebración: Online,
Fecha de celebración: 23/10/2020
Diana María Naranjo Delgado; Sebastián Risco Gallardo; Germán Moltó Martínez; Ignacio Blanquer Espert. "Gateways 2020 Proceedings". pp. null - null.

3 **Título del trabajo:** EMAP: A Cloud-Edge Hybrid Framework for EEG Monitoring and Cross-Correlation Based Real-time Anomaly Prediction
Nombre del congreso: 57th Design Automation Conference (DAC 2020)
Ciudad de celebración: Online,
Fecha de celebración: 23/07/2020
Bharath Srinivas Prabakaran; Alberto García Jiménez; Germán Moltó Martínez; Muhammad Shafique. "Proceedings of the 57th Annual Design Automation Conference (DAC)". pp. 1 - 6. IEEE, ISSN 978-1-7281-1085-1

4 **Título del trabajo:** Comparison of Container-based Virtualization Tools for HPC Platforms
Nombre del congreso: 10th Iberian Grid Infrastructure Conference (IBERGRID 2019)
Ciudad de celebración: Santiago de Compostela, España,
Fecha de celebración: 26/09/2019
Diana María Naranjo Delgado; Germán Moltó Martínez; Ignacio Blanquer Espert; Jorge Gomes; Mário David. pp. null - null.

5 **Título del trabajo:** Serverless Computing for Data-Processing Across Public and Federated Clouds
Nombre del congreso: 10th Iberian Grid Infrastructure Conference (IBERGRID 2019)
Ciudad de celebración: Santiago de Compostela, España,
Fecha de celebración: 26/09/2019
Sebastián Risco Gallardo; Alfonso María Pérez González; Miguel Caballer Fernández; Germán Moltó Martínez. pp. 19 - 19.

6 **Título del trabajo:** On-Premises Serverless Computing for Event-Driven Data Processing Applications
Nombre del congreso: 12th IEEE International Conference on Cloud Computing (CLOUD 2019)
Ciudad de celebración: Milan, Italy,
Fecha de celebración: 13/07/2019
Alfonso María Pérez González; Sebastián Risco Gallardo; Diana María Naranjo Delgado; Miguel Caballer Fernández; Germán Moltó Martínez. "PROCEEDINGS 2019 IEEE International Conference on Cloud Computing (IEEE CLOUD 2019). Part of the 2019 IEEE World Congress on Services". pp. 414 - 421. IEEE, ISSN 978-1-7281-2705-7

7 **Título del trabajo:** Contribuciones de la analítica del aprendizaje a la implicación de los estudiantes de enseñanzas científico-técnicas
Nombre del congreso: 3rd European Conference of Scholarship of Teaching and Learning (EuroSoTL 2019)
Ciudad de celebración: Bilbao, Spain,
Fecha de celebración: 14/06/2019
José Vicente Benlloch Dualde; Germán Moltó Martínez; José Damián Segrelles Quilis; David De Andrés Martínez; Mª Pilar Bonet Espinosa. "III Congreso EuroSoTL. Explorando nuevos campos a través de un enfoque académico de la enseñanza y el aprendizaje". pp. 1049 - 1056. Universidad del País Vasco, ISSN 978-84-1319-033-4

8 **Título del trabajo:** A Programming Model and Middleware for High Throughput Serverless Computing Applications
Nombre del congreso: 34th ACM/SIGAPP Symposium on Applied Computing (SAC 2019)
Ciudad de celebración: Limassol, Cyprus,
Fecha de celebración: 12/04/2019
Alfonso María Pérez González; Germán Moltó Martínez; Miguel Caballer Fernández; Amanda Calatrava Arroyo. "SAC '19: Proceedings of the 34th ACM/SIGAPP Symposium on Applied Computing". pp. 106 - 113. ACM, ISSN 978-1-4503-5933-7

9 **Título del trabajo:** Digital repository as a service: automatic deployment of an Invenio-based repository using TOSCA orchestration and Apache Mesos
Nombre del congreso: 23rd International Conference on Computing in High Energy and Nuclear Physics (CHEP 2018)
Ciudad de celebración: Sofia, Bulgaria,
Fecha de celebración: 13/07/2018
Marica Antonacci; Alberto Brigandi; Miguel Caballer Fernández; Eva Cetinic; Davor Davidovic; Giacinto Donvito; Germán Moltó Martínez; Davide Salomoni. "EPJ Web of Conferences". pp. 1 - 8. EDP Sciences,

10 **Título del trabajo:** DEEP-HybridDataCloud
Nombre del congreso: ISC High Performance 2018
Ciudad de celebración: Frankfurt, Germany,
Fecha de celebración: 28/06/2018
Giacinto Donvito; Jorge Gomes; Ana Juan Ferrer; Valentin Kozlov; Álvaro López Garcia; Ludek Matyska; Norbert Meyer; Germán Moltó Martínez; Viet Tran; Wolfgang zu Castell. pp. 0 - 0.

11 **Título del trabajo:** The Journey from On-premises to Serverless in Scientific Computing
Nombre del congreso: SIAM Conference on Parallel Processing for Scientific Computing (PP 2018)
Ciudad de celebración: Tokyo, Japan,
Fecha de celebración: 10/03/2018
Germán Moltó Martínez; Miguel Caballer Fernández; Carlos De Alfonso Laguna; Alfonso María Pérez González; Amanda Calatrava Arroyo; Ignacio Blanquer Espert. pp. 103 - 104.

12 **Título del trabajo:** Piattaforme per I□analisi di Big Data istanziate on-demand tramite la PaaS di INDIGO-DataCloud
Nombre del congreso: GARR Conference 2017. The data way to Science
Ciudad de celebración: Venice, Italy,
Fecha de celebración: 17/11/2017
Marica Antonacci; Alberto Brigandi; Miguel Caballer Fernández; Giacinto Donvito; Germán Moltó Martínez; Davide Salomoni. "Conferenza GARR_17 Selected papers". pp. 17 - 21. GARR Conference, ISSN 978-88-905077-7-9

13 **Título del trabajo:** Logotype Detection in Streaming Multimedia Using Apache Storm
Nombre del congreso: 23rd International Conference on Parallel and Distributed Processing Techniques and Applications (PDPTA'17)
Ciudad de celebración: Las Vegas, USA,
Fecha de celebración: 20/07/2017
JOSE HERRERA HERNANDEZ; Germán Moltó Martínez; Atsuhiro Takasu. "Proceedings of the 2017 International Conference on Parallel and Distributed Processing Techniques and Applications. PDPTA'17". pp. 81 - 87. CSREA Press, ISSN 1-60132-466-9

14 **Título del trabajo:** Automatic Consolidation of Virtual Machines in On-Premises Cloud Platforms
Nombre del congreso: 17th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGRID 2017)
Ciudad de celebración: Madrid, Spain,
Fecha de celebración: 17/05/2017
Carlos De Alfonso Laguna; Ignacio Blanquer Espert; Germán Moltó Martínez; Miguel Caballer Fernández. "2017 17th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing". pp. 1070 - 1079. IEEE, ISSN 978-1-5090-6611-7

15 **Título del trabajo:** IM integration in the EGI VMOps Dashboard
Nombre del congreso: EGI Conference 2017 and INDIGO Summit 2017
Ciudad de celebración: Catania, Italia,
Fecha de celebración: 12/05/2017
Miguel Caballer Fernández; Marios Chatziangelou; Amanda Calatrava Arroyo; Germán Moltó Martínez; Alfonso María Pérez González. pp. 0 - 0.

16 **Título del trabajo:** Virtual Elastic Clusters in the EGI LToS with EC3
Nombre del congreso: EGI Conference 2017 and INDIGO Summit 2017
Ciudad de celebración: Catania, Italia,
Fecha de celebración: 12/05/2017
Amanda Calatrava Arroyo; Miguel Caballer Fernández; Germán Moltó Martínez; Alfonso María Pérez González. pp. 0 - 0.

17 **Título del trabajo:** Coherent Application Delivery on Hybrid Distributed Computing Infrastructures of Virtual Machines and Docker Containers
Nombre del congreso: 25th Euromicro International Conference on Parallel, Distributed, and Network-Based Processing

Ciudad de celebración: St. Petersburg, Russia,
Fecha de celebración: 08/03/2017
Germán Moltó Martínez; Miguel Caballer Fernández; Alfonso María Pérez González; Carlos De Alfonso Laguna; Ignacio Blanquer Espert. "Proceedings (Euromicro Workshop on Parallel and Distributed Processing. Online)". pp. 486 - 490. IEEE,

18 **Título del trabajo:** Distributed and cloud-based multi-model analytics experiments on large volumes of climate change data in the Earth System Grid Federation eco-system
Nombre del congreso: IEEE International Conference on Big Data (IEEE BigData 2016)
Ciudad de celebración: Washington D.C., USA,
Fecha de celebración: 08/12/2016
Sandro Fiore; Marcin Plociennik; C. Doutriaux; C. Palazzo; J. Boutte; Tomas Zok; D. Elia; Michal Owsiak; A. D'Anca; Z. Shaheen; Riccardo Bruno; Marco Fargetta; Miguel Caballer Fernández; Germán Moltó Martínez; Ignacio Blanquer Espert; Roberto Barbera; Mário David; G. DONVITO; Dean N. Williams; Valentine Anantharaj; Davide Salomoni; Giovanni Aloisio. "Proceedings of the 2016 IEEE International Conference on Big Data (Big Data)". pp. 2911 - 2918. IEEE, ISSN 978-1-4673-9005-7

19 **Título del trabajo:** Assessment of Cloud-based Computational Environments for Higher Education
Nombre del congreso: 46th Annual Frontiers in Education Conference (FIE 2016)
Ciudad de celebración: Erie, PA, USA,
Fecha de celebración: 15/10/2016
José Damián Segrelles Quilis; Germán Moltó Martínez. "2016 IEEE Frontiers in Education Conference Proceedings". pp. 0 - 0. ISSN 978-1-5090-1790-4

20 **Título del trabajo:** Enabling scientific applications on hybrid e-Infrastructures: the FutureGateway framework
Nombre del congreso: Digital Infrastructures for Research 2016 (DI4R 2016)
Ciudad de celebración: Krakow, Poland,
Fecha de celebración: 30/09/2016
Marco Fargetta; Riccardo Bruno; Roberto Barbera; Marcin Plociennik; Sandro Fiore; Michal Owsiak; Tomasz Zok; Daniel Figat; G. DONVITO; Marco Antonio Tangaro; Federico Zambelli; Dean N. Williams; Valentine Anantharaj; Giovanni Aloisio; Emidio Giorgio; Lionel Schwarz; Germán Moltó Martínez; Bas Wegh. pp. 0 - 0.

21 **Título del trabajo:** How the INDIGO-DataCloud computing platform aims at helping scientific communities
Nombre del congreso: EGI Conference 2016
Ciudad de celebración: Amsterdam, The Netherlands,
Fecha de celebración: 08/04/2016
G. DONVITO; Ignacio Blanquer Espert; Álvaro López Garcia; Davide Salomoni; Isabel Campos Plasencia; Germán Moltó Martínez; Lukasz Dutka; Patrick Fuhrmann. pp. 0 - 0.

22 **Título del trabajo:** Detecting Events in Streaming Multimedia with Big Data Techniques
Nombre del congreso: 24th Euromicro International Conference on Parallel, Distributed, and Network-Based Processing
Ciudad de celebración: Heraklion, Crete, Greece,
Fecha de celebración: 19/02/2016
JOSE HERRERA HERNANDEZ; Germán Moltó Martínez. "PDP 2016 - 24th Euromicro International Conference on Parallel, Distributed, and Network-Based Processing". pp. 345 - 349. IEEE, ISSN 978-1-4673-8776-7

23 **Título del trabajo:** An integrated IaaS and PaaS architecture for scientific computing
Nombre del congreso: European Grid Infrastructure Community Forum 2015
Ciudad de celebración: Bari, Italy,

Fecha de celebración: 13/11/2015
Ignacio Blanquer Espert; G. DONVITO; Patrick Fuhrmann; Germán Moltó Martínez; Álvaro López Garcia. pp. 0 - 0.

24 **Título del trabajo:** Deploying Cost-Efficient Virtual Elastic Clusters across Multi-Clouds
Nombre del congreso: European Grid Infrastructure Community Forum 2015
Ciudad de celebración: Bari, Italy,
Fecha de celebración: 13/11/2015
Amanda Calatrava Arroyo; Miguel Caballer Fernández; Germán Moltó Martínez. pp. 0 - 0.

25 **Título del trabajo:** Remote Computational Labs for Educational Activities via a Cloud Computing Platform
Nombre del congreso: 32nd Information Systems Education Conference (ISECON 2015)
Ciudad de celebración: Orlando, USA,
Fecha de celebración: 07/11/2015
José Damián Segrelles Quilis; Germán Moltó Martínez; Miguel Caballer Fernández. "ISECON 2015: Complete Proceedings". pp. 309 - 321. Foundation for Information Technology Education (FITE),

26 **Título del trabajo:** Towards Migratable Elastic Virtual Clusters on Hybrid Clouds
Nombre del congreso: 8th IEEE International Conference on Cloud Computing (CLOUD 2015)
Ciudad de celebración: New York, USA,
Fecha de celebración: 02/07/2015
Amanda Calatrava Arroyo; Germán Moltó Martínez; Eloy Romero Alcalde; Miguel Caballer Fernández; Carlos De Alfonso Laguna. "2015 IEEE 8th International Conference on Cloud Computing". pp. 1013 - 1016. IEEE, ISSN 978-1-4673-7286-2

27 **Título del trabajo:** On Using the Cloud to Support Online Courses
Nombre del congreso: 44th Annual Frontiers in Education Conference (FIE 2014)
Ciudad de celebración: Madrid, Spain,
Fecha de celebración: 25/10/2014
Germán Moltó Martínez; Miguel Caballer Fernández. "2014 IEEE Frontiers in Education Conference (FIE)". pp. 330 - 338. IEEE, ISSN 978-1-4799-3921-3

28 **Título del trabajo:** High Performance Scientific Computing over Hybrid Cloud Platforms
Nombre del congreso: 10th IEEE International Conference on e-Science
Ciudad de celebración: Guarujá, Brasil,
Fecha de celebración: 24/10/2014
Amanda Calatrava Arroyo; Germán Moltó Martínez. pp. null - null.

29 **Título del trabajo:** Virtual Hybrid Elastic Clusters in the Cloud
Nombre del congreso: 8th Iberian Grid Infrastructure Conference (IBERGRID 2014)
Ciudad de celebración: Aveiro, Portugal,
Fecha de celebración: 10/09/2014
Amanda Calatrava Arroyo; Miguel Caballer Fernández; Germán Moltó Martínez; Carlos De Alfonso Laguna. "IBERGRID 2014". pp. 103 - 114. UPV, ISSN 978-84-9048-246-9

30 **Título del trabajo:** A Platform to Deploy Customized Scientific Virtual Infrastructures on the Cloud
Nombre del congreso: 6th International Workshop on Science Gateways (IWSG 2014)
Ciudad de celebración: Dublin, Ireland,
Fecha de celebración: 05/06/2014
Miguel Caballer Fernández; José Damián Segrelles Quilis; Germán Moltó Martínez; Ignacio Blanquer Espert. "2014 6th International Workshop on Science Gateways (IWSG)". pp. 42 - 47. IEEE, ISSN 978-1-4799-5819-1

31 **Título del trabajo:** Platform to Ease the Deployment and Improve the Availability of TRENCADIS Infrastructure
Nombre del congreso: 7th Iberian Grid Infrastructure Conference (IBERGRID 2013)
Ciudad de celebración: Madrid,
Fecha de celebración: 20/09/2013
Germán Moltó Martínez; José Damián Segrelles Quilis; Miguel Caballer Fernández; Erik Torres Serrano; Ignacio Blanquer Espert. "7th Iberian Grid Infrastructure Conference. Proceedings". pp. 133 - 145. Universitat Politècnica de València, ISSN 978-84-9048-110-3

32 **Título del trabajo:** Scalable Software Practice Environments Featuring Automatic Provision and Configuration in the Cloud
Nombre del congreso: 19th International Conference on Parallel and Distributed Processing Techniques and Applications (PDPTA 2013)
Ciudad de celebración: Las Vegas, Nevada, USA,
Fecha de celebración: 25/07/2013
Germán Moltó Martínez; Miguel Caballer Fernández. "Proceedings of the 2013 International Conference on Parallel and Distributed Processing Techniques and Applications(PDPTA□13)". pp. 658 - 664. CSREA Press, ISSN 1-60132-258-5

33 **Título del trabajo:** Elastic Memory Management of Virtualized Infrastructures for Applications with Dynamic Memory Requirements
Nombre del congreso: International Conference on Computational Science (ICCS 2013): "Computation at the Frontiers of Science"
Ciudad de celebración: Barcelona,
Fecha de celebración: 07/06/2013
Germán Moltó Martínez; Miguel Caballer Fernández; Eloy Romero Alcalde; Carlos De Alfonso Laguna. "Procedia Computer Science". pp. 159 - 168. Elsevier, ISSN 1877-0509

34 **Título del trabajo:** Portal TEA (Tecnologías E-learning Accesibles)
Nombre del congreso: I Congreso Internacional Universidad y Discapacidad (CIUD)
Ciudad de celebración: Madrid, España,
Fecha de celebración: 23/11/2012
Félix Buendía García; Miguel Martín Sánchez Cerviño; Juan Vicente Oltra Gutiérrez; Germán Moltó Martínez; María José Castro Bleda; Natividad Prieto Saez; Alberto Gonzalez Tellez; José Vicente Benlloch Dualde; GUILLERMO RAMIRO SALA. "Actas". pp. 1 - 2.

35 **Título del trabajo:** IberCloud: federated access to virtualized resources
Nombre del congreso: 6th Iberian Grid Infrastructure Conference (IBERGRID 2012)
Ciudad de celebración: Lisboa, Portugal,
Fecha de celebración: 09/11/2012
ALVARO LOPEZ GARCIA; Isabel Campos Plasencia; Miguel Ángel Nuñez Vega; Jesus Marco de Lucas; Álvaro Simon García; Carlos Fernández Sánchez; Jorge Gomes; Gonçalo Borges; Mário David; Germán Moltó Martínez; Miguel Caballer Fernández; Carlos De Alfonso Laguna; Enol Fernández Del Castillo; Ignacio Blanquer Espert. "6th Iberian Gris Infrastructure Conference". pp. 195 - 205. NetBiblo, ISSN 978-989-98265-0-2

36 **Título del trabajo:** Towards SLA-driven Management of Cloud Infrastructures to Elastically Execute Scientific Applications
Nombre del congreso: 6th Iberian Grid Infrastructure Conference (IBERGRID 2012)
Ciudad de celebración: Lisboa, Portugal,
Fecha de celebración: 09/11/2012

Germán Moltó Martínez; Miguel Caballer Fernández; Andrés García García; Carlos De Alfonso Laguna. "6th Iberian Gris Infrastructure Conference". pp. 207 - 218. NetBiblo, ISSN 978-989-98265-0-2

37 **Título del trabajo:** A Service-Oriented Architecture for Scientific Computing on Cloud Infrastructures
Nombre del congreso: 10th International Meeting on High-Performance Computing for Computational Science (VECPAR 2012)
Ciudad de celebración: Kobe, Japón,
Fecha de celebración: 20/07/2012
Germán Moltó Martínez; Amanda Calatrava Arroyo; Vicente Hernández García. "High Performance Computing for Computational Science - VECPAR 2012". pp. 1 - 8. Springer Lecture Notes in Computer Science Vol. 7851, ISSN 978-3-642-38717-3

38 **Título del trabajo:** TEA (Tecnologías E-learning Accesibles)
Nombre del congreso: III Congreso Iberoamericano sobre Calidad de la Formación Virtual (CAFVIR 2012)
Ciudad de celebración: Alcalá de Hernares, España,
Fecha de celebración: 27/04/2012
Miguel Martín Sánchez Cerviño; Juan Vicente Oltra Gutiérrez; Germán Moltó Martínez; María José Castro Bleda; Alberto Gonzalez Tellez; José Miguel Valiente González; Félix Buendía García. "CAFVIR 2012: III Congreso Iberoamericano sobre Calidad de la Formación Virtual". pp. 47 - 54. Universidad de Alcalá, ISSN 978-84-8138-367-6

39 **Título del trabajo:** EVALUATING AN E-LEARNING EXPERIENCE ORIENTED TOWARDS ACCESSIBLE INSTRUCTION
Nombre del congreso: 4th International Conference on Computer Supported Education (CSEDU 2012)
Ciudad de celebración: Porto, Portugal,
Fecha de celebración: 18/04/2012
Félix Buendía García; Alberto Gonzalez Tellez; José Vicente Benlloch Dualde; Germán Moltó Martínez; Natividad Prieto Saez; María José Castro Bleda; Juan Vicente Oltra Gutiérrez. "Proceedings of 4th International Conference on Computer Supported Education (CSEDU 2012)". pp. 381 - 386. SciTePress, ISSN 978 - 989-8565-07-5

40 **Título del trabajo:** Combining Grid and Cloud Resources for Hybrid Scientific Computing Executions
Nombre del congreso: 3rd IEEE International Conference on Cloud Computing Technology and Science (CLOUDCOM 2011)
Ciudad de celebración: Atenas, Grecia,
Fecha de celebración: 29/11/2011
Vicente Hernández García; Amanda Calatrava Arroyo; Germán Moltó Martínez. "2011 Third IEEE International Conference on Cloud Computing Technology and Science". pp. 494 - 501. Conference Publishing Services, ISSN 978-0-7695-4622-3

41 **Título del trabajo:** Infrastructure deployment over the Cloud
Nombre del congreso: 3rd IEEE International Conference on Cloud Computing Technology and Science (CLOUDCOM 2011)
Ciudad de celebración: Atenas, Grecia,
Fecha de celebración: 29/11/2011
Carlos De Alfonso Laguna; Miguel Caballer Fernández; Fernando Alvarruiz Bermejo; Germán Moltó Martínez; Vicente Hernández García. "2011 Third IEEE International Conference on Cloud Computing Technology and Science". pp. 517 - 521. Conference Publishing Services, ISSN 978-0-7695-4622-3

42 **Título del trabajo:** Scientific Application Execution on Hybrid Platforms Based on Grid and Cloud Computing
Nombre del congreso: 19th Euromicro International Conference on Parallel, Distributed and Network-based Processing (PDP 2011)

Ciudad de celebración: Cyprus,
Fecha de celebración: 09/02/2011
Germán Moltó Martínez; José Vicente Carrión Burguete; Vicente Hernández García. "Proceedings of the Work in Progress Session". pp. 1 - 2. Erwin Grosspietsch Konrad Klöckner, ISSN 978-3-902457-29-5

43 **Título del trabajo:** A Generic Catalog and Repository Service for Virtual Machine Images
Nombre del congreso: 2nd International ICST Conference on Cloud Computing (CLOUDCOMP 2010)
Ciudad de celebración: Barcelona, España,
Fecha de celebración: 26/10/2010
José Vicente Carrión Burguete; Germán Moltó Martínez; Carlos De Alfonso Laguna; Miguel Caballer Fernández; Vicente Hernández García. "Proceedings CD of the CLOUDCOMP 2010". pp. 1 - 15. ICST Gent, ISSN 978-963-9995-17-8

44 **Título del trabajo:** Designing Supercontinuum Spectra using Grid Technology
Nombre del congreso: 2nd Workshop on Specialty Optical Fibers and Their Applications (WSOF 2010)
Ciudad de celebración: Oaxaca, México,
Fecha de celebración: 13/10/2010
ALBERT FERRANDO COGOLLOS; Carles Milián Enrique; Germán Moltó Martínez; Vicente Hernández García. "Proceedings of SPIE". pp. 1 - 4. SPIE, ISSN 978-0-8194-8360-7

45 **Título del trabajo:** On Demand Replication of WSRF-based Grid Services via Cloud Computing
Nombre del congreso: 9th International Meeting High Performance Computing for Computational Science (VECPAR 2010)
Ciudad de celebración: Berkeley,
Fecha de celebración: 22/06/2010
Germán Moltó Martínez; Vicente Hernández García. "Proceedings of VECPAR '10". pp. 1 - 14. Lawrence Berkeley National Laboratory and University of Porto,

46 **Título del trabajo:** Management and Contextualization of Scientific Virtual Appliances
Nombre del congreso: Cloud Futures 2010: Advancing Research With Cloud Computing
Ciudad de celebración: Redmond, Estados Unidos,
Fecha de celebración: 08/04/2010
Germán Moltó Martínez; Vicente Hernández García. "Proceedings". pp. 1 - 9. Microsoft Research,

47 **Título del trabajo:** Aplicación de plataformas GRID en fotónica: optimización de espectros Súper Continuos mediante algoritmos genéticos
Nombre del congreso: XXXII Reunión Bienal de la Real Sociedad Española de Física
Ciudad de celebración: Ciudad Real, España,
Fecha de celebración: 11/09/2009
Mario Zacarés González; Carles Milián Enrique; Germán Moltó Martínez; MIGUEL AREVALILLO; ALBERT FERRANDO COGOLLOS; Vicente Hernández García. "actas". pp. 413 - 414. Comité Organizador, ISSN 978-84-692-4956-7

48 **Título del trabajo:** Estrategias para la Evaluación Continua y la Mejora del Aprendizaje Autónomo en la Asignatura EDA de ITIG e ITIS
Nombre del congreso: Metodologías Activas para la Formación en Competencias y Estrategias de Evaluación Alternativas
Ciudad de celebración: Valencia España,
Fecha de celebración: 08/07/2009
Isabel Remedios Galiano Ronda; Carlos Herrero Cuco; Germán Moltó Martínez; Natividad Prieto Saez; Oscar Sapena Vercher. "Actas". pp. 1 - 9. Editorial UPV, ISSN 978-84-8363-510-0

49 **Título del trabajo:** Optimization of Supercontinuum Spectrum Using Genetic Algorithms on Service-Oriented Grids
Nombre del congreso: 3rd Iberian Grid Infrastructure Conference (IBERGRID 2009)
Ciudad de celebración: Valencia, España,
Fecha de celebración: 22/05/2009
Germán Moltó Martínez; MIGUEL AREVALILLO; Carles Milián Enrique; Mario Zacarés González; Vicente Hernández García; ALBERT FERRANDO COGOLLOS. "3RD IBERIAN GRID INFRASTRUCTURE CONFERENCE". pp. 137 - 146. NETBIBLO SL, ISSN 978-84-9745-406-3

50 **Título del trabajo:** Effect of Lidocaine in Acute Ischemic Situations: A Computer Modelling Study
Nombre del congreso: XXXV Computers in Cardiology Conference (CinC)
Ciudad de celebración: Bolonia, Italia,
Fecha de celebración: 18/12/2008
Karen Eliana Cardona Urrego; Francisco Javier Saiz Rodríguez; José María Ferrero De Loma-Osorio; Germán Moltó Martínez; Vicente Hernández García. "Proceedings of Computers in Cardiology". pp. 1017 - 1020. IEEE, ISSN 0276-6574

51 **Título del trabajo:** Safety in Purkinje to Ventricular Conduction and Ventricular Activity under Simulated 1D Ischemia
Nombre del congreso: XXXV Computers in Cardiology Conference (CinC)
Ciudad de celebración: Bolonia, Italia,
Fecha de celebración: 18/12/2008
Beatriz Ana Trenor Gomis; Francisco Javier Saiz Rodríguez; José María Ferrero De Loma-Osorio; Germán Moltó Martínez; Vicente Hernández García. "Proceedings of Computers in Cardiology". pp. 1013 - 1016. IEEE, ISSN 0276-6574

52 **Título del trabajo:** El Grupo Base como Herramienta de Formación Integral del Profesorado Universitario
Nombre del congreso: V Congreso Iberoamericano de Docencia Universitaria
Ciudad de celebración: Valencia, España,
Fecha de celebración: 31/10/2008
Germán Moltó Martínez; Ana María Fita Fernández; Eva María Mestre i Mestre; José Francisco Monserrat Del Río; María del Carmen Poveda Coscollá; Mª Cristina Rodríguez Monzonis; Juan Carlos Ruiz García. "Actas V Congreso Iberoamericano de Docencia Universitaria - "Enseñar y aprender en la enseñanza del siglo XXI"". pp. 1104 - 1106. Universidad Politécnica de Valencia, ISSN 978-84-691-8101-0

53 **Título del trabajo:** Laboratorio Virtual para la Realización de Circuitos Eléctricos a Través de Internet
Nombre del congreso: V Congreso Iberoamericano de Docencia Universitaria
Ciudad de celebración: Valencia, España,
Fecha de celebración: 31/10/2008
José Antonio Gómez Tejedor; Germán Moltó Martínez; Carlos Alberto Barros Vidaurre. "Actas V Congreso Iberoamericano de Docencia Universitaria - "Enseñar y aprender en la enseñanza del siglo XXI"". pp. 467 - 470. Universidad Politécnica de Valencia, ISSN 978-84-691-8101-0

54 **Título del trabajo:** Efecto de la Lidocaína sobre la Restitución Eléctrica y la Vulnerabilidad
Nombre del congreso: XXVI Congreso Anual de la Sociedad Española de Ingeniería Biomédica (CASEIB 2008)
Ciudad de celebración: Valladolid, España,
Fecha de celebración: 15/10/2008
Karen Eliana Cardona Urrego; Francisco Javier Saiz Rodríguez; José María Ferrero De Loma-Osorio; Germán Moltó Martínez; Vicente Hernández García. "Actas CASEIB 2008". pp. 190 - 193. Universidad de Valladolid, ISSN 978-84-691-3641-6

55 **Título del trabajo:** Is Dispersion of Refractoriness the Key to Reentry Vulnerability in Myocardial Ischemia? Insights From Simulations.
Nombre del congreso: 12th Word Multiconference on Systemics, Cybernetics and Informatics (WMSCI 2008)
Ciudad de celebración: Orlando (Florida,USA),
Fecha de celebración: 29/06/2008
José María Ferrero De Loma-Osorio; Lucia Romero Pérez; Beatriz Ana Trenor Gomis; Francisco Javier Saiz Rodríguez; José Miguel Alonso Abalos; Germán Moltó Martínez. "Actas y CD con ISBN". pp. 0 - 0. WMSCI, ISSN 9781934272312

56 **Título del trabajo:** Análisis de la actividad reentrante en un tejido virtual mediante el factor de seguridad: papel de la refractariedad
Nombre del congreso: XXV Congreso Anual de la Sociedad Española de Ingeniería Biomédica (CASEIB 2007)
Ciudad de celebración: Cartagena, España,
Fecha de celebración: 14/11/2007
Lucia Romero Pérez; Beatriz Ana Trenor Gomis; José María Ferrero De Loma-Osorio; Francisco Javier Saiz Rodríguez; Germán Moltó Martínez; José Miguel Alonso Abalos. "Actas CASEIB 2007". pp. 1 - 9. U.P. Cartagena, ISSN 84-612-0370-3

57 **Título del trabajo:** Efecto de la Variación del pH sobre la Acción de la Lidocaína en Tejidos Ventriculares
Nombre del congreso: XXV Congreso Anual de la Sociedad Española de Ingeniería Biomédica (CASEIB 2007)
Ciudad de celebración: Cartagena, España,
Fecha de celebración: 14/11/2007
Karen Eliana Cardona Urrego; Francisco Javier Saiz Rodríguez; José María Ferrero De Loma-Osorio; Miguel Andrés Martínez Iranzo; Germán Moltó Martínez; Vicente Hernández García. "Actas CASEIB 2007". pp. 1 - 9. U.P. Cartagena, ISSN 84-612-0370-3

58 **Título del trabajo:** Dispersion of refractoriness in a simulated ischemic 2D tissue: implications in vulnerability to reentry
Nombre del congreso: XXXIV Computers in Cardiology Conference (CinC 2007)
Ciudad de celebración: Durham, USA,
Fecha de celebración: 03/10/2007
Beatriz Ana Trenor Gomis; Lucia Romero Pérez; José María Ferrero De Loma-Osorio; Francisco Javier Saiz Rodríguez; Germán Moltó Martínez; Vicente Hernández García. "Computers in Cardiology Vol.34". pp. 1 - 9. IEEE Press, ISSN 978-1-4244-2533-4

59 **Título del trabajo:** Effect of Ectopic Focus Frequency on Fibrillatory Conduction in Atrial Remodelling Tissue. A Simulation Study
Nombre del congreso: XXXIV Computers in Cardiology Conference (CinC 2007)
Ciudad de celebración: Durham, USA,
Fecha de celebración: 03/10/2007
Catalina Tobón Zuluaga; Francisco Javier Saiz Rodríguez; José María Ferrero De Loma-Osorio; Germán Moltó Martínez; José Miguel Alonso Abalos. "Computers in Cardiology Vol.34". pp. 1 - 9. IEEE Press, ISSN 978-1-4244-2533-4

60 **Título del trabajo:** Influence of 1B ischemic ventricular tissue on the automaticity of purkinje fiders: a simulation study
Nombre del congreso: XXXIV Computers in Cardiology Conference (CinC 2007)
Ciudad de celebración: Durham, USA,
Fecha de celebración: 03/10/2007

Francisco Javier Saiz Rodríguez; Beatriz Ana Trenor Gomis; José María Ferrero De Loma-Osorio; Germán Moltó Martínez; Vicente Hernández García. "Computers in Cardiology Vol.34". pp. 1 - 9. IEEE Press, ISSN 978-1-4244-2533-4

61 **Título del trabajo:** The pH Dependence on the Electrophysiological Effect of Lidocaine in Ventricular Myocardium. A Computer Modelling Study
Nombre del congreso: XXXIV Computers in Cardiology Conference (CinC 2007)
Ciudad de celebración: Durham, USA,
Fecha de celebración: 03/10/2007
Karen Eliana Cardona Urrego; Francisco Javier Saiz Rodríguez; José María Ferrero De Loma-Osorio; Miguel Andrés Martínez Iranzo; Germán Moltó Martínez; Vicente Hernández García. "Computers in Cardiology Vol.34". pp. 1 - 9. IEEE Press, ISSN 978-1-4244-2533-4

62 **Título del trabajo:** The Safety Factor Approach in the Analysis of Reentrant Patterns of Activation in the Ischemic Virtual Heart
Nombre del congreso: XXXIV Computers in Cardiology Conference (CinC 2007)
Ciudad de celebración: Durham, USA,
Fecha de celebración: 03/10/2007
Lucia Romero Pérez; Beatriz Ana Trenor Gomis; José María Ferrero De Loma-Osorio; Francisco Javier Saiz Rodríguez; Germán Moltó Martínez; José Miguel Alonso Abalos. "Computers in Cardiology Vol.34". pp. 1 - 9. IEEE Press, ISSN 978-1-4244-2533-4

63 **Título del trabajo:** Grid Enabled JaSkel Skeletons with GMarte
Nombre del congreso: 1st Iberian Grid Infrastructure Conference (IBERGRID 2007)
Ciudad de celebración: Santiago, España,
Fecha de celebración: 14/05/2007
José Miguel Alonso Abalos; Vicente Hernández García; Germán Moltó Martínez; ALBERTO PROENÇA; SOBRAL JOSÉ LUIS. "1st Iberian Grid Infrastructure Conference Proceedings". pp. 301 - 312. Fundación CESGA, ISSN 978-84-611-6634-3

64 **Título del trabajo:** GRID4BUILD: A High Performance Grid Framework for the 3D Analysis and Visualisation of Building Structures
Nombre del congreso: 1st Iberian Grid Infrastructure Conference (IBERGRID 2007)
Ciudad de celebración: Santiago, España,
Fecha de celebración: 14/05/2007
José Miguel Alonso Abalos; Vicente Hernández García; ROBERTO LÓPEZ HERRERO; Germán Moltó Martínez. "1st Iberian Grid Infrastructure Conference Proceedings". pp. 353 - 364. Fundación CESGA, ISSN 978-84-611-6634-3

65 **Título del trabajo:** A WSRF-based Computational Gateway to the EGEE infrastructure for the Simulation of Cardiac Electrical Activity (Contribution ID 62)
Nombre del congreso: 2nd Enabling Grids for E-Science (EGEE) User Forum
Ciudad de celebración: Manchester, Reino Unido,
Fecha de celebración: 09/05/2007
José Miguel Alonso Abalos; José María Ferrero De Loma-Osorio; Vicente Hernández García; Germán Moltó Martínez; Francisco Javier Saiz Rodríguez. "EGEE User Forum Book of Abstracts". pp. 62 - 62. CERN,

66 **Título del trabajo:** Towards On-Demand Ubiquitous Metascheduling on Computational Grids
Nombre del congreso: 15th Euromicro Conference on Parallel, Distributed and Network-Based Processing (PDP 2007)
Ciudad de celebración: Nápoles, Italia,
Fecha de celebración: 07/02/2007

José Miguel Alonso Abalos; Vicente Hernández García; Germán Moltó Martínez. "Proceedings of the 15th Euromicro International Conference on Parallel, Distributed and Network-Based Processing". pp. 84 - 88. IEEE Computer Society, ISSN 978-0-7695-2784-0

67 **Título del trabajo:** Efecto de la Lidocaína sobre la Refractariedad y la Vulnerabilidad a Reentradas
Nombre del congreso: XXIV Congreso Anual de la Sociedad Española de Ingeniería Biomédica (CASEIB 2006)
Ciudad de celebración: Pamplona, España,
Fecha de celebración: 08/11/2006
Karen Eliana Cardona Urrego; Francisco Javier Saiz Rodríguez; José María Ferrero De Loma-Osorio; Miguel Andrés Martínez Iranzo; Germán Moltó Martínez; Vicente Hernández García. "Libro de Actas". pp. 201 - 204. Sociedad Española de Ingeniería Biomédica, ISSN 84-9769-160-1

68 **Título del trabajo:** Estudio de la propagación y bloqueo en un tejido cardíaco virtual mediante el factor de seguridad
Nombre del congreso: XXIV Congreso Anual de la Sociedad Española de Ingeniería Biomédica (CASEIB 2006)
Ciudad de celebración: Pamplona, España,
Fecha de celebración: 08/11/2006
Lucia Romero Pérez; Beatriz Ana Trenor Gomis; José María Ferrero De Loma-Osorio; Francisco Javier Saiz Rodríguez; Germán Moltó Martínez; José Miguel Alonso Abalos. "Libro de Actas". pp. 1 - 9. Sociedad Española de Ingeniería Biomédica, ISSN 84-9769-160-1

69 **Título del trabajo:** Influencia de hiperkalemia y acidosis en la formación de rotores en pared transmural ventricular: una simulación teórica
Nombre del congreso: XXIV Congreso Anual de la Sociedad Española de Ingeniería Biomédica (CASEIB 2006)
Ciudad de celebración: Pamplona, España,
Fecha de celebración: 08/11/2006
Karen Eliana Cardona Urrego; José María Ferrero De Loma-Osorio; Francisco Javier Saiz Rodríguez; Germán Moltó Martínez; OSCAR ALBERTO HENAO. "Libro de Actas". pp. 1 - 9. Sociedad Española de Ingeniería Biomédica, ISSN 84-9769-160-1

70 **Título del trabajo:** Remodelado Eléctrico y sus Efectos en un Modelo de Tejido Auricular Humano
Nombre del congreso: XXIV Congreso Anual de la Sociedad Española de Ingeniería Biomédica (CASEIB 2006)
Ciudad de celebración: Pamplona, España,
Fecha de celebración: 08/11/2006
Catalina Tobón Zuluaga; Francisco Javier Saiz Rodríguez; Germán Moltó Martínez; Fernando Hornero. "Libro de Actas". pp. 213 - 216. Sociedad Española de Ingeniería Biomédica, ISSN 84-9769-160-1

71 **Título del trabajo:** Biomedical and Civil Engineering Experiences Using Grid Computing Technologies
Nombre del congreso: Parallel Computer ParCo 2005
Ciudad de celebración: Málaga, España,
Fecha de celebración: 01/10/2006
José Miguel Alonso Abalos; Vicente Hernández García; Germán Moltó Martínez. "Parallel Computing: Current & Future Issues of High-End Computing". pp. 647 - 654. John Von Neumann-Instituts für Computing, ISSN 3-00-017352-8

72 **Título del trabajo:** Contribution of Electrophysiological Remodelling to Generation of Anatomical Re-Entries around the Right Pulmonary Veins in Human Atrium: a Simulation Study
Nombre del congreso: XXXIII Computers in Cardiology Conference (CinC)
Ciudad de celebración: Valencia, España,

Fecha de celebración: 20/09/2006
Catalina Tobón Zuluaga; Francisco Javier Saiz Rodríguez; Fernando Hornero; Germán Moltó Martínez; Vicente Hernández García; C RUIZ. "Computers in Cardiology Vol. 33". pp. 773 - 776. IEEE Press, ISSN ISSN 0276-6547

73 **Título del trabajo:** Effect of Lidocaine on Reentrant Ventricular Circuits in Acute Ischemic Situations. A Computer Modelling Study
Nombre del congreso: XXXIII Computers in Cardiology Conference (CinC)
Ciudad de celebración: Valencia, España,
Fecha de celebración: 20/09/2006
Karen Eliana Cardona Urrego; Francisco Javier Saiz Rodríguez; José María Ferrero De Loma-Osorio; Miguel Andrés Martínez Iranzo; Germán Moltó Martínez; Vicente Hernández García. "Computers in Cardiology Vol. 33". pp. 209 - 212. IEEE Press, ISSN ISSN 0276-6547

74 **Título del trabajo:** Effect of Regional Ischemia in Arrhythmia Vulnerability for Heterogeneous Transmural Cardiac Wall: A Simulation Study
Nombre del congreso: XXXIII Computers in Cardiology Conference (CinC)
Ciudad de celebración: Valencia, España,
Fecha de celebración: 20/09/2006
OSCAR HENAO; José María Ferrero De Loma-Osorio; Francisco Javier Saiz Rodríguez; Lucia Romero Pérez; Germán Moltó Martínez; Vicente Hernández García. "Computers in Cardiology Vol. 33". pp. 777 - 780. IEEE Press, ISSN ISSN 0276-6547

75 **Título del trabajo:** Safety Factor in Simulated 2D CardiacTissue. Influence of Altered Membrane Excitability
Nombre del congreso: XXXIII Computers in Cardiology Conference (CinC)
Ciudad de celebración: Valencia, España,
Fecha de celebración: 20/09/2006
Lucia Romero Pérez; Beatriz Ana Trenor Gomis; José María Ferrero De Loma-Osorio; Francisco Javier Saiz Rodríguez; Germán Moltó Martínez; José Miguel Alonso Abalos. "Computers in Cardiology Vol. 33". pp. 217 - 220. IEEE Press, ISSN ISSN 0276-6547

76 **Título del trabajo:** Experiencies Using Grid Services in Structural Dynamics
Nombre del congreso: European Conference on Product and Process Modelling in the Construction Industry (ECPPM 2006)
Ciudad de celebración: Valencia, España,
Fecha de celebración: 13/09/2006
José Miguel Alonso Abalos; Vicente Hernández García; ROBERTO LÓPEZ HERRERO; Germán Moltó Martínez. "eWork and eBusiness in Architecture, Engineering and Construction". pp. 359 - 366. Taylor & Francis Group, ISSN 0-415-41622-1

77 **Título del trabajo:** A Grid Service Development for Three-Dimensional Structural Analysis (Paper 122)
Nombre del congreso: 5th International Conference on Engineering Computational Technology
Ciudad de celebración: Las Palmas, España,
Fecha de celebración: 12/09/2006
José Miguel Alonso Abalos; Vicente Hernández García; ROBERTO LÓPEZ HERRERO; Germán Moltó Martínez. "Proceedings of the Fifth International Conference on Engineering Computational Technology". pp. 1 - 9. Civil-Comp Press, ISSN 1-905088-10-8

78 **Título del trabajo:** Una Aproximación Orientada a Servicios Grid para el Análisis Estático y Dinámico de Estructuras de Edificación
Nombre del congreso: XXXII Conferencia Latinoamericana de Informática (CLEI)
Ciudad de celebración: Santiago de Chile, Chile,
Fecha de celebración: 20/08/2006

José Miguel Alonso Abalos; Vicente Hernández García; ROBERTO LÓPEZ HERRERO; Germán Moltó Martínez. "Trabajos de la 32a Conferencia Latinoamericana de Informática". pp. 1 - 9. CLEI,

79 **Título del trabajo:** Laboratorio Virtual de Electricidad via Web
Nombre del congreso: VII Congreso de Tecnologías Aplicadas a la Enseñanza de la Electrónica (TAEE)
Ciudad de celebración: Madrid España,
Fecha de celebración: 12/07/2006
José Antonio Gómez Tejedor; Carlos Alberto Barros Vidaurre; Germán Moltó Martínez. "Resúmenes de las Actas". pp. 57 - 58. TAEE, ISSN 84-689-9590-8

80 **Título del trabajo:** A Service Oriented System for On Demand Dynamic Structural Analysis over Computational Grids
Nombre del congreso: 7th International meeting on High Performance Computing for Computational Science (VECPAR 2006)
Ciudad de celebración: Rio de Janeiro, Brasil,
Fecha de celebración: 10/07/2006
José Miguel Alonso Abalos; Vicente Hernández García; ROBERTO LÓPEZ HERRERO; Germán Moltó Martínez. "Proceedings of VECPAR' 06". pp. 1 - 9. UFRJ,

81 **Título del trabajo:** Aplicación de la Computación Paralela y las Tecnologías Grid en el Cálculo Dinámico de Estructuras de Edificación
Nombre del congreso: 12th International Congress on Computer Science Research (CIICC 2005)
Ciudad de celebración: Monterrey, México,
Fecha de celebración: 17/11/2005
José Miguel Alonso Abalos; Vicente Hernández García; Germán Moltó Martínez. "Proceedings of CIICC 2005". pp. 3 - 14. Dirección General de Educación Superior Tecnológica, ISSN 968-5823-21-9

82 **Título del trabajo:** Simulación de la Propagación del Potencial de Acción en Tejido Auricular Humano
Nombre del congreso: XXIII Congreso Anual de la Sociedad Española de Ingeniería Biomédica (CASEIB 2005)
Ciudad de celebración: Madrid, España,
Fecha de celebración: 10/11/2005
Germán Moltó Martínez; Francisco Javier Saiz Rodríguez; José María Ferrero De Loma-Osorio; Julio Gomis-Tena Dolz; Catalina Tobón Zuluaga. "Libro de Actas". pp. 393 - 396. Fund. Rogelio Segovia, ISSN 84-7402-325-4

83 **Título del trabajo:** Effects of Antiarrythmic Drug Lidocaine on Ventricular
Nombre del congreso: XXXII Computers in Cardiology Conference (CinC)
Ciudad de celebración: Lyon, Francia,
Fecha de celebración: 25/09/2005
Karen Eliana Cardona Urrego; Francisco Javier Saiz Rodríguez; Marta María Monserrat Del Río; José María Ferrero De Loma-Osorio; Germán Moltó Martínez. "Computers in Cardiology Vol.32". pp. 893 - 896. IEEE Press, ISSN 0276-6574

84 **Título del trabajo:** A Grid-based Application for the Three-dimensional Dynamic Analysis of High-Rise Buildings (Paper 68)
Nombre del congreso: 10th International Conference on Civil, Structural and Environmental Engineering Computing (Civil-Comp 2005)
Ciudad de celebración: Roma, Italia,
Fecha de celebración: 02/09/2005
José Miguel Alonso Abalos; Carlos De Alfonso Laguna; Vicente Hernández García; Germán Moltó Martínez. "Proceedings of the Tenth International Conference on Civil, Structural and Environmental Engineering Computing (Civil-Comp 2005)". pp. 1 - 9. Civil-Comp Press, ISSN 1-905088-02-7

85 **Título del trabajo:** Laboratorio virtual
Nombre del congreso: IV Jornadas de Didáctica de la Física, III Encuentro de Investigación
Ciudad de celebración: Valencia, España,
Fecha de celebración: 27/06/2005
José Antonio Gómez Tejedor; Carlos Alberto Barros Vidaurre; Germán Moltó Martínez. "Libro de Resúmenes". pp. 197 - 202. Universidad Politécnica de Valencia, ISSN 84-9705-833-X

86 **Título del trabajo:** Experiences on a Large Scale Grid Deployment with a Computationally Intensive Biomedical Application
Nombre del congreso: 18th IEEE Symposium on Computer-Based Medical Systems (CBMS 2005)
Ciudad de celebración: Dublin, Reino Unido,
Fecha de celebración: 24/06/2005
José Miguel Alonso Abalos; Vicente Hernández García; Germán Moltó Martínez. "Proceedings of CBMS 2005". pp. 567 - 569. IEEE Computer Society, ISSN 0-7695-2355-2

87 **Título del trabajo:** An Object-Oriented View of Grid Computing Technologies to Abstract Remote Task Execution
Nombre del congreso: 13th Euromicro Conference on Parallel, Distributed and Network-based Processing (PDP 2005)
Ciudad de celebración: Lugano, Suiza,
Fecha de celebración: 09/02/2005
José Miguel Alonso Abalos; Vicente Hernández García; Germán Moltó Martínez. "Actas". pp. 235 - 242. IEEE Computer Society, ISSN 0-7695-2280-7

88 **Título del trabajo:** Efecto de la isquemia aguda sobre las curvas de restitución del tejido ventricular
Nombre del congreso: XXII Congreso Anual de la Sociedad Española de Ingeniería Biomédica (CASEIB 2004)
Ciudad de celebración: Santiago de Compostela, España,
Fecha de celebración: 13/11/2004
Lucia Romero Pérez; José María Ferrero De Loma-Osorio; Francisco Javier Saiz Rodríguez; Beatriz Ana Trenor Gomis; Marta María Monserrat Del Río; José Miguel Alonso Abalos; Germán Moltó Martínez; Fulgencio Montilla Meoro. "Libro de actas". pp. 261 - 264. Comité Organizador del CASEIB' 04, ISSN 84-688-9318-8

89 **Título del trabajo:** Empleo de Técnicas Computacionales Avanzadas para la Aceleración de las Simulaciones Cardiacas
Nombre del congreso: XXII Congreso Anual de la Sociedad Española de Ingeniería Biomédica (CASEIB 2004)
Ciudad de celebración: Santiago de Compostela, España,
Fecha de celebración: 13/11/2004
José Miguel Alonso Abalos; José María Ferrero De Loma-Osorio; Vicente Hernández García; Germán Moltó Martínez; Marta María Monserrat Del Río; Francisco Javier Saiz Rodríguez. "Libro de actas". pp. 267 - 270. Comité Organizador del CASEIB' 04, ISSN 84-688-9318-8

90 **Título del trabajo:** Effects of Acute Ischemia on the Restitution Curves of Myocardial Tissue: A Simulation Study
Nombre del congreso: XXXI Computers in Cardiology Conference (CinC)
Ciudad de celebración: Chicago, Estados Unidos,
Fecha de celebración: 19/09/2004
Lucia Romero Pérez; José María Ferrero De Loma-Osorio; Francisco Javier Saiz Rodríguez; Beatriz Ana Trenor Gomis; Marta María Monserrat Del Río; Fulgencio Montilla Meoro; José Miguel Alonso Abalos; Germán Moltó Martínez. "Computers in Cardiology vol.31". pp. 525 - 528. IEEE Press, ISSN 0276-6547

91 **Título del trabajo:** Effects of Pinacidil on Refractoriness in Acutely Ischemic Tissue: Insights from Experiments and Simulations.
Nombre del congreso: XXXI Computers in Cardiology Conference (CinC)
Ciudad de celebración: Chicago, Estados Unidos,
Fecha de celebración: 19/09/2004
Beatriz Ana Trenor Gomis; José María Ferrero De Loma-Osorio; Francisco Javier Saiz Rodríguez; ANGEL FERRERO DE LOMA-OSORIO; F.JAVIER CHORRO GASCÓ; Marta María Monserrat Del Río; Vicente Hernández García; Germán Moltó Martínez. "Computers in Cardiology vol.31". pp. 529 - 532. IEEE Press, ISSN 0276-6547

92 **Título del trabajo:** Computación de Altas Prestaciones sobre Entornos Grid en la Simulación Eléctrica de Tejidos Cardiacos
Nombre del congreso: XV Jornadas de Paralelismo
Ciudad de celebración: Almeria, España,
Fecha de celebración: 17/09/2004
José Miguel Alonso Abalos; José María Ferrero De Loma-Osorio; Vicente Hernández García; Germán Moltó Martínez; Marta María Monserrat Del Río; Francisco Javier Saiz Rodríguez. "Actas de las XV Jornadas de Paralelismo". pp. 271 - 276. Servicio Publicaciones Universidad de Almeria, ISSN 84-8240-714-7

93 **Título del trabajo:** laboratorio Virtual
Nombre del congreso: VI Congreso de Tecnologías Aplicadas a la Enseñanza de la Electrónica (TAEE 2004)
Ciudad de celebración: Valencia, España,
Fecha de celebración: 16/07/2004
Germán Moltó Martínez; José Antonio Gómez Tejedor. "Actas del VI Congreso de tecnologías Aplicadas a la Enseñanza de la Electrónica". pp. 0 - 7. Congreso, ISSN 84-688-7339-X

94 **Título del trabajo:** Three-Dimensional Cardiac Electrical Activity Simulation on Cluster and Grid Platforms
Nombre del congreso: 6th International meeting on High Performance Computing for Computational Science (VECPAR 2004)
Ciudad de celebración: Valencia, España,
Fecha de celebración: 30/06/2004
José Miguel Alonso Abalos; José María Ferrero De Loma-Osorio; Vicente Hernández García; Germán Moltó Martínez; Marta María Monserrat Del Río; Francisco Javier Saiz Rodríguez. "Proceedings of VECPAR' 04". pp. 485 - 498. UPV,

95 **Título del trabajo:** Vulnerability to reentry during the acute phase of myocardial ischemia: a simulation study
Nombre del congreso: XXX Computers in Cardiology Conference (CinC)
Ciudad de celebración: Tesalonica, Grecia,
Fecha de celebración: 21/09/2003
José María Ferrero De Loma-Osorio; Beatriz Ana Trenor Gomis; Fulgencio Montilla Meoro; Francisco Javier Saiz Rodríguez; José Miguel Alonso Abalos; Germán Moltó Martínez. "Computers in Cardiology 2003". pp. 425 - 428. IEEE Press, ISSN 0-7803-8170-X

96 **Título del trabajo:** Simulación de la Actividad Eléctrica Cardíaca: Una Implementación Basada en Computación de Altas Prestaciones
Nombre del congreso: XIV Jornadas de Paralelismo
Ciudad de celebración: Madrid, España,
Fecha de celebración: 17/09/2003

José Miguel Alonso Abalos; José María Ferrero De Loma-Osorio; Vicente Hernández García; Germán Moltó Martínez; Marta María Monserrat Del Río; Francisco Javier Saiz Rodríguez. "Actas de las XIV Jornadas de Paralelismo". pp. 33 - 38. Universidad Carlos III de Madrid, ISSN 84-89315-34-5

97 **Título del trabajo:** Computer Simulation of Action Potential Propagation on Cardiac Tissues: An Efficient and Scalable Parallel Approach
Nombre del congreso: International Conference on Parallel Computing (ParCo)
Ciudad de celebración: Dresden, Alemania,
Fecha de celebración: 05/09/2003
José Miguel Alonso Abalos; José María Ferrero De Loma-Osorio; Vicente Hernández García; Germán Moltó Martínez; Marta María Monserrat Del Río; Francisco Javier Saiz Rodríguez. "Proceedings of PARCO 2003". pp. 339 - 346. Elsevier, ISSN 0-444-51689-1

98 **Título del trabajo:** Generación Automática de Wrappers para el Acceso y Manipulación de datos XML
Nombre del congreso: VI Jornadas Iberoamericanas de Ingenieriía de Requisitos y Ambientes Software (IDEAS)
Ciudad de celebración: Asunción, Paraguay,
Fecha de celebración: 02/05/2003
Germán Moltó Martínez; José Ángel Carsí Cubel. "Actas de las VI Jornadas iberoamericanas de Ingeniería de Requisitos y Ambientes Software". pp. 280 - 285. Mario Piattini, Luca Cernuzzi, Francisco Ruiz, ISSN 84-96023-05-02

99 **Título del trabajo:** High Performance Cardiac Tissue Electrical Activity Simulation on a Parallel Environment
Nombre del congreso: 1st European HealthGrid Conference (HealthGrid 2003)
Ciudad de celebración: Lyon, Francia,
Fecha de celebración: 17/01/2003
José Miguel Alonso Abalos; José María Ferrero De Loma-Osorio; Vicente Hernández García; Germán Moltó Martínez; Marta María Monserrat Del Río; Francisco Javier Saiz Rodríguez. "Proceedings of HealthGrid". pp. 84 - 91. Dr. Sofie Norager,

100 **Título del trabajo:** Laboratorio virtual
Nombre del congreso: I Jornadas de Innovación Educativa: Metodologías Activas y Evaluación
Ciudad de celebración: Valencia, España,
Fecha de celebración: 06/11/2002
José Antonio Gómez Tejedor; José Vicente Manjón Herrera; Jorge Más Estellés; José María Meseguer Dueñas; José Molina Mateo; Germán Moltó Martínez; Juan José Olmos Sanchis; Antonio Pinci Ferrer; Montserrat Robles Viejo. "CD de Ponencias y Comunicaciones". pp. 1 - 9. UPV, ISSN 84-9705-187-4

101 **Título del trabajo:** Laboratorio virtual
Nombre del congreso: I Jornadas de Innovación Educativa: Metodologías Activas y Evaluación
Ciudad de celebración: Valencia, España,
Fecha de celebración: 06/11/2002
José Antonio Gómez Tejedor; Jorge Más Estellés; José María Meseguer Dueñas; José Molina Mateo; Germán Moltó Martínez; Juan José Olmos Sanchis; Antonio Pinci Ferrer; José Vicente Manjón Herrera; Montserrat Robles Viejo. "CD de Ponencias y Comunicaciones". pp. 85 - 85. UPV, ISSN 84-9705-187-4

102 **Título del trabajo:** Laboratorio Virtual
Nombre del congreso: III Jornadas de Didáctica de la Física, II Encuentro de Investigación
Ciudad de celebración: Valencia, España,
Fecha de celebración: 01/07/2002
José Antonio Gómez Tejedor; Germán Moltó Martínez. "Libro de Comunicaciones". pp. 189 - 192. Universidad Politécnica de Valencia, ISSN 84-9705-192-0

Gestión de I+D+i y participación en comités científicos

Comités científicos, técnicos y/o asesores

1 **Título del comité:** Computing and Informatics. Tipo participación: Comité de edición. ISSN: 1335-9150
Fecha de inicio: 2021

2 **Título del comité:** XVI Jornadas de Ciencia e Ingeniería de Servicios (JCIS 2021). Tipo participación: Miembro del comité científico
Fecha de inicio: 2021

3 **Título del comité:** Computing and Informatics. Tipo participación: Comité de edición. ISSN: 1335-9150
Fecha de inicio: 2020

4 **Título del comité:** 11th International Conference on Applied Informatics (ICAI 2020). Tipo participación: Miembro del comité científico
Fecha de inicio: 2020

5 **Título del comité:** Computing and Informatics. Tipo participación: Comité de edición. ISSN: 1335-9150
Fecha de inicio: 2019

6 **Título del comité:** Jornadas de la Sociedad de Ingeniería de Software y Tecnologías de Desarrollo de Software (SISTEDES 2019). Tipo participación: Miembro del comité científico
Fecha de inicio: 2019

7 **Título del comité:** Computing and Informatics. Tipo participación: Comité de edición. ISSN: 1335-9150
Fecha de inicio: 2018

8 **Título del comité:** XIV Jornadas de Ciencia e Ingeniería de Servicios (JCIS 2018). Tipo participación: Miembro del comité científico
Fecha de inicio: 2018

9 **Título del comité:** Computing and Informatics. Tipo participación: Comité de edición. ISSN: 1335-9150
Fecha de inicio: 2017

10 **Título del comité:** XXIII Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2017). Tipo participación: Miembro del comité científico
Fecha de inicio: 2017

11 **Título del comité:** Computing and Informatics. Tipo participación: Editor adjunto. ISSN: 1335-9150
Fecha de inicio: 2016

12 **Título del comité:** Congreso Nacional de Innovación Educativa y Docencia en Red = Congrés Nacional d'Innovació Educativa i Docència en Xarxa (IN-RED 2016). Tipo participación: Miembro del comité científico
Fecha de inicio: 2016

13 **Título del comité:** Computing and Informatics. Tipo participación: Editor adjunto. ISSN: 1335-9150
Fecha de inicio: 2015

14 **Título del comité:** Congreso Nacional de Innovación Educativa y Docencia en Red = Congrés Nacional d'Innovació Educativa i Docència en Xarxa (IN-RED 2015). Tipo participación: Miembro del comité científico
Fecha de inicio: 2015

15 **Título del comité:** 8th Iberian Grid Infrastructure Conference (IBERGRID 2014). Tipo participación: Miembro del comité científico
Fecha de inicio: 2014

Otros méritos

Consejos editoriales

1 **Nombre del Consejo editorial:** Computing and Informatics
Entidad de afiliación: AEPress
Categoría profesional: Comité de edición
Fecha de inicio: 2021 **Duración:** 12 meses

2 **Nombre del Consejo editorial:** Computing and Informatics
Entidad de afiliación: AEPress
Categoría profesional: Comité de edición
Fecha de inicio: 2020 **Duración:** 12 meses

3 **Nombre del Consejo editorial:** Computing and Informatics
Entidad de afiliación: AEPress
Categoría profesional: Comité de edición
Fecha de inicio: 2019 **Duración:** 12 meses

4 **Nombre del Consejo editorial:** Computing and Informatics
Entidad de afiliación: AEPress
Categoría profesional: Comité de edición
Fecha de inicio: 2018 **Duración:** 12 meses

5 **Nombre del Consejo editorial:** Computing and Informatics
Entidad de afiliación: AEPress
Categoría profesional: Comité de edición
Fecha de inicio: 2017 **Duración:** 12 meses

6 **Nombre del Consejo editorial:** Computing and Informatics
Entidad de afiliación: AEPress
Categoría profesional: Editor adjunto
Fecha de inicio: 2016 **Duración:** 12 meses

7 **Nombre del Consejo editorial:** Computing and Informatics
Entidad de afiliación: AEPress
Categoría profesional: Editor adjunto

Fecha de inicio: 2014 **Duración:** 12 meses

Premios, menciones y distinciones

1 **Descripción:** Best Paper Award - ISECON 2015
Entidad concesionaria: Foundation for IT Education
Fecha de concesión: 05/11/2015

2 **Descripción:** Best Student Paper Award
Entidad concesionaria: Program Chair of VECPAR'04
Fecha de concesión: 30/06/2004

Períodos de actividad investigadora

Nº de tramos reconocidos: 3
Entidad acreditante: Comisión Nacional Evaluadora de la Actividad Investigadora (CNEAI)

Acreditaciones/reconocimientos obtenidos

1 **Descripción:** Catedrático/a de Universidad en Ingeniería y Arquitectura
Entidad acreditante: Agencia Nacional de Evaluación de la Calidad y Acreditación
Fecha de obtención: 13/07/2021

2 **Descripción:** Quinquenios
Nº de tramos reconocidos: 3

Capítulo 4

Certificados Institucionales

4.1. Certificado de Méritos Docentes

La Universitat Politècnica de València,

HACE CONSTAR

Que la información contenida en el presente certificado de D./Dª Germán Moltó Martínez con DNI 52656437, adscrito/a al Dpto. de Sistemas Informáticos y Computación y área de conocimiento Ciencias De La Computacion E Inteligencia Artificial, ha sido obtenida de las bases de datos institucionales de la universidad

ACTIVIDAD DOCENTE O PROFESIONAL

DEDICACIÓN DOCENTE

Puestos Docentes Ocupados

Curso académico/ cuatrimestre	Cat. Profes.	Asignatura	Responsable	Titulación	Curso de la titul.	Teoría/ Práctica; Idiomas	Horas tot. impartidas por el interesado	Horas tot. impartidas por curso/ cuat.
2004 / B	Ayudante	Computación Numérica (5551)		I.T. Informática de Gestión / I.T. Informática de Sistemas	1 / 1	Práctica-PL	40	40
2004 / T	Ayudante	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Práctica-PL	15	15
2005 / T	Ayudante	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Teoría-TA	60	110
	Ayudante	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Práctica-PA	30	
	Ayudante	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Práctica-PL	20	
2006 / T	Ayudante	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Teoría-TA	60	108,9
	Ayudante	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Práctica-PA	30	
	Ayudante	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Práctica-PL	18,9	

Puestos Docentes Ocupados

Curso académico/ cuatrimestre	Cat. Profes.	Asignatura	Responsable	Titulación	Curso de la titul.	Teoría/ Práctica; Idiomas	Horas tot. impartidas por el interesado	Horas tot. impartidas por curso/ cuat.
2007 / T	Profesor/a Ayudante Doctor	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Teoría-TA	60	109,8
	Profesor/a Ayudante Doctor	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Práctica-PA	30	
	Profesor/a Ayudante Doctor	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Práctica-PL	19,8	
2008 / T	Profesor/a Ayudante Doctor	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Teoría-TA	60	180
	Profesor/a Ayudante Doctor	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Práctica-PA	30	
	Profesor/a Ayudante Doctor	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Práctica-PL	90	
2009 / T	Profesor/a Contratado/a Doctor	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Teoría-TA	120	210
	Profesor/a Contratado/a Doctor	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Práctica-PA	60	
	Profesor/a Contratado/a Doctor	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Práctica-PL	30	
2010 / A	Profesor/a Contratado/a Doctor	Introducción a la Informática y a la Programación (11541)		Grado en Ingeniería Informática	1	Teoría-TA	15	45
	Profesor/a Contratado/a Doctor	Introducción a la Informática y a la Programación (11541)		Grado en Ingeniería Informática	1	Teoría-TS	30	

Puestos Docentes Ocupados

Curso académico/ cuatrimestre	Cat. Profes.	Asignatura	Responsable	Titulación	Curso de la titul.	Teoría/ Práctica; Idiomas	Horas tot. impartidas por el interesado	Horas tot. impartidas por curso/ cuat.
2010 / T	Profesor/a Contratado/a Doctor	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Teoría-TA	60	150
	Profesor/a Contratado/a Doctor	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Práctica-PA	30	
	Profesor/a Contratado/a Doctor	Estructura de Datos y Algoritmos (5659)		I.T. Informática de Gestión / I.T. Informática de Sistemas	2 / 2	Práctica-PL	60	
2011 / A	Profesor/a Titular de Universidad	Introducción a la Informática y a la Programación (11541)		Grado en Ingeniería Informática	1	Teoría-TA	15	81
	Profesor/a Titular de Universidad	Introducción a la Informática y a la Programación (11541)		Grado en Ingeniería Informática	1	Teoría-TS	30	
	Profesor/a Titular de Universidad	Introducción a la Informática y a la Programación (11541)		Grado en Ingeniería Informática	1	Práctica-PL	30	
	Profesor/a Titular de Universidad	Conceptos de la Computación en Grid (30599)		Programa De Doctorado En Informática / Máster Universitario en Computación Paralela y Distribuida	1 / 1	Teoría-TA	2,5	
	Profesor/a Titular de Universidad	Conceptos de la Computación en Grid (30599)		Programa De Doctorado En Informática / Máster Universitario en Computación Paralela y Distribuida	1 / 1	Práctica-PL	3,5	
2011 / B	Profesor/a Titular de Universidad	Programación (11543)		Grado en Ingeniería Informática	1	Teoría-TA	15	82,5
	Profesor/a Titular de Universidad	Programación (11543)		Grado en Ingeniería Informática	1	Teoría-TS	30	
	Profesor/a Titular de Universidad	Programación (11543)		Grado en Ingeniería Informática	1	Práctica-PL	37,5	

Puestos Docentes Ocupados

Curso académico/ cuatrimestre	Cat. Profes.	Asignatura	Responsable	Titulación	Curso de la titul.	Teoría/ Práctica; Idiomas	Horas tot. impartidas por el interesado	Horas tot. impartidas por curso/ cuat.
2012 / A	Profesor/a Titular de Universidad	Introducción a la Informática y a la Programación (11541)		Grado en Ingeniería Informática	1	Teoría-TA	15	71
	Profesor/a Titular de Universidad	Introducción a la Informática y a la Programación (11541)		Grado en Ingeniería Informática	1	Teoría-TS	30	
	Profesor/a Titular de Universidad	Introducción a la Informática y a la Programación (11541)		Grado en Ingeniería Informática	1	Práctica-PL	15	
	Profesor/a Titular de Universidad	Conceptos de la Computación en Grid (30599)		Máster Universitario en Computación Paralela y Distribuida	1	Teoría-TA	11	
2012 / B	Profesor/a Titular de Universidad	Programación (11543)		Grado en Ingeniería Informática	1	Teoría-TA	15	45,75
	Profesor/a Titular de Universidad	Programación (11543)		Grado en Ingeniería Informática	1	Teoría-TS	30	
	Profesor/a Titular de Universidad	Aplicaciones Avanzadas de Grid (31908)		Máster Universitario en Computación Paralela y Distribuida	1	Práctica-PL	,75	
2013 / A	Profesor/a Titular de Universidad	Introducción a la Informática y a la Programación (11541)		Grado en Ingeniería Informática	1	Teoría-TA	15	75
	Profesor/a Titular de Universidad	Introducción a la Informática y a la Programación (11541)		Grado en Ingeniería Informática	1	Teoría-TS	30	
	Profesor/a Titular de Universidad	Infraestructuras Avanzadas en Cloud (Iac) (33014)	R	Máster Universitario en Computación Paralela y Distribuida	1	Teoría-TA	12	
	Profesor/a Titular de Universidad	Infraestructuras Avanzadas en Cloud (Iac) (33014)	R	Máster Universitario en Computación Paralela y Distribuida	1	Práctica-PL	18	

Puestos Docentes Ocupados

Curso académico/ cuatrimestre	Cat. Profes.	Asignatura	Responsable	Titulación	Curso de la titul.	Teoría/ Práctica; Idiomas	Horas tot. impartidas por el interesado	Horas tot. impartidas por curso/ cuat.
2013 / B	Profesor/a Titular de Universidad	Programación (11543)		Grado en Ingeniería Informática	1	Teoría-TA	15	65
	Profesor/a Titular de Universidad	Programación (11543)		Grado en Ingeniería Informática	1	Teoría-TS	30	
	Profesor/a Titular de Universidad	Modelos de Programación en Cloud (Mpc) (33002)	R	Máster Universitario en Computación Paralela y Distribuida	1	Teoría-TA	5	
	Profesor/a Titular de Universidad	Modelos de Programación en Cloud (Mpc) (33002)	R	Máster Universitario en Computación Paralela y Distribuida	1	Práctica-PL	15	
2014 / A	Profesor/a Titular de Universidad	Introducción a la informática y a la programación (11541)		Grado en Ingeniería Informática	1	Teoría-TA	15	75
	Profesor/a Titular de Universidad	Introducción a la informática y a la programación (11541)		Grado en Ingeniería Informática	1	Teoría-TS	30	
	Profesor/a Titular de Universidad	Infraestructuras Avanzadas en Cloud (Iac) (33014)	R	Máster Universitario en Computación Paralela y Distribuida	1	Teoría-TA	12	
	Profesor/a Titular de Universidad	Infraestructuras Avanzadas en Cloud (Iac) (33014)	R	Máster Universitario en Computación Paralela y Distribuida	1	Práctica-PL	18	

Puestos Docentes Ocupados

Curso académico/ cuatrimestre	Cat. Profes.	Asignatura	Responsable	Titulación	Curso de la titul.	Teoría/ Práctica; Idiomas	Horas tot. impartidas por el interesado	Horas tot. impartidas por curso/ cuat.
2014 / B	Profesor/a Titular de Universidad	Programación (11543)		Grado en Ingeniería Informática	1	Teoría-TA	15	65
	Profesor/a Titular de Universidad	Programación (11543)		Grado en Ingeniería Informática	1	Teoría-TS	30	
	Profesor/a Titular de Universidad	Modelos de Programación en Cloud (Mpc) (33002)	R	Máster Universitario en Computación Paralela y Distribuida	1	Teoría-TA	2,5	
	Profesor/a Titular de Universidad	Modelos de Programación en Cloud (Mpc) (33002)	R	Máster Universitario en Computación Paralela y Distribuida	1	Práctica-PL	2,5	
	Profesor/a Titular de Universidad	Servicios en la nube (34016)		Máster Universitario en Gestión de la Información	1	Práctica-PL	15	
2015 / A	Profesor/a Titular de Universidad	Infraestructuras Avanzadas en Cloud (Iac) (33014)	R	Programa de Doctorado en Informática / Máster Universitario en Computación Paralela y Distribuida	1 / 1	Teoría-TA; C	12	30
	Profesor/a Titular de Universidad	Infraestructuras Avanzadas en Cloud (Iac) (33014)	R	Programa de Doctorado en Informática / Máster Universitario en Computación Paralela y Distribuida	1 / 1	Práctica-PL; C	18	

Puestos Docentes Ocupados

Curso académico/ cuatrimestre	Cat. Profes.	Asignatura	Responsable	Titulación	Curso de la titul.	Teoría/ Práctica; Idiomas	Horas tot. impartidas por el interesado	Horas tot. impartidas por curso/ cuat.
2015 / B	Profesor/a Titular de Universidad	Programación (11543)		Grado en Ingeniería Informática	1	Teoría-TA; C	15	80
	Profesor/a Titular de Universidad	Programación (11543)		Grado en Ingeniería Informática	1	Teoría-TS; C	30	
	Profesor/a Titular de Universidad	Modelos de Programación en Cloud (Mpc) (33002)	R	Programa de Doctorado en Informática / Máster Universitario en Computación Paralela y Distribuida	1 / 1	Teoría-TA; C	2,5	
	Profesor/a Titular de Universidad	Modelos de Programación en Cloud (Mpc) (33002)	R	Programa de Doctorado en Informática / Máster Universitario en Computación Paralela y Distribuida	1 / 1	Práctica-PL; C	2,5	
	Profesor/a Titular de Universidad	Servicios en la nube (34016)		Máster Universitario en Gestión de la Información	1	Teoría-TA; C	7,5	
	Profesor/a Titular de Universidad	Servicios en la nube (34016)		Máster Universitario en Gestión de la Información	1	Teoría-TS; C	7,5	
	Profesor/a Titular de Universidad	Servicios en la nube (34016)		Máster Universitario en Gestión de la Información	1	Práctica-PL; C	15	
2016 / A	Profesor/a Titular de Universidad	Infraestructuras Avanzadas en Cloud (Iac) (33014)	R	Máster Universitario en Computación Paralela y Distribuida	1	Teoría-TA; C	12	30
	Profesor/a Titular de Universidad	Infraestructuras Avanzadas en Cloud (Iac) (33014)	R	Máster Universitario en Computación Paralela y Distribuida	1	Práctica-PL; C	18	

Puestos Docentes Ocupados

Curso académico/ cuatrimestre	Cat. Profes.	Asignatura	Responsable	Titulación	Curso de la titul.	Teoría/ Práctica; Idiomas	Horas tot. impartidas por el interesado	Horas tot. impartidas por curso/ cuat.
2016 / B	Profesor/a Titular de Universidad	Programación (11543)		Grado en Ingeniería Informática / Doble Titulación. Grado en Ingeniería Informática y Grado en Administración y Dirección de Empresas	1 / 1	Práctica-PL; C	15	70
	Profesor/a Titular de Universidad	Modelos de Programación en Cloud (Mpc) (33002)	R	Máster Universitario en Computación Paralela y Distribuida	1	Teoría-TA; C	5	
	Profesor/a Titular de Universidad	Modelos de Programación en Cloud (Mpc) (33002)	R	Máster Universitario en Computación Paralela y Distribuida	1	Práctica-PL; C	15	
	Profesor/a Titular de Universidad	Servicios en la nube (34016)		Máster Universitario en Gestión de la Información	1	Teoría-TA; C	10	
	Profesor/a Titular de Universidad	Servicios en la nube (34016)		Máster Universitario en Gestión de la Información	1	Teoría-TS; C	10	
	Profesor/a Titular de Universidad	Servicios en la nube (34016)		Máster Universitario en Gestión de la Información	1	Práctica-PL; C	15	
2017 / A	Profesor/a Titular de Universidad	Plataformas de Gestión de Contenedores (Pgc) (33013)		Programa de Doctorado en Informática / Máster Universitario en Computación Paralela y Distribuida	1 / 1	Práctica-PL; C	18	48
	Profesor/a Titular de Universidad	Infraestructuras de Cloud Público (Icp) (33014)	R	Programa de Doctorado en Informática / Máster Universitario en Computación Paralela y Distribuida	1 / 1	Teoría-TA; C	12	
	Profesor/a Titular de Universidad	Infraestructuras de Cloud Público (Icp) (33014)	R	Programa de Doctorado en Informática / Máster Universitario en Computación Paralela y Distribuida	1 / 1	Práctica-PL; C	18	

Puestos Docentes Ocupados

Curso académico/ cuatrimestre	Cat. Profes.	Asignatura	Responsable	Titulación	Curso de la titul.	Teoría/ Práctica; Idiomas	Horas tot. impartidas por el interesado	Horas tot. impartidas por curso/ cuat.
2017 / B	Profesor/a Titular de Universidad	Despliegue y Configuración Automatizada Mediante Devops (Dca) (33001)	R	Programa de Doctorado en Informática / Máster Universitario en Computación Paralela y Distribuida	1 / 1	Teoría-TA; C	5	85
	Profesor/a Titular de Universidad	Despliegue y Configuración Automatizada Mediante Devops (Dca) (33001)	R	Programa de Doctorado en Informática / Máster Universitario en Computación Paralela y Distribuida	1 / 1	Práctica-PL; C	15	
	Profesor/a Titular de Universidad	Estrategias y Herramientas de Computación Big Data en la Nube (Cbd) (33002)	R	Programa de Doctorado en Informática / Máster Universitario en Computación Paralela y Distribuida	1 / 1	Teoría-TA; C	5	
	Profesor/a Titular de Universidad	Estrategias y Herramientas de Computación Big Data en la Nube (Cbd) (33002)	R	Programa de Doctorado en Informática / Máster Universitario en Computación Paralela y Distribuida	1 / 1	Práctica-PL; C	15	
	Profesor/a Titular de Universidad	Servicios en la nube (34016)	R	Máster Universitario en Gestión de la Información	1	Teoría-TA; C	15	
	Profesor/a Titular de Universidad	Servicios en la nube (34016)	R	Máster Universitario en Gestión de la Información	1	Teoría-TS; C	15	
	Profesor/a Titular de Universidad	Servicios en la nube (34016)	R	Máster Universitario en Gestión de la Información	1	Práctica-PL; C	15	
2018 / A	Profesor/a Titular de Universidad	Infraestructuras de cloud público (ICP) (34576)	R	Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing	1	Teoría-TA; C	20	40
	Profesor/a Titular de Universidad	Infraestructuras de cloud público (ICP) (34576)	R	Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing	1	Práctica-PL; C	20	

Puestos Docentes Ocupados

Curso académico/ cuatrimestre	Cat. Profes.	Asignatura	Responsable	Titulación	Curso de la titul.	Teoría/ Práctica; Idiomas	Horas tot. impartidas por el interesado	Horas tot. impartidas por curso/ cuat.
2018 / B	Profesor/a Titular de Universidad	Servicios en la nube (34016)	R	Máster Universitario en Gestión de la Información	1	Teoría-TA; C	15	65
	Profesor/a Titular de Universidad	Servicios en la nube (34016)	R	Máster Universitario en Gestión de la Información	1	Teoría-TS; C	15	
	Profesor/a Titular de Universidad	Servicios en la nube (34016)	R	Máster Universitario en Gestión de la Información	1	Práctica-PL; C	15	
	Profesor/a Titular de Universidad	Estrategias y herramientas de computación big data en la nube (CBD) (34564)	R	Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing	1	Teoría-TA; C	10	
	Profesor/a Titular de Universidad	Estrategias y herramientas de computación big data en la nube (CBD) (34564)	R	Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing	1	Práctica-PL; C	10	
2019 / A	Profesor/a Titular de Universidad	Lenguajes y entornos de programación paralela (11575)		Grado en Ingeniería Informática	4	Teoría-TA; C	7,5	70
	Profesor/a Titular de Universidad	Lenguajes y entornos de programación paralela (11575)		Grado en Ingeniería Informática	4	Teoría-TS; C	7,5	
	Profesor/a Titular de Universidad	Lenguajes y entornos de programación paralela (11575)		Grado en Ingeniería Informática	4	Práctica-PL; C	15	
	Profesor/a Titular de Universidad	Infraestructuras de cloud público (ICP) (34576)	R	Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing	1	Teoría-TA; C	20	
	Profesor/a Titular de Universidad	Infraestructuras de cloud público (ICP) (34576)	R	Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing	1	Práctica-PL; C	20	

Puestos Docentes Ocupados

Curso académico/ cuatrimestre	Cat. Profes.	Asignatura	Responsable	Titulación	Curso de la titul.	Teoría/ Práctica; Idiomas	Horas tot. impartidas por el interesado	Horas tot. impartidas por curso/ cuat.
2019 / B	Profesor/a Titular de Universidad	Servicios en la nube (34016)	R	Máster Universitario en Gestión de la Información	1	Teoría-TA; C	15	45
	Profesor/a Titular de Universidad	Servicios en la nube (34016)	R	Máster Universitario en Gestión de la Información	1	Teoría-TS; C	15	
	Profesor/a Titular de Universidad	Servicios en la nube (34016)	R	Máster Universitario en Gestión de la Información	1	Práctica-PL; C	15	
2020 / A	Profesor/a Titular de Universidad	Lenguajes y entornos de programación paralela (11575)		Grado en Ingeniería Informática	4	Teoría-TA; C	3,75	81,4
	Profesor/a Titular de Universidad	Lenguajes y entornos de programación paralela (11575)		Grado en Ingeniería Informática	4	Teoría-TS; C	3,75	
	Profesor/a Titular de Universidad	Lenguajes y entornos de programación paralela (11575)		Grado en Ingeniería Informática	4	Práctica-PL; C	7,5	
	Profesor/a Titular de Universidad	Infraestructura para el procesamiento de datos (14016)		Grado en Ciencia de Datos	3	Teoría-TA; C	3,8	
	Profesor/a Titular de Universidad	Infraestructura para el procesamiento de datos (14016)		Grado en Ciencia de Datos	3	Teoría-TS; C	15	
	Profesor/a Titular de Universidad	Infraestructura para el procesamiento de datos (14016)		Grado en Ciencia de Datos	3	Práctica-PL; C	7,6	
	Profesor/a Titular de Universidad	Infraestructuras de cloud público (ICP) (34576)	R	Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing	1	Teoría-TA; C	20	
	Profesor/a Titular de Universidad	Infraestructuras de cloud público (ICP) (34576)	R	Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing	1	Práctica-PL; C	20	

Puestos Docentes Ocupados

Curso académico/ cuatrimestre	Cat. Profes.	Asignatura	Responsable	Titulación	Curso de la titul.	Teoría/ Práctica; Idiomas	Horas tot. impartidas por el interesado	Horas tot. impartidas por curso/ cuat.
2020 / B	Profesor/a Titular de Universidad	Servicios en la nube (34016)	R	Máster Universitario en Gestión de la Información	1	Teoría-TA; C	15	65
	Profesor/a Titular de Universidad	Servicios en la nube (34016)	R	Máster Universitario en Gestión de la Información	1	Teoría-TS; C	15	
	Profesor/a Titular de Universidad	Servicios en la nube (34016)	R	Máster Universitario en Gestión de la Información	1	Práctica-PL; C	15	
	Profesor/a Titular de Universidad	Estrategias y herramientas de computación big data en la nube (CBD) (34564)	R	Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing	1	Teoría-TA; C	10	
	Profesor/a Titular de Universidad	Estrategias y herramientas de computación big data en la nube (CBD) (34564)	R	Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing	1	Práctica-PL; C	10	
2020 / T	Profesor/a Titular de Universidad	Desarrollo y despliegue seguro (34877)		Máster Universitario en Ciberseguridad y Ciberinteligencia	1	Teoría-TA; C	10	30
	Profesor/a Titular de Universidad	Desarrollo y despliegue seguro (34877)		Máster Universitario en Ciberseguridad y Ciberinteligencia	1	Teoría-TS; C	10	
	Profesor/a Titular de Universidad	Desarrollo y despliegue seguro (34877)		Máster Universitario en Ciberseguridad y Ciberinteligencia	1	Práctica-PL; C	10	

Puestos Docentes Ocupados

Curso académico/ cuatrimestre	Cat. Profes.	Asignatura	Responsable	Titulación	Curso de la titul.	Teoría/ Práctica; Idiomas	Horas tot. impartidas por el interesado	Horas tot. impartidas por curso/ cuat.
2021 / A	Profesor/a Titular de Universidad	Lenguajes y entornos de programación paralela (11575)		Grado en Ingeniería Informática	4	Teoría-TA; C	7,5	96,4
	Profesor/a Titular de Universidad	Lenguajes y entornos de programación paralela (11575)		Grado en Ingeniería Informática	4	Teoría-TS; C	7,5	
	Profesor/a Titular de Universidad	Lenguajes y entornos de programación paralela (11575)		Grado en Ingeniería Informática	4	Práctica-PL; C	15	
	Profesor/a Titular de Universidad	Infraestructura para el procesamiento de datos (14016)		Grado en Ciencia de Datos	3	Teoría-TA; C	3,8	
	Profesor/a Titular de Universidad	Infraestructura para el procesamiento de datos (14016)		Grado en Ciencia de Datos	3	Teoría-TS; C	15	
	Profesor/a Titular de Universidad	Infraestructura para el procesamiento de datos (14016)		Grado en Ciencia de Datos	3	Práctica-PL; C	7,6	
	Profesor/a Titular de Universidad	Infraestructuras de cloud público (ICP) (34576)	R	Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing	1	Teoría-TA; C	20	
	Profesor/a Titular de Universidad	Infraestructuras de cloud público (ICP) (34576)	R	Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing	1	Práctica-PL; C	20	
2021 / B	Profesor/a Titular de Universidad	Estrategias y herramientas de computación big data en la nube (CBD) (34564)	R	Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing	1	Teoría-TA; C	10	20
	Profesor/a Titular de Universidad	Estrategias y herramientas de computación big data en la nube (CBD) (34564)	R	Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing	1	Práctica-PL; C	10	

Puestos Docentes Ocupados

Curso académico/ cuatrimestre	Cat. Profes.	Asignatura	Responsable	Titulación	Curso de la titul.	Teoría/ Práctica; Idiomas	Horas tot. impartidas por el interesado	Horas tot. impartidas por curso/ cuat.
2021 / T	Profesor/a Titular de Universidad	Desarrollo y despliegue seguro (34877)		Máster Universitario en Ciberseguridad y Ciberinteligencia	1	Teoría-TA; C	10	30
	Profesor/a Titular de Universidad	Desarrollo y despliegue seguro (34877)		Máster Universitario en Ciberseguridad y Ciberinteligencia	1	Teoría-TS; C	10	
	Profesor/a Titular de Universidad	Desarrollo y despliegue seguro (34877)		Máster Universitario en Ciberseguridad y Ciberinteligencia	1	Práctica-PL; C	10	
2022 / A	Profesor/a Titular de Universidad	Lenguajes y entornos de programación paralela (11575)		Grado en Ingeniería Informática	4	Teoría-TA; C	7,5	81,4
	Profesor/a Titular de Universidad	Lenguajes y entornos de programación paralela (11575)		Grado en Ingeniería Informática	4	Teoría-TS; C	7,5	
	Profesor/a Titular de Universidad	Lenguajes y entornos de programación paralela (11575)		Grado en Ingeniería Informática	4	Práctica-PL; C	7,5	
	Profesor/a Titular de Universidad	Infraestructura para el procesamiento de datos (14016)		Grado en Ciencia de Datos	3	Teoría-TA; C	3,8	
	Profesor/a Titular de Universidad	Infraestructura para el procesamiento de datos (14016)		Grado en Ciencia de Datos	3	Teoría-TS; C	7,5	
	Profesor/a Titular de Universidad	Infraestructura para el procesamiento de datos (14016)		Grado en Ciencia de Datos	3	Práctica-PL; C	7,6	
	Profesor/a Titular de Universidad	Infraestructuras de cloud público (ICP) (34576)	R	Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing	1	Teoría-TA; C	20	
	Profesor/a Titular de Universidad	Infraestructuras de cloud público (ICP) (34576)	R	Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing	1	Práctica-PL; C	20	

Puestos Docentes Ocupados

Curso académico/ cuatrimestre	Cat. Profes.	Asignatura	Responsable	Titulación	Curso de la titul.	Teoría/ Práctica; Idiomas	Horas tot. impartidas por el interesado	Horas tot. impartidas por curso/ cuat.
2022 / B	Profesor/a Titular de Universidad	Estrategias y herramientas de computación big data en la nube (CBD) (34564)	R	Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing	1	Teoría-TA; C	10	20
	Profesor/a Titular de Universidad	Estrategias y herramientas de computación big data en la nube (CBD) (34564)	R	Máster Universitario en Computación en la Nube y de Altas Prestaciones / Cloud and High-Performance Computing	1	Práctica-PL; C	10	
2022 / T	Profesor/a Titular de Universidad	Desarrollo y despliegue seguro (34877)		Máster Universitario en Ciberseguridad y Ciberinteligencia	1	Teoría-TA; C	10	30
	Profesor/a Titular de Universidad	Desarrollo y despliegue seguro (34877)		Máster Universitario en Ciberseguridad y Ciberinteligencia	1	Teoría-TS; C	10	
	Profesor/a Titular de Universidad	Desarrollo y despliegue seguro (34877)		Máster Universitario en Ciberseguridad y Ciberinteligencia	1	Práctica-PL; C	10	

Codificación
R: Responsable de Asignatura

Clasificación Teoría/Práctica:
- **Teoría- TA: Teoría de aula**
- **Teoría- TS: Teoría de seminario**
- **Práctica- PA: Prácticas de aula**
- **Práctica- PL: Prácticas de laboratorio**

Idiomas: C castellano, V valenciano, I inglés, O otros

Tesis Doctorales Dirigidas

Curso	Título	Premio Extraord.	Mención Internac.	Mención Europea	Fecha
2021-2022	Plataformes avançades en el Núvol per a la reproductibilitat d'experiments computacionals	No	No	No	03/06/2022

Alumno: Giménez Alventosa, Vicent
Calif.: SOBRESALIENTE
Director/es: Germán Moltó Martínez
José Damián Segrelles Quilis

Tesis Doctorales Dirigidas

Curso	Título	Premio Extraord.	Mención Internac.	Mención Europea	Fecha
2020-2021	Serverless Computing Strategies on Cloud Platforms **Alumno:** Naranjo Delgado, Diana María **Calif.:** SOBRESALIENTE (cum laude) **Director/es:** Ignacio Blanquer Espert Germán Moltó Martínez	No	Sí	No	07/01/2021
2019-2020	Optimización de arquitecturas distribuidas para el procesado de datos masivos **Alumno:** Herrera Hernández, José **Calif.:** SOBRESALIENTE (cum laude) **Director/es:** Germán Moltó Martínez	No	No	No	17/07/2020
2019-2020	Advanced Elastic Platforms for High Throughput Computing on Container-based and Serverless Infrastructures **Alumno:** Pérez González, Alfonso María **Calif.:** SOBRESALIENTE (cum laude) **Director/es:** Germán Moltó Martínez	No	No	No	15/05/2020
2016-2017	High Performance Scientific Computing over Hybrid Cloud Platforms **Alumno:** Calatrava Arroyo, Amanda **Calif.:** SOBRESALIENTE (cum laude) **Director/es:** Germán Moltó Martínez	No	No	No	11/11/2016
2015-2016	Efficient and elastic management of computing infrastructures **Alumno:** Alfonso Laguna, Carlos de **Calif.:** SOBRESALIENTE (cum laude) **Director/es:** Ignacio Blanquer Espert Germán Moltó Martínez	No	No	No	23/10/2015
2013-2014	Gestión de infraestructuras virtuales configuradas dinámicamente **Alumno:** Caballer Fernández, Miguel **Calif.:** SOBRESALIENTE (cum laude) **Director/es:** Germán Moltó Martínez Ignacio Blanquer Espert	Sí	No	No	25/04/2014
2013-2014	SLA-Driven Cloud Computing Domain Representation and Management **Alumno:** García García, Andrés **Calif.:** SOBRESALIENTE **Director/es:** Ignacio Blanquer Espert Germán Moltó Martínez	No	Sí	No	07/03/2014

Dirección de PFCs

Curso	Título	Fecha	NºCodir's
2020-2021	Entorno con integración continua para aplicaciones web desarrolladas	20/07/21	2

Dirección de PFCs

Curso	Título	Fecha	NºCodir's
	con AngularJS **Alumno:** FUSTER JUST, FRANCISCO **Calif.:** Aprobado		
2020-2021	Recopilación Automatizada de Analíticas de Aprendizaje Mediante Herramientas Informáticas **Alumno:** HERRERO CABO, CARLOS **Calif.:** Aprobado	11/01/21	1
2019-2020	Diseño de una Infraestructura Informática de Virtualización **Alumno:** VILA CASTELLO, ADRIAN **Calif.:** Notable	16/09/20	1
2018-2019	Val&Go: Aplicación de Movilidad Urbana para Valencia **Alumno:** GALLARDO MOSTEO, PABLO **Calif.:** Sobresaliente	19/09/19	1
2018-2019	Implementación de un chatbot mediante una arquitectura serverless **Alumno:** SOLE FONTE, MARC **Calif.:** Matric. Honor	09/07/19	1
2018-2019	Evaluación del escalamiento de un sistema en la nube con cargas realistas y ajuste del umbral de escalamiento **Alumno:** CERVIERI CARRAU, VALENTIN VICENTE **Calif.:** Aprobado	23/05/19	2
2017-2018	Portal Web de Analíticas de Uso para Cuentas Compartidas en AWS **Alumno:** PRIETO FONTCUBERTA, JOSE RAMON **Calif.:** Sobresaliente	12/07/18	1
2016-2017	Desarrollo de una Interfaz REST para una Herramienta de Despliegue de Clusters Virtuales en la Nube **Alumno:** TELLO BENEYTO, ABEL **Calif.:** Aprobado	17/01/17	1
2015-2016	Rivence: Aplicación móvil de servicios al ciudadano **Alumno:** QUINZA PEREZ, CARLOS **Calif.:** Notable	14/07/16	1
2014-2015	DESARROLLO DE UNA APLICACIÓN WEB PARA GESTIONAR LOS ARCHIVOS DE DROPBOX ENTRE VARIOS USUARIOS **Alumno:** GUAN, CHENG CHENG **Calif.:** Notable	30/09/15	2
2014-2015	Desarrollo de una aplicación web modular autogestionable **Alumno:** PERIS PEREZ, SERGIO **Calif.:** Notable	10/09/15	1
2014-2015	Desarrollo de una aplicación para gestión de productos farmacéuticos **Alumno:** FARINOS MOLINA, JAVIER **Calif.:** Notable	16/07/15	1
2013-2014	DESARROLLO DE UNA APLICACIÓN WEB ORIENTADA A FACILITAR SERVICIOS DOMÉSTICOS-AYUDA2.ES **Alumno:** PUCHADES MARTINEZ, JOSE **Calif.:** Sobresaliente	25/04/14	1
2013-2014	Sistema de iluminación animada en un cubo de LEDS **Alumno:** MORA MORCILLO, ANDRES **Calif.:** Notable	06/02/14	1
2013-2014	Sistema de iluminación animada en un cubo de LEDS	06/02/14	1

Dirección de PFCs

Curso	Título	Fecha	NºCodir's
	Alumno: SANCHEZ CHAMORRO, JEFFERSON DAVID **Calif.:** Notable		
2012-2013	AGRILUK 2.0 EL BUSCADOR DE LA AGRICULTURA **Alumno:** MANRIQUE DOMINGO, DANIEL **Calif.:** Sobresaliente	30/09/13	1
2012-2013	Agriluk 2.0 el buscador de la agricultura **Alumno:** BLAZQUEZ CALDERON, ADRIAN **Calif.:** Sobresaliente	30/09/13	1
2012-2013	DISEÑO E IMPLEMENTACIÓN CON TECNOLOGÍAS JSF Y JPA DE UNA WEB PARA UN GRUPO DE INVESTIGACIÓN EN BIOTECNOLOGÍA **Alumno:** GARCIA-MIGUEL PEREZ-LUENGO, CARLOS **Calif.:** Sobresaliente	13/06/13	2
2012-2013	PUBLICACIÓN DE ESCRITORIOS Y APLICACIONES EN REMOTO EN UN ENTORNO DE VIRTUALIZACIÓN **Alumno:** SANMARTIN GALIPIENSO, GONZALO AGUSTIN **Calif.:** Sobresaliente **Premio:** Premio Bancaja	02/05/13	2
2011-2012	Migración de un Catálogo y Repositorio de Imágenes de Maquinas Virtuales a Java/Hibernate **Alumno:** GARCIA VILLALOBOS, ANGEL LUIS **Calif.:** Notable	26/09/12	1
2011-2012	CREACIÓN DE UNA INTERFAZ DE COMUNICACIÓN ENTRE DOS SISTEMAS PARA LA GESTIÓN DE LA PRODUCCIÓN DE VEHÍCULOS **Alumno:** HOYO MORENO, ROQUE **Calif.:** Sobresaliente	26/07/12	2
2011-2012	DEVELOPMENT OF AN UNIVERSAL COMPUTER CONFIGURATION APPLICATION **Alumno:** CASERO RAMIREZ, HUGO **Calif.:** Sobresaliente	25/07/12	1
2010-2011	INTEGRACIÓN DE COMPONENTES EN SISTEMAS DE INFORMACIÓN HOSPITALARIOS **Alumno:** CUENCA BENITEZ, FRANCISCO JOSE **Calif.:** Notable	28/06/11	1
2010-2011	"GRID BASED CFD OPTIMIZATION" **Alumno:** CHAPMAN, NICHOLAI **Calif.:** Sobresaliente	22/10/10	1
2010-2011	ABSTRACCIÓN EN EL ACCESO A LA INFORMACIÓN DE EQUIPOS MÉDICOS MEDIANTE ANALIZADORES LÉXICOS Y SINTÁCTICOS Y ENCAPSULADORES DE PROTOCOLOS **Alumno:** MINUESA CUENCA, VICTOR MIGUEL **Calif.:** Notable	06/10/10	1
2009-2010	DESARROLLO DE INTERFACES DE ALTO NIVEL PARA LA INTERACCION CON GESTORES DE MAQUINAS VIRTUALES EN INFRAESTRUCTURAS TIPO CLOUD **Alumno:** CALATRAVA ARROYO, AMANDA **Calif.:** Sobresaliente	07/09/10	1
2009-2010	HERRAMIENTAS Y PROCEDIMIENTOS PARA LA ADMINISTRACION DE UN CLUSTER DE ALTAS PRESTACIONES **Alumno:** CARRION BURGUETE, JOSE VICENTE **Calif.:** Sobresaliente	31/05/10	1
2004-2005	DESARROLLO DE UNA APLICACIÓN GRÁFICA PARA LA GENERACIÓN	23/06/05	2

Dirección de PFCs

Curso	Título	Fecha	NºCodir's
	AUTOMÁTICA DE FICHEROS PARAMÉTRICOS XML EN PROBLEMAS DE SIMULACIÓN DE LA ACTIVIDAD ELÉCTRICA CARDIACA. **Alumno:** TOLEDO CATALAN, ADRIANA **Calif.:** Notable		
2004-2005	IMPLEMENTACIÓN DE UN SISTEMA PARA GESTIONAR LA EJECUCIÓN DE SIMULACIONES DE TEJIDOS CARDIACOS EN ENTORNOS GRID **Alumno:** SANTANDREU BENAVENT, MARIA MANUELA **Calif.:** Notable	15/06/05	3

Dirección de Tesinas de Máster

Curso	Título	Fecha	NºCodir's
2021-2022	Computación Serverless basada en GPUs en AWS **Alumno:** CONTRERAS RUIZ, MANUEL RAMON **Calif.:** Sobresaliente	13/12/21	2
2020-2021	Gestión de Servicios de Amazon Web Services Mediante Alexa **Alumno:** AGULLO VALLS, ADRIAN **Calif.:** Notable	09/07/21	1
2020-2021	Aplicación Web para Composición de Workflows Serverless **Alumno:** SOLER MARCO, DAVID **Calif.:** Notable	21/04/21	2
2020-2021	Aplicación web para venta de entradas de cine en AWS **Alumno:** LLORCA PEDROS, CRISTIAN **Calif.:** Notable	29/03/21	1
2020-2021	Un programa de fidelización de clientes que utiliza Blockchain **Alumno:** ALGHAMDI, OSAMA ABDULRAHMAN A **Calif.:** Notable	22/12/20	1
2019-2020	Arquitecturas y Modelos Económicos de Aplicaciones Serverless **Alumno:** PETROSYAN, LUIZA **Calif.:** Notable	24/09/20	1
2019-2020	Plataforma Serverless de Procesado de Datos Abiertos **Alumno:** ORTIZ AMAYA, JESUS **Calif.:** Sobresaliente	24/09/20	1
2019-2020	Análisis de Herramientas Software para el Ciclo de Vida de un Proyecto de Big Data **Alumno:** MATA LLORCA, MANUEL **Calif.:** Notable	24/07/20	1
2019-2020	Sistema Serverless de Monitorización de Recursos para Plataformas de Cloud Público **Alumno:** REQUENA CASARES, CRISTINA **Calif.:** Sobresaliente	24/07/20	1
2018-2019	Algoritmos predictivos basados en el aprendizaje para plataformas integradas y distribuidas en el estudio de las ondas cerebrales. **Alumno:** GARCIA JIMENEZ, ALBERTO **Calif.:** Sobresaliente	23/09/19	1
2018-2019	Ejecución Monetizada de Workflows de Algoritmos Privados en Plataformas Serverless Públicas	25/07/19	2

Dirección de Tesinas de Máster

Curso	Título	Fecha	NºCodir's
	Alumno: MENDEZ MADRIGAL, ADOLFO **Calif.:** Matric. Honor		
2018-2019	Plataforma Serverless Híbrida de Procesado de Datos	18/07/19	1
	Alumno: RISCO GALLARDO, SEBASTIAN **Calif.:** Matric. Honor		
2017-2018	Entrenamiento Escalable de Modelos de Deep Learning sobre Infraestructuras Cloud	27/09/18	2
	Alumno: JORGE CANO, JAVIER **Calif.:** Matric. Honor		
2017-2018	Interfaz para la Ejecución de Aplicaciones sobre Plataformas Serverless	27/09/18	1
	Alumno: PEIRO CASTELLO, JORDI **Calif.:** Notable		
2017-2018	Plataforma Serverless de Ejecución de Trabajos	27/09/18	1
	Alumno: ORDOÑEZ OSORTO, DORIAN ADOLFO **Calif.:** Sobresaliente		
2016-2017	Despliegue y Monitorización de un cluster Mesos	28/07/17	2
	Alumno: LOPEZ HUGUET, SERGIO **Calif.:** Sobresaliente		
2016-2017	Gestión Eficiente de Arquitecturas Basadas en Microservicios	14/12/16	1
	Alumno: CRUZ HERRERA, PABLO ROBERTO **Calif.:** Aprobado		
2016-2017	Plataforma en la Nube para la Gestión y Evaluación de Portafolios Académicos	14/12/16	2
	Alumno: MIRANDA VASQUEZ, FRANZ ROBERT **Calif.:** Sobresaliente		
2015-2016	Elasticidad Horizontal Reactiva basada en Contenedores	30/09/16	2
	Alumno: GONZALEZ SEGURA, CESAR **Calif.:** Notable		
2015-2016	Gestión Elástica de Clusters de Contenedores	30/09/16	1
	Alumno: YATSYK GAVRYLYAK, YURIY **Calif.:** Notable		
2014-2015	ANÁLISIS DE FACTORES DE DIAGNÓSTICO EN INFORMES RADIOLÓGICOS DEL PROCESO CLÍNICO DIAGNÓSTICO DE CÁNCER DE MAMA MEDIANTE MAPREDUCE	28/09/15	2
	Alumno: LOOR MASPONS, LUIS ENRIQUE **Calif.:** Notable		
2014-2015	ESTUDIO DE APLICABILIDAD DE TÉCNICAS DE BIG DATA EN EL STREAMING MULTIMEDIA PARA LA DETECCIÓN DE EVENTOS	25/02/15	1
	Alumno: HERRERA HERNANDEZ, JOSE **Calif.:** Sobresaliente		
2012-2013	VMCA: UN SISTEMA PARA LA CONSOLIDACIÓN DE RECURSOS EN PLATAFORMAS DE VIRTUALIZACIÓN	24/07/13	2
	Alumno: ALFONSO LAGUNA, CARLOS DE **Calif.:** Sobresaliente		
2011-2012	SISTEMA DE INFORMACIÓN PARA MEJORAR LAS COLABORACIONES DINÁMICAS EN EL GRID	28/02/12	2
	Alumno: TORRES SERRANO, ERIK **Calif.:** Sobresaliente		

Dirección de Tesinas de Máster

Curso	Título	Fecha	NºCodir's
2011-2012	USO DE INFRAESTRUCTURAS HÍBRIDAS GRID Y CLOUD PARA LA COMPUTACIÓN CIENTÍFICA **Alumno:** CALATRAVA ARROYO, AMANDA **Calif.:** Sobresaliente	28/02/12	1
2010-2011	ARQUITECTURA PARA UN SISTEMA DE FICHEROS DISTRIBUIDO ORIENTADO AL ÁMBITO DE LAS APLICACIONES GRID Y CLOUD **Alumno:** CARRION BURGUETE, JOSE VICENTE **Calif.:** Sobresaliente	14/07/11	2

CALIDAD ACTIVIDAD DOCENTE

Evaluaciones positivas de su actividad

Curso	Convocatoria	Puntuación	Media Convocatoria	Umbral Favorable/ Aceptable	Umbral Notable	Umbral Muy Favorable/ Excelente	Valoración Final
2020-2021	IAD(1)	75,38		19,82	29,16	49,7	Excelente
2019-2020	IAD(1)	68,55		21,56	31,53	53,31	Excelente
2018-2019	IAD(1)	60,7		21,19	31,03	52,54	Excelente
2017-2018	IAD(1)	68,33		22,06	32,23	54,38	Excelente
2016-2017	IAD(1)	54,48		23,13	33,72	56,69	Notable
2015-2016	IAD(1)	61,03		25,08	36,52	61,09	Excelente
2014-2015	IAD(1)	68,41		26,28	38,28	63,94	Excelente
2013-2014	IAD(1)	66,48		26,28	38,28	63,94	Excelente
2012-2013	IAD(1)	49,67		25,08	36,52	61,09	Notable
2011-2012	IAD(1)	64,56		24,44		59,62	Muy Favorable
2010-2011	IAD(1)	58,23		24,44		59,62	Favorable
2009-2010	IAD(1)	53,52		25,08		61,09	Favorable
2008-2009	IAD(1)	45,84		25,08		61,09	Favorable
2007-2008	IAD(1)	34,23		20		60	Favorable
2006-2007	ACE(2)	53,69	34,8				
2005-2006	ACE(2)	57,68	41,7				
2004-2005	ACE(2)	5,5	4,8				

(1) - Para evaluar la actividad docente del profesorado se empleó el Índice de Actividad Docente (IAD), parámetro basado en el modelo del Programa DOCENTIA y que fue certificado por AVAP y ANECA con fecha 19-12-2012.

(2) - Con objeto de poder evaluar la actividad docente del profesorado se empleó un parámetro, denominado ACE (Ayuda Complementaria a la Enseñanza), que incorpora las siguientes dimensiones de la actividad docente desarrollada, tanto desde el punto de vista cuantitativo como cualitativo: (i) Acto Docente, (ii) Publicaciones y Material Docente, (iii) Programa PACE (Programa Propio UPV de Convergencia Europea), (iv) Participación en Cursos y Congresos de Innovación Educativa.

Encuestas de Alumnado

Curso	Nota (Sobre 10)
2020-2021	9,50
2019-2020	9,90
2018-2019	9,42
2017-2018	9,91
2016-2017	9,07
2015-2016	9,80
2014-2015	9,43
2013-2014	9,29
2012-2013	9,67
2011-2012	8,98
2010-2011	8,94
2009-2010	9,48
2008-2009	9,52
2007-2008	8,90
2006-2007	8,83
2005-2006	9,34
2004-2005	7,39

Proyectos de Innovación Docente

Curso	Descripción
2020-2021	Estrategias y Herramientas de Analíticas del Aprendizaje para la Formación Multidisciplinar en Competencias Transversales (PIME/19-20/166)
2020-2021	Comunidades de Aprendizaje como servicios en la nube para el desarrollo y evaluación automática de Competencias Transversales y Objetivos Formativos específicos (PIME/18-19/79)
2020-2021	Metodologías activas y TICs (MATI)
2019-2020	Estrategias y Herramientas de Analíticas del Aprendizaje para la Formación Multidisciplinar en Competencias Transversales (PIME/19-20/166)
2019-2020	Comunidades de Aprendizaje como servicios en la nube para el desarrollo y evaluación automática de Competencias Transversales y Objetivos Formativos específicos (PIME/18-19/79)
2019-2020	Metodologías activas y TICs (MATI)
2018-2019	Comunidades de Aprendizaje como servicios en la nube para el desarrollo y evaluación automática de Competencias Transversales y Objetivos Formativos específicos (B79/18)
2018-2019	Metodologías activas y TICs (MATI)
2017-2018	Entornos Virtuales Computacionales para la Evaluación de Competencias Transversales en la Nube (A04-17/16)
2017-2018	Experiencias Multi-Disciplinares de Integracio¿n de Aula Inversa para el Desarrollo de Competencias Transversales (A08-17/16)
2017-2018	Metodologías activas y TICs (MATI)
2016-2017	Entornos Virtuales Computacionales para la Evaluación de Competencias Transversales en la Nube (A04/16)
2016-2017	Experiencias Multi-Disciplinares de Integracio?n de Aula Inversa para el Desarrollo de Competencias Transversales (A08/16)
2016-2017	Metodologías activas y TICs (MATI)
2015-2016	Análisis y Evaluación de Impacto del Cloud Computing en la Gestión de Entornos Virtuales Computacionales en la Enseñanza (A14-16/15)
2015-2016	Diseño de experiencias y creación de materiales para la implantación del Flipped Classroom (A17-16/15)
2015-2016	Metodologías activas y TICs (MATI)
2014-2015	Análisis y Evaluación de Impacto del Cloud Computing en la Gestión de Entornos Virtuales Computacionales en la Enseñanza (A14/14)
2014-2015	Diseño de experiencias y creación de materiales para la implantación del Flipped Classroom (A17/14)
2014-2015	Metodologías activas y TICs (MATI)

Proyectos de Innovación Docente

Curso	Descripción
2013-2014	Metodologías activas y TICs (MATI)
2013-2014	Southwestern Europe Regional Contest (SWERC) 2013 (PIEX/35)
2013-2014	Uso de Entornos Virtualizados basados en Cloud para la Realización de Prácticas Docentes (A16/13)
2012-2013	Creación y distribución de vídeo-conceptos multidisciplinares para el fomento del aprendizaje autónomo (A05/12)
2012-2013	Metodologías activas y TICs (MATI)
2012-2013	Southwestern Europe Regional Contest (SWERC) 2013 (PIEX/35)
2011-2012	Elaboración de materiales de Autoaprendizaje, Autoevaluación y Evaluación en las asignaturas IIP y PRG en el Grado de Informática (B20/11)
2011-2012	Metodologías activas y TICs (MATI)
2011-2012	Utilización de Vídeos Didácticos para la Mejora de los Procesos de Aprendizaje Autónomo Basados en la Resolución de Ejercicios (A04/11)
2010-2011	Aprendizaje virtual síncrono mediante entornos colaborativos en un contexto multidisciplinar (A001/10)
2010-2011	Grupo de Innovación docente (EICE)
2010-2011	Grupo de Innovación docente (PACE)
2010-2011	Metodologías activas y TICs (MATI)
2009-2010	Grupo de Innovación Docente (EICE)
2008-2009	Participación en Proyectos de Innovación Docente (PACE)
2007-2008	Grupo de Innovación Docente UPV

4.2. Certificado de Participación en Proyectos

Área de Programas de Investigación e Innovación
Vicerrectorado de Investigación, Innovación y Transferencia
Camino de Vera s/n Edificio 6G-46022 Valencia -- Tfno: 96 387 7000, ext. 79103
apinin@upvnet.upv.es

La Universitat Politècnica de València,

HACE CONSTAR

Que según la información disponible en las bases de datos institucionales, D./Dª Moltó Martínez, Germán con DNI 52656437, ha participado en las actividades de I+D+i cuyo listado se adjunta.

Lo que hace constar a los efectos oportunos.

Participación en Proyectos de I+D financiados en Convocatorias públicas.

(nacionales y/o internacionales).

Título del proyecto: AN INTERDISCIPLINARY DIGITAL TWIN ENGINE FOR SCIENCE (101058386)
Entidad financiadora: COMISION DE LAS COMUNIDADES EUROPEA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/09/22 hasta: 31/08/25 Cuantía de la subvención: 318.250,00
Investigadores responsables: Blanquer Espert, Ignacio
Investigadores participantes: Moltó Martínez, Germán
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: IMAGING DATA AND SERVICES FOR AQUATIC SCIENCE (101058625)
Entidad financiadora: COMISION DE LAS COMUNIDADES EUROPEA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/09/22 hasta: 31/08/25 Cuantía de la subvención: 77.937,50
Investigadores responsables: Blanquer Espert, Ignacio
Investigadores participantes: Moltó Martínez, Germán
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: COMPUTACION CIENTIFICA SERVERLESS A TRAVES DEL HIBRIDO CONTINUO CLOUD (PID2020-113126RB-I00)
Entidad financiadora: AGENCIA ESTATAL DE INVESTIGACION
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/09/21 hasta: 31/08/25 Cuantía de la subvención: 145.321,00
Investigadores responsables: Moltó Martínez, Germán; Blanquer Espert, Ignacio
Investigadores participantes: Alfonso Laguna, Carlos De; Segrelles Quilis, José Damián; Risco Gallardo, Sebastián; Martínez Peiró, Marcos Antonio; Silla Jiménez, Federico
Investigadores en formación:
Equipo de trabajo: López Huguet, Sergio; Calatrava Arroyo, Amanda

---

Título del proyecto: ARTIFICIAL INTELLIGENCE FOR THE EUROPEAN OPEN SCIENCE CLOUD (101058593)
Entidad financiadora: COMISION DE LAS COMUNIDADES EUROPEA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/09/22 hasta: 31/08/25 Cuantía de la subvención: 503.500,00
Investigadores responsables: Moltó Martínez, Germán
Investigadores participantes: Blanquer Espert, Ignacio
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: ARTIFICIAL INTELLIGENCE IN SECURE PRIVACY-PRESERVING COMPUTING CONTINUUM (101016577)
Entidad financiadora: COMISION DE LAS COMUNIDADES EUROPEA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/01/21 hasta: 31/12/23 Cuantía de la subvención: 502.000,00
Investigadores responsables: Blanquer Espert, Ignacio
Investigadores participantes: Moltó Martínez, Germán; Calatrava Arroyo, Amanda; Silla Jiménez, Federico; Prades Gasulla, Javier; Peñaranda Cebrián, Cristian; Parcero Iglesias, Estíbaliz
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: COMPUTACION ABIERTA SIN SERVIDOR PARA LA ADOPCION DE INNOVACION RAPIDA EN RECURSOS SEGUROS PREPARADOS PARA LA EMPRESA (PDC2021-120844-I00)
Entidad financiadora: AGENCIA ESTATAL DE INVESTIGACION
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/12/21 hasta: 30/11/23 Cuantía de la subvención: 143.750,00
Investigadores responsables: Moltó Martínez, Germán; Blanquer Espert, Ignacio
Investigadores participantes: Alfonso Laguna, Carlos De; Segrelles Quilis, José Damián; Civera Saiz, Jorge; Langarita Benítez, Sergio; Alarcón Marín, Caterina; Martínez Peiró, Marcos Antonio
Investigadores en formación:
Equipo de trabajo: López Huguet, Sergio

Título del proyecto: EGI ADVANCED COMPUTING FOR EOSC (101017567)
Entidad financiadora: COMISION DE LAS COMUNIDADES EUROPEA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/01/21 hasta: 30/06/23 Cuantía de la subvención: 95.813,00
Investigadores responsables: Blanquer Espert, Ignacio
Investigadores participantes: Moltó Martínez, Germán
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: EUROPEAN OPEN SCIENCE CLOUD - EXPANDING CAPACITIES BY BUILDING CAPABILITIES (857647)
Entidad financiadora: COMISION DE LAS COMUNIDADES EUROPEA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/09/19 hasta: 31/10/22 Cuantía de la subvención: 323.500,00
Investigadores responsables: Blanquer Espert, Ignacio
Investigadores participantes: Moltó Martínez, Germán; Calatrava Arroyo, Amanda; Caballer Fernández, Miguel
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: AYUDA PREDOCTORAL GVA-GIMENEZ ALVENTOSA (ACIF/2018/148)
Entidad financiadora: GENERALITAT VALENCIANA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/09/18 hasta: 09/12/21 Cuantía de la subvención: 72.743,07
Investigadores responsables: Moltó Martínez, Germán
Investigadores participantes:
Investigadores en formación: Giménez Alventosa, Vicent
Equipo de trabajo:

Título del proyecto: PLATAFORMA COLABORATIVA EN LA NUBE PARA EL DESARROLLO Y EVALUACION DE COMPETENCIAS EN LAS ENSEÑANZAS STEM (AICO/2019/313)
Entidad financiadora: GENERALITAT VALENCIANA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/01/19 hasta: 31/03/21 Cuantía de la subvención: 40.000,00
Investigadores responsables: Segrelles Quilis, José Damián
Investigadores participantes: Sentieri Omarrementeria, Carla; Moltó Martínez, Germán; Ramos Montes, Marcos; Andrés Martínez, David De; Domingo Calabuig, Débora; Benlloch Dualde, José Vicente; Blanc Clavero, Sara; Navarro Bosch, Ana María; Segarra Soriano, Encarnación; Blanquer Espert, Ignacio
Investigadores en formación:

Equipo de trabajo:

Título del proyecto: INTEGRATING AND MANAGING SERVICES FOR THE EUROPEAN OPEN SCIENCE CLOUD (777536)
Entidad financiadora: COMISION DE LAS COMUNIDADES EUROPEA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/01/18 hasta: 31/03/21 Cuantía de la subvención: 239.937,50
Investigadores responsables: Blanquer Espert, Ignacio
Investigadores participantes: Alonso Abalos, José Miguel; Moltó Martínez, Germán; Calvo Saiz, Conrado Javier; Alvarruiz Bermejo, Fernando; Risco Gallardo, Sebastián; Arce Grilo, Alexandre David
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: COMPUTACION BIG DATA Y DE ALTAS PRESTACIONES SOBRE MULTI-CLOUDS ELASTICOS (TIN2016-79951-R)
Entidad financiadora: AGENCIA ESTATAL DE INVESTIGACION
Entidades participantes: Universitat Politècnica de València
Duración, desde: 30/12/16 hasta: 29/12/20 Cuantía de la subvención: 110.594,00
Investigadores responsables: Moltó Martínez, Germán; Blanquer Espert, Ignacio
Investigadores participantes: Segrelles Quilis, José Damián; Ballester Merelo, Francisco José; Pérez González, Alfonso María; ALIC , ANDREI STEFAN; Martínez Peiró, Marcos Antonio; Alonso Abalos, José Miguel
Investigadores en formación:
Equipo de trabajo: Alfonso Laguna, Carlos De

Título del proyecto: DESIGNING AND ENABLING E-INFRASTRUCTURES FOR INTENSIVE PROCESSING IN A HYBRID DATACLOUD (777435)
Entidad financiadora: COMISION DE LAS COMUNIDADES EUROPEA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/11/17 hasta: 30/04/20 Cuantía de la subvención: 240.954,49
Investigadores responsables: Blanquer Espert, Ignacio
Investigadores participantes: Moltó Martínez, Germán; Segrelles Quilis, José Damián; Calvo Saiz, Conrado Javier; López Huguet, Sergio; Alfonso Laguna, Carlos De; ALIC , ANDREI STEFAN; Lozano Lloret, Pau
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: PLATAFORMA DE COMPUTACION INTENSIVA MEDIANTE ACELERADORES GRAFICOS (GPUS) PARA SU APLICACION EN MEDICINA PERSONALIZADA (IDIFEDER/2018/032)
Entidad financiadora: GENERALITAT VALENCIANA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/01/18 hasta: 31/12/19 Cuantía de la subvención: 318.111,42
Investigadores responsables: Blanquer Espert, Ignacio
Investigadores participantes: Saiz Rodríguez, Francisco Javier; Casamayor Rodenas, Juan Carlos; Mora Mas, Francisco José; Trenor Gomis, Beatriz Ana; Pastor López, Oscar; Martínez Peiró, Marcos Antonio; Colom Palero, Ricardo José; Gadea Gironés, Rafael; Ferrero De Loma-Osorio, José María; Mota Herranz, Laura; Rueda Molina, Urko; Calatrava Arroyo, Amanda; Segrelles Quilis, José Damián; Alonso Abalos, José Miguel; LEÓN PALACIO, ANA; Franco Martins Souza , Beatriz; Alvarruiz Bermejo, Fernando; Romero Pérez, Lucia; Moltó Martínez, Germán; Caballer Fernández, Miguel; Ballester Merelo, Francisco José
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: Ejecución de aplicaciones sobre plataformas on-premises elásticas de funciones como servicio (FaaS) (SP20180068)
Entidad financiadora: UNIVERSIDAD POLITECNICA DE VALENCIA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/01/19 hasta: 31/12/19 Cuantía de la subvención: 5.000,00
Investigadores responsables: Caballer Fernández, Miguel
Investigadores participantes: Moltó Martínez, Germán; López Huguet, Sergio; Pérez González, Alfonso María; Blanquer Espert, Ignacio; Calatrava Arroyo, Amanda
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: ADAPTIVE, TRUSTWORTHY, MANAGEABLE, ORCHESTRATED, SECURE, PRIVACY-ASSURING, HYBRID ECOSYSTEM FOR RESILIENT CLOUD COMPUTING (777154)
Entidad financiadora: COMISION DE LAS COMUNIDADES EUROPEA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/11/17 hasta: 31/10/19 Cuantía de la subvención: 283.085,59
Investigadores responsables: Blanquer Espert, Ignacio
Investigadores participantes: Alfonso Laguna, Carlos De; Moltó Martínez, Germán; Calatrava Arroyo, Amanda; Caballer Fernández, Miguel
Investigadores en formación:
Equipo de trabajo: ANDRADE , IVAN

Título del proyecto: Elastic Kubernetes as a Service in EGI Federated Cloud ( )
Entidad financiadora: STICHTING EGI
Entidades participantes: Universitat Politècnica de València
Duración, desde: 22/03/19 hasta: 21/09/19 Cuantía de la subvención: 30.478,80
Investigadores responsables: Blanquer Espert, Ignacio
Investigadores participantes: Moltó Martínez, Germán; Alvarruiz Bermejo, Fernando; Alonso Abalos, José Miguel; Alfonso Laguna, Carlos De
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: Elastic Serverless Platform for High Throughput Computing Scientific Application ( )
Entidad financiadora: STICHTING EGI
Entidades participantes: Universitat Politècnica de València
Duración, desde: 13/03/19 hasta: 12/09/19 Cuantía de la subvención: 15.000,00
Investigadores responsables: Moltó Martínez, Germán
Investigadores participantes: Blanquer Espert, Ignacio; Alvarruiz Bermejo, Fernando; Alonso Abalos, José Miguel; Alfonso Laguna, Carlos De
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: ATMOSPHERE. ADAPTIVE, TRUSTWORTHY, MANAGEABLE, ORCHESTRATED, SECURE PRIVACY-ASSURING HYBRID, ECOSYSTEM FOR RESILIENT CLOUD COMPUTING (APE/2017/009)
Entidad financiadora: GENERALITAT VALENCIANA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/01/17 hasta: 31/12/17 Cuantía de la subvención: 8.900,00
Investigadores responsables: Blanquer Espert, Ignacio
Investigadores participantes: Moltó Martínez, Germán; Alvarruiz Bermejo, Fernando; Alonso Abalos, José Miguel; Alfonso Laguna, Carlos De
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: COLLABORATIVE CLOUD PLATFORM FOR CONTINUOUS INTEGRATION OF QUANTITATIVE IMAGING BIOMARKERS THROUGH THE SMART SPECIALISATION. (APE/2017/033)
Entidad financiadora: GENERALITAT VALENCIANA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/01/17 hasta: 31/12/17 Cuantía de la subvención: 8.950,00
Investigadores responsables: Segrelles Quilis, José Damián
Investigadores participantes: Moltó Martínez, Germán; Alvarruiz Bermejo, Fernando; Alonso Abalos, José Miguel; Alfonso Laguna, Carlos De
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: EUROPE-BRAZIL COLLABORATION ON BIG DATA SCIENTIFIC RESEARCH THROUGH CLOUD-CENTRIC APPLICATIONS (690116)
Entidad financiadora: COMISION DE LAS COMUNIDADES EUROPEA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/01/16 hasta: 31/12/17 Cuantía de la subvención: 285.017,99
Investigadores responsables: Blanquer Espert, Ignacio
Investigadores participantes: Alonso Abalos, José Miguel; Torres Serrano, Erik; Moltó Martínez, Germán; Calatrava Arroyo, Amanda; López Huguet, Sergio; ALIC , ANDREI STEFAN; Arce Grilo, Alexandre David; Lozano Lloret, Pau
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: INtegrating Distributed data Infrastructures for Global ExplOitation. INDIGO-DataCloud (653549)
Entidad financiadora: COMISION DE LAS COMUNIDADES EUROPEA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/04/15 hasta: 30/09/17 Cuantía de la subvención: 457.570,47
Investigadores responsables: Blanquer Espert, Ignacio
Investigadores participantes: Caballer Fernández, Miguel; Alfonso Laguna, Carlos De; Moltó Martínez, Germán; López Huguet, Sergio; Pérez González, Alfonso María; Borreguero Torró, Ferrán; Bayonne Sopo, Enrique; Alvarruiz Bermejo, Fernando; Alonso Abalos, José Miguel; Meseguer Anastasio, Javier Enrique; Lozano Lloret, Pau
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: Engaging the EGI Community towards an Open Science Commons EGI-Engage (654142)
Entidad financiadora: COMISION DE LAS COMUNIDADES EUROPEA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/07/15 hasta: 31/08/17 Cuantía de la subvención: 90.147,25
Investigadores responsables: Blanquer Espert, Ignacio
Investigadores participantes: Moltó Martínez, Germán; Meseguer Anastasio, Javier Enrique; Arce Grilo, Alexandre David
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: CLUSTERS VIRTUALES ELASTICOS Y MIGRABLES SOBRE INFRAESTRUCTURAS CLOUD HIBRIDAS (TIN2013-44390-R-AR)
Entidad financiadora: MINISTERIO DE ECONOMIA Y EMPRESA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/01/14 hasta: 31/12/16 Cuantía de la subvención: 79.876,94
Investigadores responsables: Moltó Martínez, Germán; Blanquer Espert, Ignacio
Investigadores participantes: Alfonso Laguna, Carlos De; Hernández García, Vicente; Alvarruiz Bermejo, Fernando; Alonso Abalos, José Miguel; Calatrava Arroyo, Amanda; Carrión Collado, Abel Antonio
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: ADVANCED CLOUD INFRASTRUCTURE FOR BIG DATA APPLICATIONS IN EUROPE-BRAZIL (APE/2016/012)
Entidad financiadora: GENERALITAT VALENCIANA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/01/16 hasta: 31/12/16 Cuantía de la subvención: 6.000,00
Investigadores responsables: Blanquer Espert, Ignacio
Investigadores participantes: Moltó Martínez, Germán; Alvarruiz Bermejo, Fernando; Alonso Abalos, José Miguel; Segrelles Quilis, José Damián
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: AYUDA PARA LA CONTRATACION DE PERSONAL EN FORMACION DE CARACTER PREDOCTORAL PROGRAMA VALI+D-CALATRAVA ARROYO, AMANDA (ACIF/2013/003)
Entidad financiadora: GENERALITAT VALENCIANA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/06/13 hasta: 01/06/16 Cuantía de la subvención: 66.577,30
Investigadores responsables: Moltó Martínez, Germán
Investigadores participantes: Calatrava Arroyo, Amanda
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: EU-Brazil Cloud infrastructure Connecting federated resources for Scientific Advancement (614048)
Entidad financiadora: COMISION DE LAS COMUNIDADES EUROPEA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/10/13 hasta: 31/01/16 Cuantía de la subvención: 245.589,00
Investigadores responsables: Blanquer Espert, Ignacio
Investigadores participantes: Torres Serrano, Erik; Moltó Martínez, Germán
Investigadores en formación: Giménez Fayos, María Teresa
Equipo de trabajo:

Título del proyecto: SERVICIOS AVANZADOS PARA EL DESPLIEGUE Y CONTEXTUALIZACION DE APLICACIONES VIRTUALIZADAS PARA DAR SOPORTE A MODELOS DE PROGRAMACION EN ENTORNOS CLOUD (TIN2010-17804)
Entidad financiadora: MINISTERIO DE ECONOMIA Y EMPRESA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/01/11 hasta: 01/01/14 Cuantía de la subvención: 252.890,00
Investigadores responsables: Hernández García, Vicente
Investigadores participantes: Caballer Fernández, Miguel; Alfonso Laguna, Carlos De; Moltó Martínez, Germán; Segrelles Quilis, José Damián; Carrión Burguete, José Vicente; Martí García, Elisabeth; Ruíz Martínez, Pedro Antonio; Peinado Pinilla, Jesús; Guerrero López, David; Alvarruiz Bermejo, Fernando; Blanquer Espert, Ignacio; Ibáñez González, Jacinto Javier; Alonso Abalos, José Miguel; Meseguer Anastasio, Javier Enrique
Investigadores en formación: García García, Andrés
Equipo de trabajo:

Título del proyecto: DISEÑO DE COMPONENTES CLOUD FACILITADORES DE DESPLIEGUE Y LA ALTA DISPONIBILIDAD DE SERVICIOS TRENCADIS, PARA COMPARTIR IMAGENES MEDICAS DICOM E INFORMES ASOCIADOS DICOM-SR. (2024)
Entidad financiadora: UNIVERSIDAD POLITECNICA DE VALENCIA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/12/11 hasta: 01/12/13 Cuantía de la subvención: 9.000,00
Investigadores responsables: Segrelles Quilis, José Damián
Investigadores participantes: Caballer Fernández, Miguel; Moltó Martínez, Germán; Torres Serrano, Erik
Investigadores en formación: Giménez Fayos, María Teresa
Equipo de trabajo:

Título del proyecto: GESTION ELASTICA Y EFICIENTE DE ENTORNOS CLOUD PARA LA EJECUCION DE APLICACIONES CIENTIFICAS (GV/2012/076)
Entidad financiadora: GENERALITAT VALENCIANA; GENERALITAT VALENCIANA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/01/12 hasta: 30/11/13 Cuantía de la subvención: 6.000,00
Investigadores responsables: Moltó Martínez, Germán
Investigadores participantes: Caballer Fernández, Miguel; Alfonso Laguna, Carlos De; Torres Serrano, Erik; Segrelles Quilis, José Damián; Alvarruiz Bermejo, Fernando
Investigadores en formación: LAMAS DAVIÑA, ALEJANDRO
Equipo de trabajo:

Título del proyecto: SERVICIOS AVANZADOS PARA EL DESPLIEGUE Y CONTEXTUALIZACION DE APLICACIONES VIRTUALIZADAS PARA DAR SOPORTE A MODELOS DE PROGRAMACION EN ENTORNOS CLC. (ACOMP/2013/127)
Entidad financiadora: GENERALITAT VALENCIANA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/01/13 hasta: 30/11/13 Cuantía de la subvención: 10.043,04
Investigadores responsables: Hernández García, Vicente
Investigadores participantes: Moltó Martínez, Germán; Segrelles Quilis, José Damián; Ruíz Martínez, Pedro Antonio; Peinado Pinilla, Jesús; Guerrero López, David; Alvarruiz Bermejo, Fernando; Blanquer Espert, Ignacio; Ibáñez González, Jacinto Javier; Alonso Abalos, José Miguel
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: TEA (TECNOLOGIAS E-LEARNING ACCESIBLES) (2791)
Entidad financiadora: UNIVERSIDAD POLITECNICA DE VALENCIA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/12/11 hasta: 30/12/12 Cuantía de la subvención: 6.000,00
Investigadores responsables: Buendía García, Félix
Investigadores participantes: Moltó Martínez, Germán; Benlloch Dualde, José Vicente; Prieto Saez, Natividad; Castro Bleda, María José; Gonzalez Tellez, Alberto; Oltra Gutiérrez, Juan Vicente
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: EJECUCION ESCALABLE DE APLICACIONES CIENTIFICAS EN INFRAESTRUCTURAS VIRTUALIZADAS MULTICAPA MEDIANTE TECNOLOGIAS GRID Y CLOUD (PAID-06-09-2810)
Entidad financiadora: UNIVERSIDAD POLITECNICA DE VALENCIA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/12/09 hasta: 01/12/11 Cuantía de la subvención: 12.000,00
Investigadores responsables: Moltó Martínez, Germán
Investigadores participantes: Caballer Fernández, Miguel; Alfonso Laguna, Carlos De; Segrelles Quilis, José Damián; Hernández García, Vicente
Investigadores en formación: Calatrava Arroyo, Amanda
Equipo de trabajo:

Título del proyecto: COMPONENTES DE NUEVA GENERACION PARA LA EXPORTACION EFICIENTE DE INFRAESTRUCTURAS GRID EN E CIENCIA (TIN2006-12890)
Entidad financiadora: MINISTERIO DE EDUCACION
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/04/09 hasta: 01/10/11 Cuantía de la subvención: 435.600,00
Investigadores responsables: Hernández García, Vicente
Investigadores participantes: Caballer Fernández, Miguel; Alfonso Laguna, Carlos De; García García, Gabriel; Moltó Martínez, Germán; Carrión Burguete, José Vicente; LÓPEZ HERRERO, ROBERTO; Segrelles Quilis, José Damián; Báguena Añó, Mª Minerva; Ruíz Martínez, Pedro Antonio; Urchueguía Schölzel, Javier Fermín; Peinado Pinilla, Jesús; Guerrero López, David; Alvarruiz Bermejo, Fernando; Blanquer Espert, Ignacio; Ibáñez González, Jacinto Javier; Alonso Abalos, José Miguel
Investigadores en formación: Zacarés González, Mario
Equipo de trabajo:

Título del proyecto: INTEGRACION DE UN MOTOR DE BUSQUEDA TIPO BLAST A UNA APLICACION DE ANALISIS DE VARIACIONES DE SECUENCIAS GENOMICAS (PAID-05-09-4301)
Entidad financiadora: UNIVERSIDAD POLITECNICA DE VALENCIA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 15/12/09 hasta: 15/12/10 Cuantía de la subvención: 12.000,00
Investigadores responsables: Pastor López, Oscar
Investigadores participantes: Moltó Martínez, Germán; Villanueva Del Pozo, Maria José; Segrelles Quilis, José Damián; Celma Giménez, Matilde; Casamayor Rodenas, Juan Carlos; Hernández García, Vicente; Blanquer Espert, Ignacio; Pastor Cubillo, Mª Ángeles
Investigadores en formación: Martínez Ferrandis, Ana María; Burriel Coll, Verónica; Carrión Collado, Abel Antonio
Equipo de trabajo:

Título del proyecto: ORGANIZACION Y PUESTA EN MARCHA DE LA RED DE E-CIENCIA EN ESPAÑA (CAC-2007-52)
Entidad financiadora: MINISTERIO DE EDUCACION
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/10/07 hasta: 01/10/10 Cuantía de la subvención: 473.830,00
Investigadores responsables: Hernández García, Vicente
Investigadores participantes: Vuillemin ., Philippe; Caballer Fernández, Miguel; ELENA FITO, SANTIAGO FCO; Alfonso Solar, David; Martí García, Elisabeth; García García, Gabriel; Moltó Martínez, Germán; MOLAS GALLART, JORDI; Haynes ., Paul Jason; Vargas Salgado, Carlos Afranio; Segrelles Quilis, José Damián; LÓPEZ HERRERO, ROBERTO; Peñalvo López, Elisa; PEREZ AMADOR, MIGUEL ANGEL; Báguena Añó, Mª Minerva; Mugarra Llopis, Fernando; Gadea Vacas, José; Forment Millet, José Javier; Desantes Fernández, José Mª; Fernández De Córdoba Castellá, Pedro José; Ruíz Martínez, Pedro Antonio; Capmany Francoy, José; Reyes López, Ernesto De Los; GRANELL RICHART, ANTONIO; Barberá Tomás, José David; Casacuberta Nolla, Francisco; Pérez-Navarro Gómez, Ángel; Juan Císcar, Alfonso; Albert Berenguer, Jose Rafael; Urchueguía Schölzel, Javier Fermín; Martínez Perales, Javier; Tomás Domínguez, Andrés Enrique; Lerma Peris, María José; Vidal Ruiz, Enrique; Soto Camino, Juan; Serrano Salom, Ramón; Torregrosa Cabanilles, Constantino; García Breijo, Eduardo; Sánchez Díaz, Carlos; Torregrosa Huguet, Antonio José; Maquieira Catala, Ángel; Martínez Mañez, Ramón; Meseguer Dueñas, José María; Ibañez Escobar, Fernando; Monleón Pradas, Manuel; Payri González, Francisco; Peinado Pinilla, Jesús; Gómez Tejedor, José Antonio; Álvarez Bel, Carlos María; Conejero Tomás, Vicente; Benedí Ruiz, José Miguel; Sabater i Serra, Roser; Guerrero López, David; Sánchez Peiró, Joan Andreu; Molina Mateo, José; Muñoz Muñoz, Pascual; Escrivá Escrivá, Guillermo; Pastor Enguídanos, José Manuel; Blanquer Espert, Ignacio; Ibáñez González, Jacinto Javier; Paredes Palacios, Roberto; Pallás Benet, Vicente; Margot ., Xandra Marcelle; Alonso Abalos, José Miguel; Segura Heras, Isidoro; Zacarés González, Mario; Meseguer Anastasio, Javier Enrique; Ortigosa Blanch, Arturo; Carrión Burguete, José Vicente
Investigadores en formación: Salavert Torres, José; Alcázar Ortega, Manuel; Gasulla Mestre, Ivana; Carrión Collado, Abel Antonio
Equipo de trabajo:

Título del proyecto: COMPONENTES DE NUEVA GENERACION PARA LA EXPLOTACION EFICIENTE DE INFRAESTRUCTURAS GRID EN ECIENCIA (ACOMP/2009/052)
Entidad financiadora: GENERALITAT VALENCIANA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/01/09 hasta: 01/01/10 Cuantía de la subvención: 7.000,00
Investigadores responsables: Hernández García, Vicente
Investigadores participantes: Caballer Fernández, Miguel; Alfonso Laguna, Carlos De; Martí García, Elisabeth; García García, Gabriel; Moltó Martínez, Germán; Segrelles Quilis, José Damián; LÓPEZ HERRERO, ROBERTO; Peinado Pinilla, Jesús; Guerrero López, David; Alvarruiz Bermejo, Fernando; Blanquer Espert, Ignacio; Ibáñez González, Jacinto Javier; Alonso Abalos, José Miguel; Carrión Burguete, José Vicente
Investigadores en formación:
Equipo de trabajo:

Título del proyecto: MODELOS TEÓRICOS Y COMPUTACIÓN AVANZADA EN EL ESTUDIO DE SEÑALES BIOELÉCTRICAS EN CÉLULAS Y TEJIDOS. IMPLICACIONES EN EL ANÁLISIS DE ARRITMIAS CARDÍACAS, ELECTROESTIMULACIÓN Y ABLACIÓN POR RADIOFR.... (TEC2005-04199)
Entidad financiadora: MINISTERIO DE EDUCACION
Entidades participantes: Universitat Politècnica de València
Duración, desde: 31/12/05 hasta: 31/12/08 Cuantía de la subvención: 191.114,20
Investigadores responsables: Ferrero De Loma-Osorio, José María
Investigadores participantes: Trenor Gomis, Beatriz Ana; Monserrat Del Río, Marta María; Montilla Meoro, Fulgencio; Saiz Rodríguez, Francisco Javier; Colomar Pous, Enrique; Gomis-Tena Dolz, Julio; Berjano Zanón, Enrique; Alonso Abalos, José Miguel
Investigadores en formación: Moltó Martínez, Germán; Cardona Urrego, Karen Eliana; Romero Pérez, Lucia; Tobón Zuluaga, Catalina
Equipo de trabajo:

Título del proyecto: PREPARACION DE PROPUESTA IDEALS (INTEGRATED DATA ANALYSIS ENVIRONMENT FOR ADVANCED LIFE SCIENCES) (TIN2007-30808-E)
Entidad financiadora: MINISTERIO DE EDUCACION
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/07/07 hasta: 31/12/07 Cuantía de la subvención: 3.000,00
Investigadores responsables: Hernández García, Vicente
Investigadores participantes: Moltó Martínez, Germán; Blanquer Espert, Ignacio
Investigadores en formación: Torres Serrano, Erik
Equipo de trabajo:

Título del proyecto: IMAGEN MEDICAL MOLECULAR Y MULTIMODALIDAD: PORTAL GRID DE POSTPROCESO DE IMAGENES (PI052716)
Entidad financiadora: INSTITUTO DE SALUD CARLOS III
Entidades participantes: Universitat Politècnica de València
Duración, desde: 30/12/05 hasta: 30/12/06 Cuantía de la subvención: 14.875,00
Investigadores responsables: Hernández García, Vicente
Investigadores participantes: Moltó Martínez, Germán; Segrelles Quilis, José Damián; Moratal Pérez, David; Mas Domenech, Ferran; Millet Roig, José; Blanquer Espert, Ignacio
Investigadores en formación: FLÓREZ ORDÓÑEZ, YUDY NATALIA
Equipo de trabajo:

Título del proyecto: PROYECTO DE CREACION DEL METACENTRO DE APLICACIONES DE LA SUPERCOMPUTACION Y LAS TECNOLOGIAS GRID DE LA COMUNIDAD VALENCIANA (IIARC0/2004/74)
Entidad financiadora: GENERALITAT VALENCIANA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 01/01/04 hasta: 01/01/06 Cuantía de la subvención: 25.032,36
Investigadores responsables: Hernández García, Vicente
Investigadores participantes: Caballer Fernández, Miguel; Alonso Abalos, José Miguel; Blanquer Espert, Ignacio; García García, Gabriel; Guerrero López, David
Investigadores en formación: Moltó Martínez, Germán; Mas Domenech, Ferran
Equipo de trabajo:

Título del proyecto: COMPUTACION AVANZADA EN LA MODELIZACION DE LA ACTIVIDAD ELECTRICA CARDIACA. SIMULACION Y VISUALIZACION DE LAS ALTERACIONES PRODUCIDAS EN ARRITMIAS VENTRICULARES POR LA ACCION DE FARMACOS ANTIARRITMICOS Y LA APLICACION DE CAMPOS ELECTRICOS (TIC2001-2686)
Entidad financiadora: MINISTERIO DE CIENCIA Y TECNOLOGIA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 28/12/01 hasta: 28/12/04 Cuantía de la subvención: 80.144,97
Investigadores responsables: Saiz Rodríguez, Francisco Javier
Investigadores participantes: Moltó Martínez, Germán; Trenor Gomis, Beatriz Ana; Monserrat Del Río, Marta María; Montilla Meoro, Fulgencio; Colomar Pous, Enrique; Rodríguez López, Blanca; Gomis-Tena Dolz, Julio; Alonso Abalos, José Miguel
Investigadores en formación: Villaescusa López, Francisco José
Equipo de trabajo:

Título del proyecto: SUBPROYECTO COMPUTACION AVANZADA EN LA MODELIZACION, SIMULACION Y VISUALIZACION DE ARRITMIAS VENTRICULARES (PPI-05-01 6023-2)
Entidad financiadora: UNIVERSIDAD POLITECNICA DE VALENCIA
Entidades participantes: Universitat Politècnica de València
Duración, desde: 20/06/02 hasta: 20/09/03 Cuantía de la subvención: ,00
Investigadores responsables: Hernández García, Vicente
Investigadores participantes: Ruíz Martínez, Pedro Antonio; Alonso Abalos, José Miguel
Investigadores en formación: Moltó Martínez, Germán
Equipo de trabajo:

Participación en contratos de I+D de especial relevancia con Empresas y/o Administraciones

(nacionales y/o internacionales).

Título del contrato/proyecto: APOYO TÉCNICO EN EL DESARROLLO DEL PROYECTO CDPS (CLOUD DATA PROCESSING SERVICE) ( )
Tipo de contrato: Consultorías, estudios técnicos y asesoramiento
Empresa/Administración financiadora: INDRA SISTEMAS, S.A.
Entidades participantes: Universitat Politècnica de València
Duración, desde: 14/12/20 hasta: 13/03/22
Investigadores responsables: Blanquer Espert, Ignacio
Investigadores participantes: Segrelles Quilis, José Damián; Moltó Martínez, Germán
Investigadores en formación:
Equipo de trabajo:

PRECIO TOTAL DEL PROYECTO: 37.370,00

Título del contrato/proyecto: PRESTACIONES DE SERVICIO DE GERMAN MOLTO MARTINEZ ( )
Tipo de contrato: Consultorías, estudios técnicos y asesoramiento
Empresa/Administración financiadora: SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA; ALCANZIA ENERGIA, S.L.; ASOCIACION ESPAÑOLA DE NORMALIZACION
Entidades participantes: Universitat Politècnica de València
Duración, desde: 28/10/10 hasta: 30/12/16
Investigadores responsables: Moltó Martínez, Germán
Investigadores participantes:
Investigadores en formación:
Equipo de trabajo:

PRECIO TOTAL DEL PROYECTO: 19.115,65

Título del contrato/proyecto: INFRAESTRUCTURA TECNOLOGICA Y METODOLOGICA DE SOPORTE PARA UN CORE BANCARIO (CENIT 2006)
Tipo de contrato: I+D Colaborativa contratada
Empresa/Administración financiadora: GRID SYSTEMS S.A.
Entidades participantes: Universitat Politècnica de València
Duración, desde: 17/01/06 hasta: 17/01/10
Investigadores responsables: Hernández García, Vicente
Investigadores participantes: Blanquer Espert, Ignacio; Alonso Abalos, José Miguel; Alfonso Laguna, Carlos De; Moltó Martínez, Germán; Caballer Fernández, Miguel
Investigadores en formación: De la Fuente Aragón, Pedro; Lozano Lloret, Pau
Equipo de trabajo:

PRECIO TOTAL DEL PROYECTO: 400.000,00

Título del contrato/proyecto: INVESTIGACION Y DESARROLLO DE UNA TECNOLOGIA DE IMAGEN ANOTOMO-FUNCIONAL BASADA EN LA EMISION DE POSITRONES Y RAYOS-X PARA SU APLICACION EN INVESTIGACION PRE-CLINICA (CENIT 2006)
Tipo de contrato: I+D Colaborativa contratada
Empresa/Administración financiadora: SUINSA, MEDICAL SYSTEMS
Entidades participantes: Universitat Politècnica de València
Duración, desde: 12/01/06 hasta: 12/01/10
Investigadores responsables: Hernández García, Vicente
Investigadores participantes: Blanquer Espert, Ignacio; Román Moltó, José Enrique; Alonso Abalos, José Miguel; Tomás Domínguez, Andrés Enrique; Alfonso Laguna, Carlos De; Moltó Martínez, Germán; Caballer Fernández, Miguel
Investigadores en formación:
Equipo de trabajo:

PRECIO TOTAL DEL PROYECTO: 415.000,00

4.3. Certificado de Prestaciones de Servicio

La Universitat Politècnica de València

HACE CONSTAR

Que según la información disponible en las bases de datos institucionales, D. / Dña **Moltó Martínez, Germán**

ha realizado las siguientes actividades de acuerdo con el artículo 83 de la ley orgánica de Universidades, catalogado como **prestaciones de servicio**.

Título	*Empresa*	*Importe (euros) IVA no incluido*	*Fecha*
CONSULTORIA, ESTUDIOS TÉCNICOS Y ASESORAMIENTO			
EVALUACIÓN COMO EXPERTO TÉCNICO DEL PROYECTO I+D+I AMAEMCLOUD (ANUALIDAD 2020) PARA GERMÁN MOLTÓ MARTÍNEZ Nº PEDIDO: 6051979.---	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	03/03/2022
EVALUACIÓN COMO EXPERTO TÉCNICO DEL PROYECTO I+D+I DIGITALHDG (ANUALIDAD 2020) PARA GERMÁN MOLTÓ MARTÍNEZ PEDIDO Nº: 6051980.---	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	03/03/2022
EVALUACIÓN COMO EXPERTO TÉCNICO DEL PROYECTO I+D+I SISGESEMER (2020) PARA GERMÁN MOLTÓ MARTÍNEZ PEDIDO: 6048790	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	26/10/2021
EVALUACIÓN COMO EXPERTO TÉCNICO DEL PROYECTO I+D+I CMANDODIRK (2020) PARA GERMÁN MOLTÓ MARTÍNEZ PEDIDO: 6048788.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	26/10/2021
COLABORACION COMO EXPERTO EN EL DESPLIEGUE DE UNA SOLUCION TECNOLOGICA EN LA NUBE PARA LA GESTION DE DISPOSITIVOS IOT Y LA DOCUMENTACION DEL PROCESO, ASI COMO, EL ASESORAMIENTO TECNICO PERTINENTE DE ACUERDO A LOS TERMINOS INDICADOS EN EL DOCUMENTO TITULADO "DESCRIPCION TECNICA DE LA PRESTACION DE SERVICIOS I3M-CIRCUTOR", REALIZADO EN EL MARCO DEL PROYECTO CIR19PJHAR700 ARMONIA UPV.------	CIRCUTOR, S.A.	4.536	30/09/2021
EVALUACIÓN COMO EXPERTO TÉCNICO DEL PROYECTO I+D+I ABACOGES20 (2020) PARA GERMAN MOLTO MARTINEZ NÚMERO DE PEDIDO: 6047289.-------	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	16/09/2021

EVALUACIÓN COMO EXPERTO TÉCNICO DEL PROYECTO I+D+I REWEBMETAB (2020) PARA GERMAN MOLTO MARTINEZ NÚMERO DE PEDIDO: 6047295.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	16/09/2021
EVALUACIÓN COMO EXPERTO TÉCNICO DEL PROYECTO I+D+I PLATASETEM (2019) PARA GERMAN MOLTO MARTINEZ NÚMERO DE PEDIDO: 6047904.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	16/09/2021
COLABORACIÓN COMO EXPERTO EN LA EVALUACIÓN TÉCNICA DEL PROYECTO: 2021/0837/PIDI/01 BASFD2VEDL - DESARROLLO DE UNA PLATAFORMA EN LA NUBE PARA RECOPILACIÓN GESTION Y APROVECHAMIENTO DE DATOS DE LA EMPRESA BASF DIGITAL SOLUTIONS, SL.------	AENOR INTERNACIONAL, S.A.	500	13/09/2021
COLABORACIÓN COMO EXPERTO EN LA EVALUACIÓN TÉCNICA DEL PROYECTO: 2020/1599/PIDI/01 CLOUDPLANE - PLATAFORMA DE ENRUTAMIENTO EN NUBE CON PLANO DE CONTROL DE ALTA DISPONIBILIDAD Y REINICIO ELEGANTE PERTENECIENTE A EMPRESA VOLTA XARXA ESPAÑA, S.L.------	AENOR INTERNACIONAL, S.A.	500	04/03/2021
EVALUACIÓN COMO EXPERTO TÉCNICO DEL PROYECTO I+D+I GESTRETUR (ANUALIDAD 2019) PARA GERMÁN MOLTÓ MARTÍNEZ. NÚMERO DE REFERENCIA: 6043722.------	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	215	12/02/2021
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I HIPERVIRTU (ANUALIDAD 2018) PARA GERMAN MOLTO MARTINEZ. Nº REFERENCIA: 6041901.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	16/11/2020
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I NEWPLATUBE (ANUALIDAD 2019) PARA GERMAN MOLTO MARTINEZ. Nº REFERENCIA: 6041103.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	21/09/2020
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I GESTIBADOR (ANUALIDAD 2017) PARA GERMAN MOLTO MARTINEZ. Nº REFERENCIA: 6040089.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	31/07/2020
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I VIRTUACORP (ANUALIDAD 2016) PARA GERMAN MOLTO MARTINEZ. Nº REFERENCIA: 6039497.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	31/07/2020
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I GESTIBADOR (ANUALIDAD 2018) PARA GERMAN MOLTO MARTINEZ. Nº REFERENCIA: 6040087.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	215	31/07/2020
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I CLOUDGES19 (ANUALIDAD 2018) PARA GERMAN MOLTO MARTINEZ. Nº REFERENCIA: 6039189.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	215	08/05/2020

EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I SISTRDEAAT (ANUALIDAD 2018) PARA GERMAN MOLTO MARTINEZ. Nº REFERENCIA: 6036347.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	215	27/04/2020
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I GESTRESTUR PARA GERMAN MOLTO MARTINEZ. Nº REFERENCIA: 6037379.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	06/02/2020
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I BISOS1701 (ANUALIDAD 2017) PARA GERMAN MOLTO MARTINEZ. Nº REFERENCIA: 6036341.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	29/01/2020
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I BISOS1702 (ANUALIDAD 2018) PARA GERMAN MOLTO MARTINEZ. Nº REFERENCIA: 6036340.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	215	29/01/2020
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I BRICDATA17 (ANUALIDAD 2018) PARA GERMAN MOLTO MARTINEZ. Nº REFERENCIA: 6036068.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	18/12/2019
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I CLOUDGES18 (ANUALIDAD 2018) PARA GERMAN MOLTO MARTINEZ. Nº REFERENCIA: 6035903.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	22/11/2019
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I VERECOMM17 (ANUALIDAD 2017) PARA GERMAN MOLTO MARTINEZ. Nº REFERENCIA: 6030355.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	12/04/2019
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I BISOS01701 (ANUALIDAD 2017) PARA GERMAN MOLTO MARTINEZ. Nº REFERENCIA: 6030203.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	215	13/03/2019
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I BISOS01701 (ANUALIDAD 2017) PARA GERMAN MOLTO MARTINEZ. Nº REFERENCIA: 6030201.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	13/03/2019
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I ALGOREOSIA (ANUALIDAD 2017) PARA GERMAN MOLTO MARTINEZ. Nº REFERENCIA: 6029317.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	19/12/2018
COLABORACION COMO EXPERTO EN LA EMISION DE INFORMES TECNICOS DE DISEÑO DE ARQUITECTURA DE APLICACION EN LA NUBE Y ASESORAMIENTO TECNICO DE ACUERDO A LOS TERMINOS INDICADOS EN EL DOCUMENTO ANEXO TITULADO "DESCRIPCION TECNICA DE LA PRESTACION DE SERVICIOS I3M-MOBILENDO".-----	MOBILENDO, S.L.	18.000	14/12/2018

EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I SISTRDEAAT (ANUALIDAD 2017) PARA GERMAN MOLTO MARTINEZ. NUMERO DE REFERENCIA 6028846.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	215	16/11/2018
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I BRICDATA17 (ANUALIDAD 2017) PARA GERMAN MOLTO MARTINEZ. NUMERO DE REFERENCIA 6027283.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	19/09/2018
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I GESTPDEAAT 8ANUALIDAD 2016) PARA GERMAN MOLTO MARTINEZ. NUMERO DE REFERENCIA 6023807.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	23/03/2018
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I VEBOT2016 PARA GERMAN MOLTO MARTINEZ. NUMERO DE REFERENCIA 6023180.----	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	05/02/2018
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I SISTRDEAAT(2016) PARA GERMAN MOLTO RODRIGUEZ. NUMERO DE REFERENCIA 6023367.---	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	31/01/2018
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO: 2017/0769/PIDI/02 DICEPROYEC- DESARROLLO DE APLICACIONES CON DATOS INTENSIVOS EN LA NUBE BASADO EN MEJORAS INTERATIVAS DE CALIDAD ITERATIVA- PERTENECIENTES A LA EMPRESA PRODEVELOP, S.L.-----	AENOR INTERNACIONAL, S.A.	500	30/12/2017
NUMERO DE PEDIDO OD 17008726. COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO : 2014/0670/PIDI/17 SEG 2016"CLOUDOPT 14"- MIGRACION A LA NUBE DE SERVICIOS PUBLICOS ABIERTOS DE LA EMPRESA WORDLINE IBERIA , S.A. CODIGO UNESCO 1203.18. EVALUADOR GERMAN MOLTO MARTINEZ.---	AENOR INTERNACIONAL, S.A.	500	18/12/2017
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO: 1996/0228/PIDI/83 SEG 2016 "COCOCLOUD0"-CONFIDENTIAL AND COMPLIANT CLOUDS DE LA EMPRESA ATOS SPAIN, S.A.----------	AENOR INTERNACIONAL, S.A.	400	28/07/2017
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO : 1996/0228/PIDI/82 "EASYIMP000" - COLLABORATIVE DEVELOPMENT OF INTELLIGENT WEARABLE META- PRODUCTS INTHE CLOUD DE LA EMPRESA ATOS SPAIN, S.A.----------	AENOR INTERNACIONAL, S.A.	400	21/07/2017

COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO : 2014/0670/PIDI/08"CLOUDOPT 14"SEG2015-CLOUDOPTING:MIGRACION A LA NUBE DE SERVICIOS PUBLICOS ABIERTOS DE LA EMPRESA WORDLINE IBERIA , S.A ---------- SEGUN NOTA DE ENTREGA 3 DE ABRIL DE 2017	AENOR INTERNACIONAL, S.A.	500	28/04/2017
COLABORACION COMO EXPERTO EN LA EVLAUACION DEL PROYECTO DE I+D+I: 2014/0670/PIDI/06 "CLOUDOPT14" - CLOUDOPTING, PERTENECIENTE A LA EMPRESA WORDLINE IBERIA, S.A.---------- (SEGUN NOTA DE ENTREGA DE FECHA 20/09/2016).	ASOCIACION ESPAÑOLA DE NORMALIZACION	600	04/11/2016
COLABORACION COMO EXPERTO EN LA EVLAUACION DEL PROYECTO DE I+D+I: 1996/0228/PIDI/64 SEGUIMIENTO 2015 "EASYIMP000" COLLABORATIVE DEVELOPMENT OF INTELLIGENT WEARABLE META-PRODUCTS IN THE CLOUD - DE LA EMPRESA ATOS SPAIN, S.A..---------- (SEGUN NOTA DE ENTREGA DE FECHA 24/06/2016).	ASOCIACION ESPAÑOLA DE NORMALIZACION	400	04/11/2016
COLABORACION COMO EXPERTO EN LA EVLAUACION DEL PROYECTO DE I+D+I: 1996/0228/PIDI/71 SEGUIMIENTO 2015 "MODACLOUDS" MODEL-DRIVEN APPROACH FOR DESIGN AND EXECUTION OF APPLICATIONS MULTIPLE CLOUDS - DE LA EMPRESA ATOS SPAIN, S.A.---------- (SEGUN NOTA DE ENTREGA DE FECHA 20/09/2016).	ASOCIACION ESPAÑOLA DE NORMALIZACION	400	04/11/2016
COLABORACION COMO EXPERTO EN LA EVLAUACION DEL PROYECTO DE I+D+I: 1996/0228/PIDI/61 SEGUIMIENTO 2015 "COCOCLOUD0" CONFIDENTIAL AND COMPLIANT CLOUDS, PERTENECIENTE A LA EMPRESA ATOS SPAIN, S.A.---------- (SEGUN NOTA DE ENTREGA DE FECHA 30/06/2016).	ASOCIACION ESPAÑOLA DE NORMALIZACION	400	07/07/2016
COLABORACION COMO EXPERTO EN LA EVLAUACION DEL PROYECTO DE I+D+I: 1996/0228/PIDI/63 SEGUIMIENTO 2015 "CUMULUS000" CERTIFICATION INFRAESTRUCTURES FOR MULTI-LAYER CLOUD SERVICES, PERTENECIENTE A LA EMPRESA ATOS SPAIN, S.A.---------- (SEGUN NOTA DE ENTREGA DE FECHA 19/04/2016).	ASOCIACION ESPAÑOLA DE NORMALIZACION	400	06/05/2016

COLABORACION COMO EXPERTO EN LA EVLAUACION DEL PROYECTO DE I+D+I: 1996/0228/PIDI/56 "MODACLOUDS" SEG2014-MODEL-DRIVEN APPROACH FOR DESIGN AND EXECUTION OF APPLICATIONS ON MULTIPLE CLOUDS - DE LA EMPRESA ATOS SPAIN, S.A.---------- (SEGUN NOTA DE ENTREGA DE FECHA 22/03/2016).	ASOCIACION ESPAÑOLA DE NORMALIZACION	400	15/04/2016
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 2015/0547/PIDI/01 "EVAOS11111" - SOFTWARE DE VIRTUALIZACIIB DE ESCRITORIOS Y APLICACIONES OPEN SOURCES DE LA EMPRESA SOLUTIA INNOVAWORLD TECHNOLOGIES, S.L.---------- (SEGUN NOTA DE ENTREGA DE FECHA 22/03/2016).	ASOCIACION ESPAÑOLA DE NORMALIZACION	600	14/04/2016
COLABORACION COMO EXPERTO EN LA EMISION DE LA TERCERA Y ULTIMA VERSION DE INFORME TECNICO Y ASESORAMIENTO TECNICO DE ACUERDO A LOS TERMINOS INDICADOS EN EL DOCUMENTO ANEXO A LA HOJA DE ENCARGO TITULADO "DESCRIPCION TECNICA DE LA PRESTACION DE SERVICIOS I3M-ALCANZIA". ENTREGA H4 Y H6.---------- (SEGUN NOTA DE ENTREGA DE FECHA 12/01/2016).	ALCANZIA ENERGIA, S.L.	1.393	18/02/2016
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 199/0602/PIDI/07 "SEPRICETRA" - SECURITY AND PROTECTION OF CRITICAL INFRAESTRUCTURE, PERTENECIENTE A LA EMPRESA ETRA INVESTIGACION Y DESARROLLO, S.A.---------- (SEGUN NOTA DE ENTREGA DE FECHA 09/10/2015).	ASOCIACION ESPAÑOLA DE NORMALIZACION	600	10/02/2016
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 1996/0228/PIDI/50 "CUMULUS000" - CERTIFICATION INFRASTRUCTURE FOR MULTI-LAYER CLOUD SERVICES DE LA EMPRESA ATOS SPAIN, S.A.---------- (SEGUN NOTA DE ENTREGA DE FECHA 21/09/2015).	ASOCIACION ESPAÑOLA DE NORMALIZACION	600	10/02/2016
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 1996/0228/PIDI/54 "XIFI000000" - EXPERIMENTAL INFRASTRUCTURES FOR THE FUTURE INTERNET DE LA EMPRESA ATOS SPAIN, S.A.---------- (SEGUN NOTA DE ENTREGA DE FECHA 18/11/2015).	ASOCIACION ESPAÑOLA DE NORMALIZACION	400	10/02/2016
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 1996/228/PIDI/51 "COCOCLOUD0" - CONFIDENTIAL AND COMPLIANT CLOUDS DE LA EMPRESA ATOS SPAIN, S.A.---------- (SEGUN NOTA DE ENTREGA DE FECHA 18/09/2015).	ASOCIACION ESPAÑOLA DE NORMALIZACION	700	10/02/2016

COLABORACION COMO EXPERTO EN LA EMISION DE LA PRIMERA VERSION DE INFORME TECNICO Y ASESORAMIENTO TECNICO DE ACUERDO A LOS TERMINOS INDICADOS EN EL DOCUMENTO ANEXO A LA HOJA DE ENCARGO TITULADO "DESCRIPCION TECNICA DE LA PRESTACION DE SERVICIOS I3M-ALCANZIA". ENTREGA H1 Y H2.---------- (SEGUN NOTA DE ENTREGA DE FECHA 03/12/2015).	ALCANZIA ENERGIA, S.L.	1.771,4	08/02/2016
COLABORACION COMO EXPERTO EN LA EMISION DE LA PRIMERA VERSION DE INFORME TECNICO Y ASESORAMIENTO TECNICO DE ACUERDO A LOS TERMINOS INDICADOS EN EL DOCUMENTO ANEXO A LA HOJA DE ENCARGO TITULADO "DESCRIPCION TECNICA DE LA PRESTACION DE SERVICIOS I3M-ALCANZIA". ENTREGA H3.---------- (SEGUN NOTA DE ENTREGA DE FECHA 23/12/2015).	ALCANZIA ENERGIA, S.L.	821,25	08/02/2016
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 1996/228/PIDI/31 "EASYIMP000" - COLLABORATIVE DEVELOPMENT OF INTELLIGENT WEARABLE META-PRODUCTS IN THE CLOUD.---------- (SEGUN NOTA DE ENTREGA DE FECHA 21/05/2015).	ASOCIACION ESPAÑOLA DE NORMALIZACION	700	28/10/2015
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 1996/228/PIDI/25 "ECO2CLOUDS" - EXPERIMENTAL AWARENESS OF CO2 IN FEDERATED CLOUD SOURCING.---------- (SEGUN NOTA DE ENTREGA DE FECHA 14/01/2015).	ASOCIACION ESPAÑOLA DE NORMALIZACION	600	30/03/2015
EVALUACION COMO EXPERTO TECNICO DEL PROYECTO I+D+I 13COMME360. Nº DE REFERENCIA: 6007594.---------- (SEGUN NOTA DE ENTREGA DE FECHA 20/01/2015).	SGS INTERNATIONAL CERTIFICATION SERVICES IBERICA SA	430	20/02/2015
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 1996/228/PIDI/19 "XIFI000000" - EXPERIMENTAL INFRASTRUCTURES FOR THE FUTURE INTERNET.---------- (SEGUN NOTA DE ENTREGA DE FECHA 23/12/2014).	ASOCIACION ESPAÑOLA DE NORMALIZACION	600	18/02/2015
COLABORACION COMO TEP/SUPERVISOR EN LA SUPERVISION DEL PROCESO DE EVALUACION DEL PROYECTO DE I+D+I: 1996/0228/PIDI/17 ENABLING KNOWLEDGE SUSTAINABILITY USABILITY AND RECOVERY FOR ECONOMIC VALUE_ENSURE.---------- (SEGUN NOTA DE ENTREGA DE FECHA 10/07/2014).	ASOCIACION ESPAÑOLA DE NORMALIZACION	150	21/11/2014

COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 1996/0228/PIDI/13 "MODACLOUDS" - MODEL-DRIVEN APPROACH FOR DESIGN AND EXECUTION OF APPLICATIONS ON MULTIPLE CLOUDS.---------- (SEGUN NOTA DE ENTREGA DE FECHA 27/06/2014).	ASOCIACION ESPAÑOLA DE NORMALIZACION	600	30/07/2014
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 1652 SEG FINAL (CTA-564) "PLATAFORMA CLOUD".---------- (SEGUN NOTA DE ENTREGA DE FECHA 24/09/2013).	ASOCIACION ESPAÑOLA DE NORMALIZACION	500	30/10/2013
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 2009/0121/02 SEGUIMIENTO 2012 "GESTION DE REMODELADO CARDIOVASCULAR MEDIANTE INTERACCION DE TECNOLOGIAS DE MONITORIZACION UBICUA Y CONCEPTOS DEL HUMANO FISIOLOGICO VIRTUAL".---------- (SEGUN NOTA DE ENTREGA DE FECHA 27/06/2013).	ASOCIACION ESPAÑOLA DE NORMALIZACION	400	31/07/2013
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 1520_SEG FINAL(CTA-519) "FCLOUD".---------- (SEGUN NOTA DE ENTREGA DE FECHA 04/06/2013).	ASOCIACION ESPAÑOLA DE NORMALIZACION	500	20/06/2013
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 1652 SEG 2012 (CTA-564) "PLATAFORMA CLOUD".---------- (SEGUN NOTA DE ENTREGA DE FECHA 05/04/2013).	ASOCIACION ESPAÑOLA DE NORMALIZACION	350	26/04/2013
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 2009/0121/PIDI/01 SEGUIMIENTO 2011 CVREMODELA: "GESTION DE REMODELADO CARDIOVASCULAR MEDIANTE INTERACCION DE TECNOLOGIAS DE MONITORIZACION UBICUA Y CONCEPTOS DEL HUMANO FISIOLOGICO VIRTUAL".---------- (SEGUN NOTA DE ENTREGA DE FECHA 13/07/2012).	ASOCIACION ESPAÑOLA DE NORMALIZACION	400	20/07/2012
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 1681 (CTA PRE-1024) "EFX". TECNOLOGIAS PARA EL CALCULO DE ALGORITMOS FINANCIEROS CON ULTRA BAJA LATENCIA.----------	ASOCIACION ESPAÑOLA DE NORMALIZACION	400	01/06/2012
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 1652 PLATAFORMA CLOUD.----------	ASOCIACION ESPAÑOLA DE NORMALIZACION	700	14/12/2011

COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 1068_1519: CVREMODELA "GESTION DE REMODELADO CARDIOVASCULAR MEDIANTE INTERACCION DE TECNOLOGIAS DE MONITORIZACION UBICUA Y CONCEPTOS DEL HUMANO FISIOLOGICO VIRTUAL".----------	ASOCIACION ESPAÑOLA DE NORMALIZACION	700	29/07/2011
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 068/1520-FCLOUD-FRAMEWORK AVANZADO DE SERVICIOS.----------	ASOCIACION ESPAÑOLA DE NORMALIZACION	700	06/04/2011
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: 1508- GMONITOR - DESARROLLO DE NUEVOS SERVICIOS DE MONITORIZACION PARA PLATAFORMAS CLOUD COMPUTING.----------	ASOCIACION ESPAÑOLA DE NORMALIZACION	700	23/02/2011
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: HITO 10.26. "SISTEMA E.R.P. SAAS-EXPERTO.----------	ASOCIACION ESPAÑOLA DE NORMALIZACION	400	03/12/2010
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: HITO 10-51. "DESARROLLO DE UNA PLATAFORMA TECNOLOGICA PAAS PARA APLICACIONES MOVILES EMPRESARIALES EN LA NUBE BAJO DEMANDA.----------	ASOCIACION ESPAÑOLA DE NORMALIZACION	400	03/12/2010
COLABORACION COMO EXPERTO EN LA EVALUACION DEL PROYECTO DE I+D+I: HITO-10-27. "CREACION DE UN CENTRO GRID PARA LA EVALUACION DE LA APLICACION DE ARCHIVO EN UN ENTORNO GRID.----------	ASOCIACION ESPAÑOLA DE NORMALIZACION	400	03/12/2010

4.4. Certificado de Patentes y Registros de Software

Servicio de Promoción y Apoyo a la Investigación, Innovación y Transferencia - I2T
Vicerrectorado de Investigación, Innovación y Transferencia
Camino de Vera s/n Edificio 6G-46022 Valencia
i2t@upv.es

La Universitat Politècnica de València,

HACE CONSTAR

Que según la información disponible en las bases de datos institucionales, D./Dª Moltó Martínez, Germán con DNI 52656437, figura como inventor o autor de activos de propiedad intelectual o industrial bajo titularidad de la UPV cuyo listado se adjunta.

La condición de examen previo en solicitudes de patente de la OEPM se acredita mediante la información de expediente de la misma obtenible en la página de la OEPM que se adjunte al listado.

Lo que hace constar a los efectos oportunos.

Servicio de Promoción y Apoyo a la Investigación, Innovación y Transferencia - I2T
Vicerrectorado de Investigación, Innovación y Transferencia
Camino de Vera s/n Edificio 6G-46022 Valencia
i2t@upv.es

Software y Know How

Título: R-17368-2015 -Elastic Cloud Computing Cluster (EC3)
Fecha registro: 21/05/15

Título: R-17353-2015 -Infrastructure Manager (IM)
Fecha registro: 30/03/15

Título: Advanced Platform for Reproducible Infrastructures in the Cloud via Open Tools (APRICOT)
Fecha registro: 12/05/21

Título: MApReduce on AWS Lambda (MARLA)
Fecha registro: 12/05/21

Título: Task Scheduler as a Service (TaScaaS)
Fecha registro: 12/05/21

Título: R12512-2008 - GRID4BUILD: Un Entorno Grid de Altas Prestaciones para el Análisis Estático y Dinámico y la Visualización en 3D de Estructuras de Edificación
Fecha registro: 15/12/08

Título: Open Source Serverless Computing for Data-Processing Applications (OSCAR)
Fecha registro: 09/12/19

Título: R-17370-2015 - Virtual Machine Image Repository & Catalog (VMRC)
Fecha registro: 21/05/15

Título: Serverless Container-aware Architectures (SCAR)
Fecha registro: 20/02/19

Servicio de Promoción y Apoyo a la Investigación, Innovación y Transferencia - I2T
Vicerrectorado de Investigación, Innovación y Transferencia
Camino de Vera s/n Edificio 6G-46022 Valencia
i2t@upv.es

Título: Runtime Unpredictable Performance Load Balancer (RUPER-LB)
Fecha registro: 19/05/21

4.5. Certificado de Cursos de Formación Permanente (como alumno)

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

FORMACIÓN CONTINUA Y PERMANENTE

Alumno: GERMÁN MOLTÓ MARTÍNEZ

Relación de certificados emitidos como alumno de formación continua y permanente.

Curso	Título	Horas	Créd. ECTS	F. inicio	F. fin	Tipo	Registro
2021-2022	Cómo proporcionar un feedback de calidad	10		1/10/21	22/10/21	Aprovechamiento	21/42668
	Curso incluido en el plan de formación del profesorado del Instituto de Ciencias de la Educación. Actividad financiada con fondos de formación continua de la Generalitat Valenciana.						
2021-2022	Creación de vídeos con preguntas interactivas con Stream y Forms de Microsoft 365	3		27/9/21	27/9/21	Aprovechamiento	21/37685
	Curso incluido en el plan de formación del profesorado del Instituto de Ciencias de la Educación.						
2020-2021	VII Congreso de Innovación Educativa y Docencia en Red - INRED 2021	-		13/7/21	15/7/21	Asistencia	21/29596
2020-2021	DEL SOFÁ Y LAS PALOMITAS A LAS AULAS. ACERCAMIENTO A LA LEY DESDE LA PANTALLA	5		8/6/21	8/6/21	Asistencia	21/21902
2020-2021	Cómo editar tus grabaciones de clases de TEAMS: propuestas para mejorar el resultado final de los vídeos	2		8/3/21	8/3/21	Aprovechamiento	21/9904
	Curso incluido en el plan de formación del profesorado del Instituto de Ciencias de la Educación.						
2020-2021	Gamificación mediante recursos digitales en la enseñanza universitaria	12		10/2/21	24/2/21	Aprovechamiento	21/8542
	Curso incluido en el plan de formación del profesorado del Instituto de Ciencias de la Educación.						
2020-2021	La enseñanza basada en retos	2		19/1/21	19/1/21	Aprovechamiento	21/2953
	Curso incluido en el plan de formación del profesorado del Instituto de Ciencias de la Educación.						
2019-2020	Prevención frente a los contagios por coronavirus SARS-CoV-2 en el trabajo. Personal Docente e Investigador.	2		-	-	Aprovechamiento	20/21248
2019-2020	Lo que saben nuestros entornos de aprendizaje sobre lo que hacen (o no) nuestros alumnos	3		20/2/20	20/2/20	Aprovechamiento	20/7345
	Curso incluido en el plan de formación del alumnado del Instituto de Ciencias de la Educación.						
2019-2020	Comunicación asertiva	4		23/1/20	23/1/20	Aprovechamiento	20/4253
	Curso incluido en el plan de formación del profesorado del Instituto de Ciencias de la Educación.						

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Alumno: GERMÁN MOLTÓ MARTÍNEZ

Relación de certificados emitidos como alumno de formación continua y permanente.

Curso	Título	Horas	Créd. ECTS	F. inicio	F. fin	Tipo	Registro
2018-2019	V CONGRESO DE INNOVACIÓN EDUCATIVA Y DOCENCIA EN RED - INRED 2019	-		11/7/19	12/7/19	Asistencia	19/28058
2018-2019	Jornada de aprendizaje orientado a proyectos Curso dirigido al personal Docente e Investigador de la Universitat Politècnica de València.	6		30/1/19	30/1/19	Aprovechamiento	19/10549
2018-2019	Lenguaje corporal y relaciones sociales: la comunicación no verbal Curso incluido en el plan de formación del profesorado del Instituto de Ciencias de la Educación.	6		5/3/19	12/3/19	Aprovechamiento	19/9733
2018-2019	Gestión académica asociada a la dirección de tesis doctorales en el nuevo marco normativo Curso incluido en el plan de formación del profesorado del Instituto de Ciencias de la Educación.	4		21/2/19	21/2/19	Aprovechamiento	19/5946
2017-2018	Módulo de iniciación a la investigación educativa	100	5	18/1/18	23/1/20	Aprovechamiento	20/7230
2017-2018	TALLER PARA PROFESORES "AULA EMPRENDE"	8		5/7/18	10/7/18	Asistencia	18/29863
2017-2018	Examen Ciclo Superior de Inglés C1 - CERTACLES	-		11/6/18	16/6/18	Competencia	18/28084
2017-2018	JORNADA DE INNOVACIÓN DOCENTE DE LA ETSINF Curso dirigido al personal Docente e Investigador de la Universitat Politècnica de València.	5		3/7/18	3/7/18	Aprovechamiento	18/26608
2017-2018	Educación de la voz Curso incluido en el plan de formación del profesorado del Instituto de Ciencias de la Educación.	8		15/1/18	17/1/18	Aprovechamiento	18/2639
2017-2018	Creación de contenidos con la herramienta LESSONS Curso incluido en el plan de formación del profesorado del Instituto de Ciencias de la Educación.	4		17/1/18	17/1/18	Aprovechamiento	18/2578
2017-2018	INNODOCT 2017	-		25/10/17	27/10/17	Asistencia	17/40367
2016-2017	Elaboración de cuestionarios para la investigación educativa Curso incluido en el plan de formación del profesorado del Instituto de Ciencias de la Educación. Actividad financiada con fondos de formación contínua de la Generalitat Valenciana.	8		16/5/17	18/5/17	Aprovechamiento	17/19203
2016-2017	JORNADA DE INNOVACIÓN DOCENTE DE LA ETSINF	4		19/1/17	19/1/17	Aprovechamiento	17/3061

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Alumno: GERMÁN MOLTÓ MARTÍNEZ

Relación de certificados emitidos como alumno de formación continua y permanente.

Curso	Título	Horas	Créd. ECTS	F. inicio	F. fin	Tipo	Registro
2015-2016	Innovaciones y propuestas para la e-evaluación de competencias en la universidad Curso incluido en el plan de formación del profesorado del Instituto de Ciencias de la Educación	8		1/2/16	10/3/16	Aprovechamiento	16/22365
2015-2016	Competencia transversal. Instrumental específica Curso incluido en el plan de formación del profesorado del Instituto de Ciencias de la Educación	4		27/1/16	27/1/16	Aprovechamiento	16/2896
2015-2016	Ser amables con nosotros mismos: la autocompasión como fuente de autocuidado para afrontar el sufrimiento y disfrutar de la vida Curso incluido en el plan de formación del profesorado del Instituto de Ciencias de la Educación	8		14/1/16	15/1/16	Aprovechamiento	16/2378
2014-2015	REALIZACION DE EXAMENES A TRAVES DE PLATAFORMAS EDUCATIVAS: POLIFORMAT Perteneciente: Formación Pedagógica y Tecnológica Universitaria	10	1	3/6/15	15/7/15	Aprovechamiento	15/35983
2014-2015	LOS CAMBIOS EN LA NORMATIVA DE ACREDITACIÓN DEL PROFESORADO	2	0,08	1/12/14	1/12/14	Asistencia	14/30243
2013-2014	PROGRAMACION DE ASIGNATURAS SEMIPRESENCIALES Y ON LINE Perteneciente: Formación Pedagógica y Tecnológica Universitaria	10	1	12/5/14	12/6/14	Asistencia	18/11207
2013-2014	JORNADAS DE INNOVACIÓN Y DOCENCIA EN RED Jornadas organizadas conjuntamente por el Vicerrectorado de las Tecnologías de la Información y de las Comunicaciones y Vicerrectorado de Estudios, Calidad y Acreditación.	10	0,4	15/7/14	16/7/14	Aprovechamiento	14/25118
2013-2014	ELABORACION DE RECURSOS MULTIMEDIA PARA LA DOCENCIA: PUBLICACIONES DOCENTES CON LA PLANTILLA LATEX DE LA UPV Asignatura incluida en el Título Propio de Experto Universitario en Formación On-Line. Perteneciente: Formación Pedagógica y Tecnológica Universitaria	25	1	15/1/14	6/2/14	Aprovechamiento	14/23369
2013-2014	RECURSOS TECNOLOGICOS DE APOYO AL APRENDIZAJE OFERTADOS POR LA UPV Asignatura incluida en el Título Propio de Experto Universitario en Formación On-Line Perteneciente: Formación Pedagógica y Tecnológica Universitaria	25	1	24/6/14	17/7/14	Aprovechamiento	14/23259

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Alumno: GERMÁN MOLTÓ MARTÍNEZ

Relación de certificados emitidos como alumno de formación continua y permanente.

Curso	Título	Horas	Créd. ECTS	F. inicio	F. fin	Tipo	Registro
2013-2014	BUSQUEDA Y GESTION DE INFORMACION ON LINE Asignatura incluida en el Título Propio de Experto Universitario en Formación On-Line. Perteneciente: Formación Pedagógica y Tecnológica Universitaria	37,5	1,5	30/4/14	29/5/14	Aprovechamiento	14/23230
2013-2014	LA TUTORIA Y EL SEGUIMIENTO DEL TRABAJO DEL ALUMNO Asignatura incluida en el Título Propio de Experto Universitario en Formación On-Line. Perteneciente: Formación Pedagógica y Tecnológica Universitaria	25	1	7/4/14	29/4/14	Aprovechamiento	14/23203
2013-2014	PLATAFORMAS DE TRABAJO COLABORATIVO Asignatura incluida en el Título Propio de Experto Universitario en Formación On-Line. Perteneciente: Formación Pedagógica y Tecnológica Universitaria	25	1	9/6/14	24/6/14	Aprovechamiento	14/23142
2013-2014	LOS BLOGS AL SERVICIO DE LA DOCENCIA Asignatura incluida en el Título Propio de Experto Universitario en Formación On-Line. Perteneciente: Formación Pedagógica y Tecnológica Universitaria	12,5	0,5	6/5/14	27/5/14	Aprovechamiento	14/23124
2013-2014	AULA 2.0. LAS TIC COMO ELEMENTO DINAMIZADOR DE LA INTERACTIVIDAD Asignatura incluida en el Título Propio de Experto Universitario en Formación On-Line. Perteneciente: Formación Pedagógica y Tecnológica Universitaria	12,5	0,5	17/1/14	31/1/14	Aprovechamiento	14/23104
2013-2014	INNOVACIONES Y PROPUESTAS PARA LA E-EVALUACION DE COMPETENCIAS EN LA UNIVERSIDAD Asignatura incluida en el Título Propio de Experto Universitario en Formación On-Line. Perteneciente: Formación Pedagógica y Tecnológica Universitaria	25	1	24/3/14	8/4/14	Aprovechamiento	14/23081
2013-2014	PEDAGOGIA UNIVERSITARIA Y E-LEARNING Asignatura incluida en el Título Propio de Experto Universitario en Formación On-Line. Perteneciente: Formación Pedagógica y Tecnológica Universitaria	25	1	3/2/14	18/2/14	Aprovechamiento	14/23036

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Alumno: GERMÁN MOLTÓ MARTÍNEZ

Relación de certificados emitidos como alumno de formación continua y permanente.

Curso	Título	Horas	Créd. ECTS	F. inicio	F. fin	Tipo	Registro
2013-2014	PLATAFORMAS EDUCATIVAS COMO APOYO A LA ENSEÑANZA Asignatura incluida en el Título Propio de Experto Universitario en Formación On-Line Perteneciente: Formación Pedagógica y Tecnológica Universitaria	25	1	20/1/14	10/2/14	Aprovechamiento	14/23011
2013-2014	REALIZACION DE TAREAS A TRAVES DE PLATAFORMAS EDUCATIVAS: POLIFORMAT Asignatura incluida en el Título Propio de Experto Universitario en Formación On-Line. Perteneciente: Formación Pedagógica y Tecnológica Universitaria	25	1	17/2/14	10/3/14	Aprovechamiento	14/22595
2012-2013	Tus publicaciones en Senia accesibles en RiuNet Curso incluido en el plan de formación del profesorado del Instituto de Ciencias de la Educación	4		21/5/13	21/5/13	Aprovechamiento	13/10317
2012-2013	V JORNADA DE INNOVACIÓN DOCENTE DE LA ETSINF Curso dirigido al personal Docente e Investigador de la Universitat Politècnica de València	4,5		13/12/12	13/12/12	Aprovechamiento	13/1484
2012-2013	Meditación (Mindfulness) Curso incluido en el plan de formación del profesorado del Instituto de Ciencias de la Educación	12		10/1/13	17/1/13	Aprovechamiento	13/1198
2012-2013	CONFERENCIA-COL·LOQUI: “Mirant al futur en la docència de la UPV” Curso incluido en el plan de formación del profesorado del Instituto de Ciencias de la Educación	2		21/1/13	21/1/13	Aprovechamiento	13/1149
2012-2013	CURSO EN PREVENCIÓN DE RIESGOS LABORALES EN LA ACTIVIDAD DOCENTE EN EL AULA O LABORATORIO INFORMÁTICO	15		1/10/12	19/10/12	Aprovechamiento	12/26449
2011-2012	JORNADAS DE INNOVACIÓN EDUCATIVA 2012	16		11/5/12	13/7/12	Asistencia	12/23999
2011-2012	Seducir con la palabra y triunfar en las reuniones	12		11/6/12	12/6/12	Aprovechamiento	12/19056
2011-2012	Habilidades para la vida: mejorando la competencia emocional y relacional	12		25/6/12	29/6/12	Aprovechamiento	12/16552
2011-2012	El uso de las rúbricas para mejorar los criterios de calidad en la evaluación	8		6/6/12	7/6/12	Aprovechamiento	12/15216
2011-2012	La participación del alumnado en la evaluación en la enseñanza universitaria: autoevaluación, evaluación entre iguales y evaluación compartida	8		20/4/12	20/4/12	Aprovechamiento	12/10185

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Alumno: GERMÁN MOLTÓ MARTÍNEZ

Relación de certificados emitidos como alumno de formación continua y permanente.

Curso	Título	Horas	Créd. ECTS	F. inicio	F. fin	Tipo	Registro
2011-2012	El grupo como espacio de aprendizaje	8		1/2/12	2/2/12	Aprovechamiento	12/3093
2011-2012	ECOSISTEMAS DE APRENDIZAJE: RETOS DE LA EDUCACIÓN DE INGENIERÍA/CIENCIAS EN EL SIGLO XXI	6		24/1/12	24/1/12	Aprovechamiento	12/2314
2011-2012	Elaboración del proyecto de investigación	5		26/1/12	26/1/12	Aprovechamiento	12/2281
2011-2012	IV JORNADA DE INNOVACIÓN DOCENTE DE LA ETSINF	4		24/11/11	24/11/11	Aprovechamiento	12/2171
2010-2011	EL PENSAMIENTO ESTADÍSTICO EN LA INVESTIGACIÓN	5		3/6/11	3/6/11	Aprovechamiento	11/24546
2010-2011	II JORNADAS DE PDI. La Acreditación en la trayectoria del profesor universitario y evaluación de su actividad investigadora	6		16/11/10	19/11/10	Asistencia	11/11344
2010-2011	FINANCIACIÓN PÚBLICA	10		1/2/11	8/2/11	Aprovechamiento	11/6009
2010-2011	EL SISTEMA DE I+D+I	5		21/1/11	21/1/11	Aprovechamiento	11/2774
2009-2010	Tablets-PC + Tinta digítal. Una oportunidad para dinamizar las aulas	4		20/4/10	29/4/10	Aprovechamiento	10/12444
2008-2009	JORNADAS DE INTERCAMBIO DE EXPERIENCIAS SOBRE METODOLOGÍAS ACTIVAS PARA LA FORMACIÓN EN COMPETENCIAS	4		8/7/09	8/7/09	Aprovechamiento	09/20217
2008-2009	EL PLAN DOCENCIA EN RED DE LA UPV: OBJETOS Y MÓDULOS DE APRENDIZAJE Y ASIGNATURAS OCW	5		14/7/09	14/7/09	Aprovechamiento	09/19773
2008-2009	METODOLOGÍA PARTICIPATIVA EN LA UNIVERSIDAD	7		15/7/09	15/7/09	Aprovechamiento	09/19669
2008-2009	CÓMO CALCULAR EL TIEMPO DE TRABAJO DEL ESTUDIANTE: LOS ECTS	4		6/7/09	6/7/09	Aprovechamiento	09/17988
2008-2009	IBERGRID'09	-		20/5/09	22/5/09	Asistencia	09/11972
2008-2009	CONSOLIDATE YOUR ENGLISH	21		12/1/09	20/1/09	Aprovechamiento	09/5114
2007-2008	HERRAMIENTAS PARA EL EJERCICIO DE LA FUNCION DOCENTE Perteneciente: Formación Pedagógica y Tecnológica Universitaria	10	1	8/9/07	30/6/08	Asistencia	16/25920
2007-2008	INNOVACION Y MEJORA DE LA ENSEÑANZA Perteneciente: Formación Pedagógica y Tecnológica Universitaria	10	1	8/9/07	30/6/08	Asistencia	16/25904

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Alumno: GERMÁN MOLTÓ MARTÍNEZ

Relación de certificados emitidos como alumno de formación continua y permanente.

Curso	Título	Horas	Créd. ECTS	F. inicio	F. fin	Tipo	Registro
2007-2008	LAS TECNOLOGIAS DE LA INFORMACION Y LA COMUNICACION Perteneciente: Formación Pedagógica y Tecnológica Universitaria	10	1	8/9/07	30/6/08	Asistencia	16/25888
2007-2008	HABILIDADES DOCENTES PARA LA COMUNICACION EDUCATIVA Perteneciente: Formación Pedagógica y Tecnológica Universitaria	50	3	8/9/07	30/6/08	Asistencia	16/25872
2007-2008	EVALUACION DE LOS APRENDIZAJES Perteneciente: Formación Pedagógica y Tecnológica Universitaria	45	2,5	8/9/07	30/6/08	Asistencia	16/25856
2007-2008	MEJORA DE LA TAREA DOCENTE Perteneciente: Formación Pedagógica y Tecnológica Universitaria	7	0,7	8/9/07	30/6/08	Asistencia	16/25840
2007-2008	LA ACCION TUTORIAL EN EL CONTEXTO UNIVERSITARIO Perteneciente: Formación Pedagógica y Tecnológica Universitaria	38	1,8	8/9/07	30/6/08	Asistencia	16/25824
2007-2008	PANORAMICA GENERAL DE LOS METODOS DE APRENDIZAJE-ENSEÑANZA EN LA UNIVERSIDAD Perteneciente: Formación Pedagógica y Tecnológica Universitaria	45	2,5	8/9/07	30/6/08	Asistencia	16/25808
2007-2008	PLANIFICACION DE LA ENSEÑANZA DESDE LA PERSPECTIVA DEL ECTS Perteneciente: Formación Pedagógica y Tecnológica Universitaria	45	2,5	8/9/07	30/6/08	Asistencia	16/25792
2007-2008	DISEÑO DE PROYECTOS Perteneciente: Formación Pedagógica y Tecnológica Universitaria	5	0,5	8/9/07	30/6/08	Asistencia	16/25776
2007-2008	TEORIA DEL APRENDIZAJE EN LA UNIVERSIDAD Perteneciente: Formación Pedagógica y Tecnológica Universitaria	45	2,5	8/9/07	30/6/08	Asistencia	16/25695
2007-2008	LA UNIVERSIDAD COMO ESCENARIO DE LA FORMACION Perteneciente: Formación Pedagógica y Tecnológica Universitaria	5	0,5	8/9/07	30/6/08	Asistencia	16/25679
2007-2008	LA PROFESION DE PROFESOR DE UNIVERSIDAD Perteneciente: Formación Pedagógica y Tecnológica Universitaria	5	0,5	8/9/07	30/6/08	Asistencia	16/25663
2007-2008	EXPERIENCIAS INNOVADORAS EN POLIFORMAT	5		11/7/08	11/7/08	Aprovechamiento	08/20077
2007-2008	INGLÉS ADVANCED	20		15/1/08	7/2/08	Aprovechamiento	08/8078
2006-2007	COACHING PARA DOCENTES: EL DESARROLLO DE HABILIDADES EN EL AULA	12		11/1/07	25/1/07	Aprovechamiento	07/4646

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Alumno: GERMÁN MOLTÓ MARTÍNEZ

Relación de certificados emitidos como alumno de formación continua y permanente.

Curso	Título	Horas	Créd. ECTS	F. inicio	F. fin	Tipo	Registro
2005-2006	Uso eficaz del tiempo: cómo alcanzar el éxito sin estrés	8		7/2/06	9/2/06	Aprovechamiento	IC/49637
2005-2006	Argumentación oral en situaciones del ámbito universitario (B)	8		25/1/06	25/1/06	Aprovechamiento	IC/49422
2005-2006	Los contratos de aprendizaje como elemento favorecedor de la autonomía del alumno	14		19/1/06	2/6/06	Aprovechamiento	IC/49283
2004-2005	El portafolio docente	8		29/6/05	30/6/05	Aprovechamiento	IC/48813
2004-2005	Cognitive thinking tools for the classroom and for collaborative work	8		19/5/05	20/5/05	Aprovechamiento	IC/48760
2004-2005	Estilos de aprendizaje y estrategias de enseñanza	12		4/7/05	5/7/05	Aprovechamiento	IC/48405

4.6. Certificado de Cursos de Formación Permanente (como profesor)

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

FORMACIÓN CONTINUA Y PERMANENTE

Profesor: GERMÁN MOLTÓ MARTÍNEZ

Docencia Universitaria Impartida en cursos de formación continua y permanente.

Curso	Título	Horas	F. inicio	F. fin	Registro
2020-2021	CLOUD COMPUTING CON AMAZON WEB SERVICES (AWS)	60	1/9/20	29/12/21	22/1958
2020-2021	Café con profesorado UPV sobre el Marco de Desarrollo Académico Docente (MDAD) Curso incluido en el plan de formación del profesorado del Instituto de Ciencias de la Educación.	2	6/5/21	6/5/21	21/17612
2019-2020	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES (AWS)	60	1/9/19	29/12/20	21/1156
2019-2020	COMPUTACIÓN Y GESTIÓN DE DATOS EN LA NUBE PARA BIG DATA Perteneciente: Máster en Big Data Analytics	30	20/12/19	11/1/20	20/40062
2019-2020	MODELOS Y ENTORNOS DE GESTIÓN BIG DATA Perteneciente: Máster en Big Data Analytics	10	17/1/20	18/1/20	20/37508
2018-2019	COMPUTACIÓN Y GESTIÓN DE DATOS EN LA NUBE PARA BIG DATA Perteneciente: Máster en Big Data Analytics	30	23/11/18	12/1/19	20/45550
2018-2019	MODELOS Y ENTORNOS DE GESTIÓN BIG DATA Perteneciente: Máster en Big Data Analytics	10	18/12/18	19/1/19	20/45517
2018-2019	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES (AWS)	60	1/9/18	29/12/19	20/5463
2018-2019	SISTEMAS INTELIGENTES Y TECNOLOGÍAS EMERGENTES	13	1/7/19	19/7/19	19/33726
2017-2018	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES (AWS)	60	1/9/17	29/12/18	19/2562
2016-2017	COMPUTACIÓN Y GESTIÓN DE DATOS EN LA NUBE PARA BIG DATA Perteneciente: Máster en Big Data Analytics	30	16/12/16	14/1/17	18/21655
2016-2017	MODELOS Y ENTORNOS DE GESTIÓN BIG DATA Perteneciente: Máster en Big Data Analytics	10	20/1/17	20/1/17	18/21644
2016-2017	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES (AWS)	50	1/9/16	9/11/17	17/46801
2015-2016	COMPUTACIÓN Y GESTIÓN DE DATOS EN LA NUBE PARA BIG DATA II Perteneciente: Máster en Big Data Analytics	10	16/1/16	22/1/16	18/21305
2015-2016	MODELOS Y ENTORNOS DE GESTIÓN BIG DATA Perteneciente: Máster en Big Data Analytics	10	22/1/16	23/1/16	18/21269

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Profesor: GERMÁN MOLTÓ MARTÍNEZ

Docencia Universitaria Impartida en cursos de formación continua y permanente.

Curso	Título	Horas	F. inicio	F. fin	Registro
2015-2016	COMPUTACIÓN Y GESTIÓN DE DATOS EN LA NUBE PARA BIG DATA Perteneciente: Máster en Big Data Analytics	20	9/1/16	16/1/16	18/21268
2015-2016	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES	50	2/9/15	9/11/16	16/51391
2014-2015	MODELOS Y ENTORNOS DE GESTIÓN BIG DATA Perteneciente: Máster en Big Data Analytics	10	23/1/15	24/1/15	16/8961
2014-2015	COMPUTACIÓN Y GESTIÓN DE DATOS EN LA NUBE PARA BIG DATA Perteneciente: Máster en Big Data Analytics	20	9/1/15	17/1/15	16/8960
2014-2015	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES	30	5/9/14	20/10/15	15/41785
2013-2014	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES	25	9/6/14	14/7/14	14/17967
2013-2014	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES	12	28/4/14	26/5/14	14/11592
2013-2014	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES	12	10/3/14	7/4/14	14/8648
2013-2014	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES	12	27/1/14	24/2/14	14/4506
2013-2014	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES	12	25/11/13	16/12/13	13/30587
2013-2014	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES	12	9/10/13	30/10/13	13/24577
2012-2013	INTRODUCCIÓN AL CLOUD COMPUTING CON AMAZON WEB SERVICES	12	25/3/13	27/3/13	13/22526
2012-2013	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES	12	8/7/13	26/7/13	13/22523
2012-2013	INTRODUCCION AL CLOUD COMPUTING Perteneciente: Diploma de Especialización en Servicios y Aplicaciones Móviles (SAM)	5	1/2/13	2/2/13	13/22422

4.7. Certificado de Cursos de Formación Permanente (como responsable)

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

FORMACIÓN CONTINUA Y PERMANENTE

Responsable: GERMÁN MOLTÓ MARTÍNEZ

Relación de certificados emitidos como responsable de cursos de formación continua y permanente.

Curso	Título	Horas	F. inicio	F. fin	Tipo	Registro
2020-2021	CLOUD COMPUTING CON AMAZON WEB SERVICES (AWS)	60	1/9/20	29/12/21	Responsable de actividad	22/1959
2019-2020	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES (AWS)	60	1/9/19	29/12/20	Responsable de actividad	21/3442
2018-2019	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES (AWS)	60	1/9/18	29/12/19	Responsable de actividad	20/5464
2017-2018	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES (AWS)	60	1/9/17	29/12/18	Responsable de actividad	19/2563
2016-2017	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES (AWS)	50	1/9/16	9/11/17	Director/a del curso	17/46802
2015-2016	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES	50	2/9/15	9/11/16	Director/a del curso	16/51392
2014-2015	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES	30	5/9/14	20/10/15	Director/a del curso	15/41786
2013-2014	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES	30	9/6/14	14/7/14	Director/a del curso	14/17968
2013-2014	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES	-	28/4/14	26/5/14	Director/a del curso	14/11593
2013-2014	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES	-	10/3/14	7/4/14	Director/a del curso	14/8649
2013-2014	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES	-	27/1/14	24/2/14	Director/a del curso	14/4507
2013-2014	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES	-	25/11/13	23/12/13	Director/a del curso	13/30588
2013-2014	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES	-	9/10/13	30/10/13	Director/a del curso	13/24578
2012-2013	INTRODUCCIÓN AL CLOUD COMPUTING CON AMAZON WEB SERVICES	12	25/3/13	27/3/13	Director/a del curso	13/22527
2012-2013	CURSO ONLINE DE CLOUD COMPUTING CON AMAZON WEB SERVICES	-	8/7/13	26/7/13	Director/a del curso	13/22524

Capítulo 5

Justificación Documental de los Principales Méritos Alegados

La selección de méritos se ha realizado siguiendo las directrices de la ANECA para el programa ACADEMIA de acreditación a plazas de Catedrático de Universidad, que distingue las publicaciones entre muy relevantes y relevantes.

Por motivos de brevedad, tan solo se incluye la primera y la última página del artículo, salvo aquellos casos en los que los agradecimientos a los proyectos no están en la última página. En cualquier caso, se incluye un enlace mediante el DOI correspondiente para poder verificar la autenticidad de la publicación.

5.1. Méritos de Investigación

5.1.1. Publicaciones Muy Relevantes

Las contribuciones muy relevantes son aquellas que están publicadas en revistas situadas en el primer cuartil (Q1) del Journal Citation Reports (JCR)[1], así como congresos clase 1 del listado GII-GRIN-SCIE[2].

[1] Journal Citation Reports - Clarivate. https://jcr.clarivate.com
[2] Índice GII-GRIN-SCIE. https://scie.lcc.uma.es:8443/

5.1.1.1. Combining Neural Networks and Genetic Algorithms to Predict and Reduce Diesel Engine Emissions

J. M. Alonso, F. Alvarruiz, J. M. Desantes, L. Hernández, V. Hernández, and G. Moltó, "Combining Neural Networks and Genetic Algorithms to Predict and Reduce Diesel Engine Emissions," IEEE Trans. Evol. Comput., vol. 11, no. 1, pp. 46–55, Feb. 2007, doi: https://dx.doi.org/10.1109/TEVC.2006.876364.

Base de datos de indexación	SCI
Índice de impacto	2.426
Año	2007
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	5 de 79
Tercil	T1
Cuartil	Q1
Número de citas en JCR	92
Número de citas totales	157

Comentario. Este artículo supuso mi primera colaboración con el Departamento de Máquinas y Motores Térmicos de la Universitat Politècnica de València y en el se utilizaron mecanismos de entrenamiento basados en redes neuronales y de predicción mediante algoritmos genéticos para obtener configuraciones óptimas de funcionamiento de motores diésel para minimizar las emisiones contaminantes. Más de una década después todavía recibe citas, algunas de ellas procedentes de importantes revistas del área como IEEE Evolutionary Computation o Applied Energy.

Combining Neural Networks and Genetic Algorithms to Predict and Reduce Diesel Engine Emissions

José M. Alonso, Fernando Alvarruiz, José M. Desantes, Leonor Hernández, Vicente Hernández, and Germán Moltó

***Abstract*—Diesel engines are fuel efficient which benefits the reduction of CO_2 released to the atmosphere compared with gasoline engines, but still result in negative environmental impact related to their emissions. As new degrees of freedom are created, due to advances in technology, the complicated processes of emission formation are difficult to assess. This paper studies the feasibility of using artificial neural networks (ANNs) in combination with genetic algorithms (GAs) to optimize the diesel engine settings. The objective of the optimization was to find settings that complied with the increasingly stringent emission regulations while also maintaining, or even reducing the fuel consumption. A large database of stationary engine tests, covering a wide range of experimental conditions was used for this analysis. The ANNs were used as a simulation tool, receiving as inputs the engine operating parameters, and producing as outputs the resulting emission levels and fuel consumption. The ANN outputs were then used to evaluate the objective function of the optimization process, which was performed with a GA approach. The combination of ANN and GA for the optimization of two different engine operating conditions was analyzed and important reductions in emissions and fuel consumption were reached, while also keeping the computational times low.**

***Index Terms*—Diesel engines, emission regulations, genetic algorithms (GAs), neural networks.**

I. Introduction

OVER THE LAST few decades, the industrial and economic expansion of developed countries has involved a sharp increase in vehicle production and transport volume. Environmental concerns such as global warming, greenhouse effects, acid rain, and air pollution problems related to the emissions of carbon dioxide (CO_2), nitrogen oxides (NOx), particulate matter (PM), carbon monoxide (CO), and unburned hydrocarbons (HC), together with the consumption of fossil fuels, combine to create serious problems at a global level [1].

In that sense, the exhaust emission regulatory bodies around the world have been simultaneously reducing the admissible limits on exhaust emissions over the last decades, while the market has also been striving to maintain or even reduce fuel consumption [2].

In order to comply with these regulations, the diesel engine industry has undergone a great technological development in the last few years, creating a high number of new strategies such as electronic control, new injection systems allowing higher pressures, different injection events, etc., [3]–[6]. As a result, the problem of optimizing the engine management in order to simultaneously comply with emission regulations and fuel economy requirements has become a difficult task, especially due to the increased number of degrees of freedom in the engine operating parameters. This optimization process is carried out during the development of a new engine, and is usually known in the mechanical engineering field as *engine calibration*. Although calibrations were in the past based entirely on empirical results, the development in technology has incorporated new model-based techniques [7]–[12].

The formation of the different kinds of pollutants in diesel engines as a result of combustion is a complex process that depends on local variables, and is also highly dependent on the engine settings, influences, and interconnections. Physical and chemical models have been proposed but a general solution has not yet been found [13]–[16]. Computational fluid dynamic codes require detailed unknown local data and also imply large calculation times [17].

Artificial neural networks (ANNs) are an emerging tool of artificial intelligence, which have been shown to be effective in solving a wide range of problems, including many applications to engine modeling [18]. The structure of ANNs enables them to model complex nonlinear multiple problems, which makes them a well-suited method for pollutant modeling. In addition, an ANN can produce fast prediction responses, which represent an important advantage in comparison with alternative modeling techniques, such as physical and chemical models.

As a first objective in this paper, ANN modeling was used to predict diesel NOx, PM, CO, HC exhaust emissions, and brake specific fuel consumption (BSFC) in terms of engine operating parameters. The working operation of the engine is defined by the combination of the engine operating parameters values, which in turn determine the engine exhaust emission levels and fuel consumption. The number of operating parameters has increased in the last few years due to the engine development, making it difficult to directly combine them to comply with different constraints.

The second main objective of the study was to define an optimization process that, using the ANN predictions, could find combinations of operating parameters that simultaneously minimize fuel consumption, while also keeping the overall emissions

Manuscript received August 6, 2004; revised July 19, 2005 and November 23, 2005.This work was supported in part by the Plan Valenciano de Investigación Científica, Desarrollo Tecnológico e Innovación from the Conselleria de Empresa, Universidad y Ciencia of the Generalitat Valenciana, Spain, under Project CITDIB/2002/34.

J. M. Alonso, F. Alvarruiz, V. Hernández, and G. Moltó are with the High Performance Networking and Computing Group, Universidad Politécnica de Valencia, Valencia 42022, Spain (e-mail: jmalonso@dsic.upv.es; fbermejo@dsic.upv.es; vhernand@dsic.upv.es; gmolto@dsic.upv.es).

J. M. Desantes is with the CMT-Thermal Engines Group, Universidad Politécnica de Valencia, Valencia 46022, Spain (e-mail: jmdesant@mot.upv.es).

L. Hernández is with the Departamento de Ingeniería Mecánica y Construcción, Universitat Jaume I, Castellón de la Plana 12071, Spain (e-mail: lhernand@emc.uji.es).

Digital Object Identifier 10.1109/TEVC.2006.876364

[35] J. Galindo, J. M. Luján, J. R. Serrrano, and L. Hernández, "Combustion simulation of turbocharger HSDI Diesel engines during transient operation using neural networks," *Appl. Thermal Eng.*, vol. 25/5-6, pp. 877–898, 2005.
[36] C. Wang, S. S. Venkatesh, and J. S. Judd, "Optimal stopping and effective machine complexity in learning," in *Proc. Conf. Neural Inf. Process. Syst.*, Denver, CO, 1993, pp. 303–310.
[37] K. Levenberg, "A method for the solution of certain non-linear problems in least squares," *Quart. Appl. Math.*, vol. 2, pp. 164–168, 1944.
[38] D.W. Marquardt, "An algorithm for least-squares estimations of nonlinear parameters," *SIAM J. Appl. Math.*, vol. 11, pp. 431–441, 1963.
[39] L. Davis, *The Handbook of Genetic Algorithms*. New York: Van Nostrand Reingold, 1992.
[40] Z. Michalewicz, *Genetic Algorithms + Data Structures = Evolution Programs*. New York: Springer-Verlag, 1996, AI Series.
[41] A. H. Wright, "Genetic algorithms for real parameter optimization," in *Foundations of Genetic Algorithms*. San Mateo, CA: Morgan Kauffman, 1991, pp. 205–218.
[42] D. D. Wickman, P. K. Senecal, and R. D. Reitz, "Diesel engine combustion chamber geometry optimization using genetic algorithms and multi-dimensional spray and combustion modeling," SAE 2001-01-0547, 2001.
[43] M. J. Brauer, M. T. Holder, L. A. Dries, D. J. Zwickl, P. O. Lewis, and D. M. Hillis, "Genetic algorithms and parallel processing in maximum-likelihood phylogeny inference," *Molecular Biology and Evolution*, vol. 10, no. 19, pp. 1717–1726, 2002.
[44] T. Starkweather, D. Whitley, and K. Mathias, "Optimization using distributed genetic algorithms," *Lecture Notes in Computer Science*, vol. 496, pp. 176–185, 1991.
[45] J. E. Baker, "Reducing bias and inefficiency in the selection algorithm," in *Proc. 2nd Int. Conf. Genetic Algorithms*, 1987, pp. 14–21.
[46] H. Mühlenbein and D. Schlierkamp-Voosen, "Predictive models for the breeder genetic algorithms," *Evol. Comput.*, vol. 1, no. 1, pp. 25–49, 1993.
[47] R. Salomon, "Short notes on the schema theorem and the building bock hypothesis in genetic algorithms," in *Evolutionary Programming VII*. New York: Springer-Verlag, 1998, pp. 113–122.
[48] D. M. Tate and A. E. Smith, "Expected allele coverage and the role of mutation in genetic algorithms," in *Proc. ICGA 5*, 1993, pp. 31–37.
[49] A. Chipperfield, P. Fleming, H. Pohlheim, and C. Fonseca, Genetic algorithm toolbox user's guide 1.2 Dept. Autom. Control Syst. Eng., Univ. Sheffield. Sheffield, U.K. [Online]. Available: http://www.shef.ac.uk/content/1/c6/03/35/06/manual.pdf

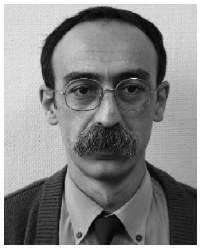
José M. Alonso received the M.Sc. degree in computer science from the Universidad Politécnica de Valencia (UPV), Valencia, Spain, in 1997. He is currently working towards the Ph.D. degree in the field of parallel and grid computing in simulation of building structures at UPV

He is a member of the High Performance Networking and Computing Group, UPV, since 1996. Since 2000, he has been an Assistant Lecturer at UPV. He has also participated in different research projects about the application of parallel and grid computing techniques to several areas of engineering. Other fields of interest include neural networks and evolutionary computation.

Fernando Alvarruiz received the M.Sc. degree in computer science from the Universidad Politécnica de Valencia (UPV), Valencia, Spain, in 1995. He is currently working towards the Ph.D. degree, related to the application of parallel computing to simulation and optimization processes in water distribution networks at UPV.

Since 2000, he has been an Assistant Lecturer at UPV. Other fields of interest include neural networks and evolutionary computation.

Mr. Alvarruiz received a scholarship for postgraduate studies in the High Performance Networking and Computing Group, UPV.



José M. Desantes received the Degree in mechanical engineering from the Universidad Politécnica de Madrid, Madrid, Spain, in 1978 and the Ph.D. degree in engineering from the Universidad Politécnica de Valencia (UPV), Valencia, Spain, in 1980.

Since 1984, he has been a Full Professor at the Department of Thermal Engines, UPV. Director of the University Research Institute CMT-Motores Térmicos, he has collaborated in 150 journal and conference papers related to ICE topics. He has supervised 15 Ph.D. thesis, has collaborated in 200 research projects funded by national programs, European union programs, or directly by the industry. His research interest is on thermofluidynamics of internal combustion engines (ICE), mainly focused in pollutant emission control and engine efficiency improvements.

Leonor Hernández received the Degree in physics from the Universidad de Valencia, Valencia, Spain, in 1998 and the Ph.D. degree from the Universidad Politécnica de Valencia (UPV), Valencia, in 2004.

Since 2005, she holds an Assistant Lecturer position at the Universitat Jaume I, Castellón, Spain. Her research interests are in emission modeling and optimization techniques.

Vicente Hernández received the Ph.D. degree in mathematics from the Universidad de Valencia, Valencia, Spain, in 1979.

Since 1991, he has been a Full Professor in the Department of Information Systems and Computation, Universidad Politécnica de Valencia (UPV), Valencia. Leader of the High Performance Networking and Computing Group, he has written over 220 journal and conference papers on numerical methods, parallel computing, grid computing and their applications on different fields. He has supervised over 20 Ph.D. thesis on computational science and applied mathematics. He has acted as coordinator or main researcher in more than 30 projects funded by national and international programs.

Germán Moltó was born in Valencia, Spain, on January 6, 1979. He received the M.Sc. degree in computer science from the Universidad Politécnica de Valencia (UPV), Valencia, Spain, in 2002. He is currently working towards the Ph.D. degree in the field of grid computing applied to biomedical applications at UPV.

Since 2002, he has been a Researcher at the High Performance Networking and Computing Group, UPV. In 2005, he received an Assistant Lecturer position.

5.1.1.2. Vulnerability to Reentry in a Regionally Ischemic Tissue: A Simulation Study

B. Trénor, L. Romero, J. M. Ferrero, J. Sáiz, G. Moltó, and J. M. Alonso, "Vulnerability to Reentry in a Regionally Ischemic Tissue: A Simulation Study," Ann. Biomed. Eng., vol. 35, no. 10, pp. 1756–1770, Oct. 2007, doi: https://dx.doi.org/10.1007/s10439-007-9353-3

Base de datos de indexación	SCI
Índice de impacto	2.346
Año	2007
Categoría	Engineering, Biomedical
Posición de la revista en el área	11 de 44
Tercil	T1
Cuartil	Q1
Número de citas en JCR	27
Número de citas totales	42

Comentario. Este artículo involucró el uso del simulador paralelo de la actividad eléctrica cardíaca que implementé en el marco del proyecto de Plan Nacional de Investigación Científica de código TEC 2005-04199 y durante mi tesis doctoral, para poder analizar la vulnerabilidad a reentradas de tejidos cardiacos en situación de isquemia.

Annals of Biomedical Engineering, Vol. 35, No. 10, October 2007 *(© 2007)* pp. 1756–1770
DOI: 10.1007/s10439-007-9353-3

Vulnerability to Reentry in a Regionally Ischemic Tissue: A Simulation Study

BEATRIZ TRÉNOR,[1,2] LUCÍA ROMERO,[1] JOSÉ MARÍA FERRERO JR.,[1] JAVIER SÁIZ,[1] GERMÁN MOLTÓ,[3] and JOSÉ MIGUEL ALONSO[3]

[1]Centro de Investigación e Innovación en Bioingeniería, Universidad Politécnica de Valencia, Camino de Vera s/n, Valencia 46022, Spain; [2]Departamento de Ingeniería Electrónica, Universidad Politécnica de Valencia, Camino de Vera s/n, Valencia 46022, Spain; and [3]Departamento de Sistemas Informáticos y Computación, Universidad Politécnica de Valencia, Camino de Vera s/n, Valencia 46022, Spain

(Received 30 November 2006; accepted 29 June 2007; published online 7 July 2007)

Abstract—Sudden cardiac death is mainly provoked by arrhythmogenic processes. During myocardial ischemia many malignant arrhythmias, such as reentry, take place and can degenerate into ventricular fibrillation. It is thus of great interest to unravel the intricate mechanisms underlying the initiation and maintenance of a reentry. In this computational study, we analyze the probability of reentry during different stages of the acute phase of ischemia. We also aimed at the understanding of the role of its main components: hypoxia, hyperkalemia, and acidosis analyzing the intricate ionic mechanisms responsible for reentry generation. We simulated the electrical activity of a ventricular tissue affected by regional ischemia based on a modified version of the Luo-Rudy model (LRd00). The ischemic conditions were varied to simulate different stages of this pathology. After premature stimulation, we evaluated the vulnerability to reentry. We obtained an unimodal behavior for the vulnerable window as ischemia progressed, peaking at the eighth minute after the onset of ischemia where the vulnerable window yielded 58 ms. Under more severe conditions the vulnerable window decreased and became zero for minute 8.75. The present work provides insight into the mechanisms of reentry generation during ischemia, highlighting the role of acidosis and hypoxia when hyperkalemia is present.

Keywords—Ischemia, Reentrant arrhythmias, Ionic mechanisms, Vulnerable window, Hypoxia, Acidosis, Hyperkalemia.

INTRODUCTION

Ventricular fibrillation (VF) remains a notable cause of sudden death and much attention has been paid to the mechanisms that initiate and sustain these lethal events. There is substantial experimental evidence to support the belief that reentrant arrhythmias are a precursor to VF.[22] However, the initiation and maintenance mechanisms for reentry are still not completely understood and currently represent an important research problem.

It is well known that slow conduction and unidirectional block (UDB) set the stage for reentry[23] after a premature stimulation. Many experimental[5,21,27,31] and computational studies[2,9,47] have also been undertaken to evaluate the effects of dispersion of electrophysiological conditions within the heart muscle on the vulnerability to reentry. For instance, Gough *et al.*[21] demonstrated experimentally that the spatial pattern of refractoriness was fundamental to reentry development. Simulation studies have also shed light on the effects of action potential duration (APD) and heterogeneities in refractoriness on reentrant arrhythmias under different circumstances.[2,9,47]

Electrophysiological heterogeneities arise under several heart pathologies, such as ischemia. Under ischemic conditions, within the acute phase, the lack of oxygen and glucose in cardiac cells alters many electrophysiological parameters. First, hypoxia significantly reduces APD in the ischemic tissue.[17,51] Second, extracellular potassium accumulation delays action potential (AP) propagation, thus conduction velocity (CV) is reduced,[26] excitability is decreased and post-repolarization refractoriness[14,23,41] arises in the affected tissue. Finally, acidosis alters the activity of certain ionic channels.[24] As ischemia progresses, within the sub-acute phase, cellular uncoupling[23] and many other electrophysiological alterations take place.

The aforementioned electrophysiological alterations arising within the acute phase of myocardial ischemia, predispose the heart to the occurrence of reentrant arrhythmias.[23,53] Indeed, heterogeneities between the affected tissue and normal tissue favor UDB. It has also been documented that the likelihood of arrhythmias

Address correspondence to Beatriz Trénor, Departamento de Ingeniería Electrónica, Universidad Politécnica de Valencia, Camino de Vera s/n, Valencia 46022, Spain. Electronic mail: btrenor@eln.upv.es

APD reduction induced by $I_{K(ATP)}$ activation was also the reason behind the asymmetric unimodal distribution of the VW for reentry. And finally hyperkalemia was proved to be pivotal to initiate reentry.

Clinical Implications

As regional ischemia in the heart is clinically far more common than global ischemia, this study was intended to rigorously analyze the ionic mechanisms leading to reentry in the time course of regional ischemia. Much attention has been paid to the reentrant mechanism as it has been identified as one of the major culprits in the genesis of VF, which provokes sudden cardiac death.

The higher vulnerability to reentry before 10 min of acute myocardial ischemia, which has been experimentally reported,[10] has been approached in this study. An important finding of this study was the widespread conduction block and suppression of reentry after 10 min of acute ischemia, which could explain the spontaneous termination of reentry during continued ischemia.

The steep unimodal behavior of the VW in the time course of acute ischemia obtained in our simulations is an indicator of vulnerability to reentries, but not totally equivalent. The probability of reentrant arrhythmias would be represented by a flatter curve, especially for the later stages of acute ischemia. Indeed, under severe ischemia, when narrower VWs were obtained, it is to be noted that reentries were elicited for higher CIs than in earlier stages of ischemia. Clinically, acceleration of the sinus rhythm or spontaneous premature stimuli would arise at higher CIs. Thus, when both factors are considered, i.e., width of the VW and probability of spontaneous activity, the curve of vulnerability to reentry would become flatter and more symmetrical.

As regards the mechanisms of action leading to reentrant arrhythmias during myocardial ischemia, it remains to be determined which of these are most important in clinical observations. Our simulations showed that the incidence of arrhythmias depends on multiple factors simultaneously and not in a monotonic manner, giving a theoretical frame and support to experimental and clinical observations of concomitant proarrhythmic and antiarrhythmic effects of drug treatments.[32] Indeed, antiarrhythmic drugs have been tested to prevent initiation of VT, via the suppression of triggered activity or by altering the substrate for reentry.[50] However, the failure of these clinical therapies has proven the necessity of new therapeutical approaches. In this way, the mechanistic insight provided by this work and other simulation studies, may represent an important starting point for researchers.

Limitations of the Study

Simulations were confined to 2D representations of tissue structure. Despite the electrophysiological detail considered by the AP model and the realistic ischemic representation, anatomic and mechanic effects are not taken into account in our study. Not only these considerations, but also transmural effects are of importance in the genesis of ventricular arrhythmias,[8,55] as noteworthy differences in electrical behavior of endocardium and epicardium alter the activation patterns. In this way, a 3D setting would therefore be expected to alter our quantitative findings.

In trying to reproduce realistically regional ischemia, we simulated a round shaped CZ and a ring shaped BZ of a specific dimension so as to nest reentries. However, regional heterogeneities in infarcted hearts are highly variable in size and shape, and also (though in a lesser extent) in gradient.

The central ischemic zone we defined in this work simulated the three main components of acute ischemia. However, it is well documented that other changes arise in the course of myocardial ischemia, such as the inhibition of the sodium potassium pump[37,52] or further alterations in ionic currents exerted by acidosis.[24,49]

Despite these limitations, our simulations are an attempt to rigorously examine the intricate mechanisms leading to reentry in a regional ischemic myocardial tissue. They have also provided insight of how different degrees of ischemia impact vulnerability to reentrant arrhythmias. Although our quantitative findings would depend on the simulation conditions and the model chosen, attention must be paid to the formulated mechanistic hypothesis and the qualitative results.

ACKNOWLEDGMENT

This work was partially supported by the "Plan Nacional de Investigación Científica, Desarrollo e Innovación Tecnológica del Ministerio de Educación y Ciencia" of Spain (TEC 2005-04199).

REFERENCES

[1]Arce, H., A. Xu, H. Gonzalez, and M. R. Guevara. Alternans and higher-order rhythms in an ionic model of a sheet of ischemic ventricular muscle. *Chaos* 10:411–426, 2000.

[2]Bardou, A. L., P. M. Auger, S. Achour, P. Dumee, P. J. Birkui, and M. C. Govaere. Effect of myocardial infarction and ischemia on induction of cardiac reentries and ventricular fibrillation. *Acta Biotheor*. 43:363–372, 1995.

[3]Biktasheva, I. V., R. D. Simitev, R. Suckley, and V. N. Biktashev. Asymptotic properties of mathematical models of excitability. *Philos. Transact. A Math. Phys. Eng Sci.* 364:1283–1298, 2006.

[4]Cascio, W. E. Myocardial ischemia: what factors determine arrhythmogenesis? *J. Cardiovasc. Electrophysiol.* 12:726–729, 2001.

[5]Chen, P. S., P. D. Wolf, E. G. Dixon, N. D. Danieley, D. W. Frazier, W. M. Smith, and R. E. Ideker. Mechanism of ventricular vulnerability to single premature stimuli in open-chest dogs. *Circ. Res.* 62:1191–1209, 1988.

[6]Cimponeriu, A., C. F. Starmer, and A. Bezerianos. A theoretical analysis of acute ischemia and infarction using ECG reconstruction on a 2D model of myocardium. *IEEE Trans. Biomed. Eng.* 48:41–54, 2001.

[7]Cinca, J., M. Warren, A. Carreno, M. Tresanchez, L. Armadans, P. Gomez, and J. Soler-Soler. Changes in myocardial electrical impedance induced by coronary artery occlusion in pigs with and without preconditioning: correlation with local ST-segment potential and ventricular arrhythmias. *Circulation* 96:3079–3086, 1997.

[8]Clayton, R. H., and A. V. Holden. Effect of regional differences in cardiac cellular electrophysiology on the stability of ventricular arrhythmias: a computational study. *Phys. Med. Biol.* 48:95–111, 2003.

[9]Clayton, R. H., and A. V. Holden. Dispersion of cardiac action potential duration and the initiation of re-entry: a computational study. *Biomed. Eng Online* 4:11, 2005.

[10]Coronel, R. Heterogeneity in extracellular potassium concentration during early myocardial ischaemia and reperfusion: implications for arrhythmogenesis. *Cardiovasc. Res.* 28:770–777, 1994.

[11]Coronel, R., J. W. Fiolet, F. J. Wilms-Schopman, A. F. Schaapherder, T. A. Johnson, L. S. Gettes, and M. J. Janse. Distribution of extracellular potassium and its relation to electrophysiologic changes during acute myocardial ischemia in the isolated perfused porcine heart. *Circulation* 77:1125–1138, 1988.

[12]Coronel, R., F. J. Wilms-Schopman, L. R. Dekker, and M. J. Janse. Heterogeneities in $[K+]_o$ and TQ potential and the inducibility of ventricular fibrillation during acute regional ischemia in the isolated perfused porcine heart. *Circulation* 92:120–129, 1995.

[13]de Groot, J. R., and R. Coronel. Acute ischemia-induced gap junctional uncoupling and arrhythmogenesis. *Cardiovasc. Res.* 62:323–334, 2004.

[14]Downar, E., M. J. Janse, and D. Durrer. The effect of "ischemic" blood on transmembrane potentials of normal porcine ventricular myocardium. *Circulation* 55:455–462, 1977.

[15]Downar, E., J. Saito, J. C. Doig, T. C. Chen, E. Sevaptsidis, S. Masse, S. Kimber, L. Mickleborough, and L. Harris. Endocardial mapping of ventricular tachycardia in the intact human ventricle. III. Evidence of multiuse reentry with spontaneous and induced block in portions of reentrant path complex. *J. Am. Coll. Cardiol.* 25:1591–1600, 1995.

[16]Faber, G. M., and Y. Rudy. Action potential and contractility changes in [Na(+)](i) overloaded cardiac myocytes: a simulation study. *Biophys. J.* 78:2392–2404, 2000.

[17]Ferrero, J. M. Jr., J. Saiz, J. M. Ferrero, and N. V. Thakor. Simulation of action potentials from metabolically impaired cardiac myocytes. Role of ATP-sensitive K+ current. *Circ. Res.* 79:208–221, 1996.

[18]Ferrero, J. M. Jr., J. Saiz, J. M. Ferrero Sr., and N. V. Thakor. Postrepolarization refractoriness in ventricular cardiac cells: a simulation study. *Comput. Cardiol.* 26:487–490, 1999.

[19]Ferrero, J. M. Jr., B. Trenor, B. Rodriguez, and J. Saiz. Electrical activity and reentry during acute regional myocardial ischemia: insights from simulations. *Intl. J. Bifurcat. Chaos* 13:67–78, 2003.

[20]Gilmour, R. F. Jr., and D. P. Zipes. Different electrophysiological responses of canine endocardium and epicardium to combined hyperkalemia, hypoxia, and acidosis. *Circ. Res.* 46:814–825, 1980.

[21]Gough, W. B., R. Mehra, M. Restivo, R.H. Zeiler, and N. el Sherif. Reentrant ventricular arrhythmias in the late myocardial infarction period in the dog. 13. Correlation of activation and refractory maps. *Circ. Res.* 57:432–442, 1985.

[22]Jalife, J. Ventricular fibrillation: mechanisms of initiation and maintenance. *Annu. Rev. Physiol.* 62:25–50, 2000.

[23]Janse, M. J., and A. G. Kleber. Electrophysiological changes and ventricular arrhythmias in the early phase of regional myocardial ischemia. *Circ. Res.* 49:1069–1081, 1981.

[24]Kagiyama, Y., J. L. Hill, and L. S. Gettes. Interaction of acidosis and increased extracellular potassium on action potential characteristics and conduction in guinea pig ventricular muscle. *Circ. Res.* 51:614–623, 1982.

[25]Kleber, A. G., M. J. Janse, F. J. van Capelle, and D. Durrer. Mechanism and time course of S–T and T–Q segment changes during acute regional myocardial ischemia in the pig heart determined by extracellular and intracellular recordings. *Circ. Res.* 42:603–613, 1978.

[26]Kleber, A. G., M. J. Janse, F. J. Wilms-Schopmann, A. A. Wilde, and R. Coronel. Changes in conduction velocity during acute ischemia in ventricular myocardium of the isolated porcine heart. *Circulation* 73:189–198, 1986.

[27]Kuo, C.-S., C. P. Reddy, K. Munakata, and B. Surawicz. Arrhythmias dependent predominantly on dispersion of repolarization. In: Cardiac Electrophysiology and Arrhythmias, edited by D. P. Zipes and J. Jalife. Orlando, FL: Grune & Stratton, 1985, pp. 277–285.

[28]Leon, L. J., F. A. Roberge, and A. Vinet. Simulation of two-dimensional anisotropic cardiac reentry: effects of the wavelength on the reentry characteristics. *Ann. Biomed. Eng* 22:592–609, 1994.

[29]Luo, C. H., and Y. Rudy. A model of the ventricular cardiac action potential. Depolarization, repolarization, and their interaction. *Circ. Res.* 68:1501–1526, 1991.

[30]Morena, H., M. J. Janse, J. W. Fiolet, W. J. Krieger, H. Crijns, and D. Durrer. Comparison of the effects of regional ischemia, hypoxia, hyperkalemia, and acidosis on intracellular and extracellular potentials and metabolism in the isolated porcine heart. *Circ. Res.* 46:634–646, 1980.

[31]Ogawa, S., I. Furuno, Y. Satoh, S. Yoh, K. Saeki, T. Sadanaga, H. Katoh, and Y. Nakamura. Quantitative indices of dispersion of refractoriness for identification of propensity to re-entrant ventricular tachycardia in a canine model of myocardial infarction. *Cardiovasc. Res.* 25:378–383, 1991.

[32]Padrini, R., S. Bova, G. Cargnelli, D. Piovan, and M. Ferrari. Effects of pinacidil on guinea-pig isolated perfused heart with particular reference to the proarrhythmic effect. *Br. J. Pharmacol.* 105:715–719, 1992.

[33]Picard, S., R. Rouet, P. Ducouret, P. E. Puddu, F. Flais, A. Criniti, F. Monti, and J. L. Gerard. KATP channels and 'border zone' arrhythmias: role of the repolarization dispersion between normal and ischaemic ventricular regions. *Br. J. Pharmacol.* 127:1687–1695, 1999.

[34]Pumir, A., A. Arutunyan, V. Krinsky, and N. Sarvazyan. Genesis of ectopic waves: role of coupling, automaticity, and heterogeneity. *Biophys. J.* 89:2332–2349, 2005.

[35]Qu, Z., H. S. Karagueuzian, A. Garfinkel, and J. N. Weiss. Effects of Na(+) channel and cell coupling abnormalities on vulnerability to reentry: a simulation study. *Am. J. Physiol. Heart Circ. Physiol.* 286:H1310–H1321, 2004.

[36]Qu, Z., and J. N. Weiss. Effects of Na(+) and K(+) channel blockade on vulnerability to and termination of fibrillation in simulated normal cardiac tissue. *Am. J. Physiol. Heart Circ. Physiol.* 289:H1692–H1701, 2005.

[37]Rodriguez, B., J. M. Ferrero, and B. Trenor. Mechanistic investigation of extracellular K+ accumulation during acute myocardial ischemia: a simulation study. *Am. J. Physiol. Heart Circ. Physiol.* 283:H490–H500, 2002.

[38]Romero, L., B. Trenor, J. M. Ferrero, and J. Saiz. A sensitivity study of the safety factor for conduction in the myocardium. *Comput. Cardiol. 2005* 32:873–876, 2005.

[39]Rudy, Y. Reentry: insights from theoretical simulations in a fixed pathway. *J. Cardiovasc. Electrophysiol.* 6:294–312, 1995.

[40]Shaw, R. M., and Y. Rudy. Electrophysiologic effects of acute myocardial ischemia. A mechanistic investigation of action potential conduction and conduction failure. *Circ. Res.* 80:124–138, 1997.

[41]Shaw, R. M., and Y. Rudy. Electrophysiologic effects of acute myocardial ischemia: a theoretical study of altered cell excitability and action potential duration. *Cardiovasc. Res.* 35:256–272, 1997.

[42]Shaw, R. M., and Y. Rudy. Ionic mechanisms of propagation in cardiac tissue. Roles of the sodium and L-type calcium currents during reduced excitability and decreased gap junction coupling. *Circ. Res.* 81:727–741, 1997.

[43]Smith, W. T., W. F. Fleet, T. A. Johnson, C. L. Engle, and W. E. Cascio. The Ib phase of ventricular arrhythmias in ischemic in situ porcine heart is related to changes in cell-to-cell electrical coupling. Experimental Cardiology Group, University of North Carolina. *Circulation* 92:3051–3060, 1995.

[44]Starmer, C. F., D. N. Romashko, R. S. Reddy, Y. I. Zilberter, J. Starobin, A. O. Grant, and V. I. Krinsky. Proarrhythmic response to potassium channel blockade. Numerical studies of polymorphic tachyarrhythmias. *Circulation* 92:595–605, 1995.

[45]Trenor, B., J. M. Ferrero, B. Rodriguez, and F. Montilla. Effects of pinacidil on reentrant arrhythmias generated during acute regional ischemia: a simulation study. *Annl. Biomed. Eng.* 33:897–906, 2005.

[46]Trenor, B., and J. M. Ferrero Jr.. Pinacidil-induced block of action potential propagation in ischaemic tissue: a simulation study. *Comput. Cardiol. 2000.* 27:319–322, 2000.

[47]Vigmond, E. J., V. Tsoi, S. Kuo, H. Arevalo, J. Kneller, S. Nattel, and N. Trayanova. The effect of vagally induced dispersion of action potential duration on atrial arrhythmogenesis. *Heart Rhythm.* 1:334–344, 2004.

[48]Wang, Y., and Y. Rudy. Action potential propagation in inhomogeneous cardiac tissue: safety factor considerations and ionic mechanism. *Am. J. Physiol. Heart Circ. Physiol.* 278:H1019–H1029, 2000.

[49]Watson, C. L., and M. R. Gold. Effect of intracellular and extracellular acidosis on sodium current in ventricular myocytes. *Am. J. Physiol.* 268:H1749–H1756, 1995.

[50]Weiss, J. N., P. S. Chen, Z. Qu, H. S. Karagueuzian, and A. Garfinkel. Ventricular fibrillation: how do we stop the waves from breaking? *Circ. Res.* 87:1103–1107, 2000.

[51]Weiss, J. N., N. Venkatesh, and S. T. Lamp. ATP-sensitive K+ channels and cellular K+ loss in hypoxic and ischaemic mammalian ventricle. *J. Physiol.* 447:649–673, 1992.

[52]Wilde, A. A., and G. Aksnes. Myocardial potassium loss and cell depolarisation in ischaemia and hypoxia. *Cardiovasc. Res.* 29:1–15, 1995.

[53]Wit, A. L., and J. Coromilas. Role of alterations in refractoriness and conduction in the genesis of reentrant arrhythmias. Implications for antiarrhythmic effects of class III drugs. *Am. J. Cardiol.* 72:3F–12F, 1993.

[54]Wit, A. L., and M. J. Janse. The Ventricular Arrhythmias of Ischemia and Infarction: Electrophysiological Mechanisms. Mount Kisko: Futura Publishing, 1993.

[55]Wu, J., and D. P. Zipes. Transmural reentry during acute global ischemia and reperfusion in canine ventricular muscle. *Am. J. Physiol. Heart Circ. Physiol.* 280:H2717–H2725, 2001.

[56]Zhang, H., Z. X. Zhang, L. Yang, Y. B. Jin, and Y. Z. Huang. Relevance of ventricular electrical dispersion to arrhythmogenesis in ischemic myocardium—a simulation study. *Gen. Physiol. Biophys.* 24:365–380, 2005.

5.1.1.3. A service-oriented WSRF-based architecture for metascheduling on computational Grids

G. Moltó, V. Hernández, and J. M. Alonso, "A service-oriented WSRF-based architecture for metascheduling on computational Grids," Futur. Gener. Comput. Syst., vol. 24, no. 4, pp. 317–328, Apr. 2008, doi: https://dx.doi.org/10.1016/j.future.2007.05.001

Base de datos de indexación	SCI
Índice de impacto	1.476
Año	2008
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	27 de 85
Tercil	T1
Cuartil	Q2
Número de citas en JCR	15
Número de citas totales	39

Comentario. Esta contribución fue uno de los resultados del proyecto de Plan Nacional ngGrid (TIN2006-12890) en el que el candidato describe la creación de una librería de replicación automatizado para servicios Grid. El candidato participó en el proyecto, fue el principal desarrollador de la librería y el autor principal del artículo.

Available online at www.sciencedirect.com
ScienceDirect
Future Generation Computer Systems 24 (2008) 317–328
FGCS FUTURE GENERATION COMPUTER SYSTEMS
www.elsevier.com/locate/fgcs

A service-oriented WSRF-based architecture for metascheduling on computational Grids☆

G. Moltó*, V. Hernández, J.M. Alonso

Departamento de Sistemas Informáticos y Computación, Universidad Politécnica de Valencia, Camino de Vera S/N, 46022 Valencia, Spain

Received 21 February 2007; received in revised form 7 May 2007; accepted 10 May 2007
Available online 18 May 2007

Abstract

This paper describes a Grid service developed over the Globus Toolkit 4, which provides multi-user resource brokering on computational Grids. Both the architecture and implementation details are covered, emphasising the usage of the WSRF specifications and GSI-based security to create a generic, secure and interoperable metascheduler. In addition, we also describe the development of a graphical client-side application that provides an ubiquitous access to the metascheduler service. This work is currently being employed in production for the execution of a biomedical application that simulates the electrical activity of cardiac tissues.

Keywords: Grid computing; Metascheduling; Globus Toolkit; WSRF; Service-oriented architectures

1. Introduction

Grid computing technologies [1] have emerged as a solution for the computational problems of Virtual Organisations (VOs), enabling the collaborative usage of remote resources to satisfy the computational requirements of time-consuming tasks.

Among all the available Grid middlewares, the Globus Toolkit (GT) [2,3] is broadly accepted to be the current de facto standard for deploying computational Grids. However, the GT only provides the basic services and capabilities to deploy and use Grid infrastructures. Performing remote executions of scientific applications on a computational Grid typically requires the usage of *metascheduling* technologies [5], that provide all the functionality required for task management.

Metascheduling is the process that efficiently allocates a set of tasks on the available computational resources of the different organisations that compose a Grid infrastructure. We envisage Grid metascheduling technologies as a set of interoperable components which abstract all the underlying complexity of the Grid middleware, which offers the execution support. Only if these Grid technologies get closer to the end user will they be adopted in many scientific fields.

In this paper, we go one step beyond the traditional usage of metascheduling, and we propose a metascheduler Grid service that can be accessed throughout the network by users interested in task allocation on computational Grids. It has been developed by exposing a Grid service interface to GMarte [6,7], a previously developed metascheduler.

With the proposed approach, the user just focuses on defining the computational tasks to be executed, and delegates to this Grid service their efficient execution on the available Grid infrastructure. As opposed to traditional metaschedulers, which typically require an installation and configuration on the client machine, and are typically bounded to a given platform (usually Unix-based), we propose a Service-Oriented Architecture (SOA) that can be used from different architectures and operating systems. This approach dramatically simplifies the usage of computational Grids for job executions, even accessible for Windows-based desktop PCs, thus paving the way for the widespread adoption of Grid technologies by the least experienced users.

In addition, creating a generic and interoperable component based on standard technologies contributes to the ecosystem of tools employed to interact with computational Grids.

☆ The authors are grateful for the financial support received from the Spanish Ministry of Science and Technology to develop the project GRID-IT (TIC2003-01318). This work has been partially supported by the Structural Funds of the European Regional Development Fund (ERDF).

* Corresponding author. Tel.: +34 963877356; fax: +34 963877359.
E-mail address: gmolto@dsic.upv.es (G. Moltó).

0167-739X/$ - see front matter
doi:10.1016/j.future.2007.05.001

[19] I. Rodero, J. Corbalan, R. Badia, J. Labarta, eNANOS Grid resource broker, in: Advances in Grid Computing — EGC, vol. 3470, 2005, pp. 111–121.
[20] E. Elmroth, J. Tordsson, An interoperable standards-based Grid resource broker and job submission service, in: e-Science 2005, First IEEE Conference on e-Science and Grid Computing, 2005, pp. 212–220.
[21] W. Xiaohui, D. Zhaohui, Y. Shutao, H. Chang, L. Huizhen, CSF4: A WSRF compliant meta-scheduler, in: The 2006 World Congress in Computer Science, Computer Engineering, and Applied Computing, GCA'06, 2006. pp. 61–67.
[22] S. Venugopal, R. Buyya, L. Winton, A grid service broker for scheduling e-science applications on global data grids, Concurrency and Computation: Practice & Experience 18 (6) (2006) 685–699.

Germán Moltó received his M.Sc. degree in computer science from the Universidad Politécnica de Valencia (UPV) in 2002. Since then, he has been a researcher at the High Performance Networking and Computing Group, at UPV. In 2005, he obtained an assistant lecturer position at the same university. He is currently working towards a Ph.D. degree in the field of Grid Computing applied to biomedical applications such as cardiac electrical activity simulation and the design of proteins.

Vicente Hernández obtained his Ph.D. degree in Mathematics from the Universidad de Valencia, Spain, in 1979. From 1991 he has been a full Professor in the Department of Information Systems and Computation, Universidad Politécnica de Valencia, Spain. Leader of the High Performance Networking and Computing Group, he has written over 220 journal and conference papers on Numerical Methods, Parallel Computing, Grid Computing and their Applications on different fields. He has supervised over 20 Ph.D. theses on Computational Science and Applied Mathematics.

He has acted as coordinator or main researcher in more than 30 projects funded by national and international programmes.

José M. Alonso obtained his M.Sc. degree in Computer Science from the Universidad Politécnica de Valencia (UPV), Spain, in 1997. He has been a member of the High Performance Networking and Computing group of UPV since 1996. Since 2000 he has been an assistant lecturer in the same university. He is currently working towards a Ph.D. degree in the field of parallel and grid computing in simulation of building structures. He has also participated in different research projects on the application of parallel and grid computing techniques to several areas of engineering. Other fields of interest include neural networks and evolutionary computation.

5.1.1.4. A Grid Computing-Based Approach for the Acceleration of Simulations in Cardiology

J. M. Alonso, J. M. Ferrero, V. Hernandez, G. Moltó, J. Saiz, and B. Trenor, "A Grid Computing-Based Approach for the Acceleration of Simulations in Cardiology," IEEE Trans. Inf. Technol. Biomed., vol. 12, no. 2, pp. 138–144, Mar. 2008, doi: https://dx.doi.org/10.1109/TITB.2007.907982

Base de datos de indexación	SCI
Índice de impacto	1.939
Año	2008
Categoría	Computer Science, Interdisciplinary Applications
Posición de la revista en el área	21 de 94
Tercil	T1
Cuartil	Q1
Número de citas en JCR	4
Número de citas totales	9

Comentario. Esta contribución es uno de los resultados de la aplicación de las herramientas de computación Grid creadas en el proyecto de Plan Nacional GRID-IT TIC2003-01318 a los casos de uso de simulación cardiaca del proyecto de Plan Nacional TEC2005-04199 para poder acelerar la ejecución de múltiples simulaciones sobre infraestructuras distribuidas. El candidato participó en ambos proyectos y fue el desarrollador principal de la herramienta y principal autor de la publicación, en la se usó orden alfabético de firma.

A Grid Computing-Based Approach for the Acceleration of Simulations in Cardiology

José M. Alonso, José M. Ferrero, Jr., Vicente Hernández, Germán Moltó, Javier Saiz, and Beatriz Trénor

***Abstract*—This paper combines high-performance computing and grid computing technologies to accelerate multiple executions of a biomedical application that simulates the action potential propagation on cardiac tissues. First, a parallelization strategy was employed to accelerate the execution of simulations on a cluster of personal computers (PCs). Then, grid computing was employed to concurrently perform the multiple simulations that compose the cardiac case studies on the resources of a grid deployment, by means of a service-oriented approach. This way, biomedical experts are provided with a gateway to easily access a grid infrastructure for the execution of these research studies. Emphasis is stressed on the methodology employed. In order to assess the benefits of the grid, a cardiac case study, which analyzes the effects of premature stimulation on reentry generation during myocardial ischemia, has been carried out. The collaborative usage of a distributed computing infrastructure has reduced the time required for the execution of cardiac case studies, which allows, for example, to take more accurate decisions when evaluating the effects of new antiarrhythmic drugs on the electrical activity of the heart.**

***Index Terms*—Action potential (AP) propagation, grid computing, high-performance computing, myocardial ischemia, service-orientedarchitecture.**

I. Introduction

MATHEMATICAL models of propagation of cardiac electrical potentials are considered a powerful and helpful tool to better understand the mechanisms involved in the development of ventricular fibrillation, a lethal arrhythmia. By means of modeling and simulation in computers, the origin and evolution of fibrillation can be first studied *in silico*, where hypotheses can be formulated and studied prior to their validation *in vivo*, thus reducing the requirements of many complex intrusive techniques.

It is known that the action potential (AP) is propagated along a specialized conduction system in the heart, until it reaches all the cardiac muscle cells. The arrival of this signal to a cell provokes several phenomena that results in its contraction. This way, the AP and the electric conduction system guarantee the synchronized contraction of cardiac muscle and the effective blood pump [1].

The electrophysiological data obtained with the help of experimental techniques has led to the formulation of mathematical models of the electrical behavior of excitable cells. Specifically, the electrical activity of cardiac cells has been quantitatively described, since the early 1960s, by models that have become more and more detailed as new ion channels and channel properties have been discovered and studied in depth. One of the most detailed models of ventricular AP is the Luo–Rudy Phase II [2].

If the mathematical formulation of the membrane ion kinetics (the cellular model) is combined with a representation of the electrical characteristics of the tissue, the resulting mathematical model (a system of differential equations) can be used to simulate the electrical activity, that is the AP propagation, of cardiac preparations, or even of the whole heart.

However, as the size of the simulated cardiac tissue increases, the very large numerical burden resulting from calculating currents and voltages on many cells, and then simulating electrical interactions among the coupled cells, require the usage of very large-scale computational resources. For instance, taking into account that a cardiac tissue consists of irregular, densely packed cells of 30–100-μm long and 10–20-μm width, a 1 cm $\times$ 1 cm tissue is composed of approximately 100,000 coupled cells. A simulation of the AP propagation during 2 s requires the execution of 250,000 timesteps of typically 8 μs, which implies a total simulation time that can last almost 4 days on a Pentium IV with 1 GB of RAM. Moreover, ischemic behavior may require the simulation of a cardiac tissue electrical state during several minutes. As an example, a simulation of 5 min would require 18 months of computation in such a platform.

In addition, studies of vulnerable windows in ischemia require to vary the time interval between two consecutive stimuli in order to detect the range of values that provokes a reentry, a phenomenon that can derive into heart fibrillation. Besides, to study the effects of late ischemia, it is necessary to vary the coupling resistances in all the dimensions of the tissue and investigate the evolution of the electrical activity for different anisotropy ratios. Moreover, to evaluate the influence of certain drugs, it is crucial to alter the concentration of these drugs, over a determined range, to study how it affects the propagation of the AP in the tissue. All of them are parametric studies composed of independent cardiac simulations.

Manuscript received October 6, 2006; revised February 28, 2007. This work was supported in part by the Spanish Ministry of Science and Technology under Grant TIC2003-01318 to Project GRID-IT, in part by the Plan Nacional de Investigación Científica, Desarrollo e Innovación Tecnológica del Ministerio de Educación y Ciencia of Spain under Grant TIN2004-03602 and Grant TEC2005-04199/TCM, and in part by the Structural Funds of the European Regional Development Fund (ERDF).

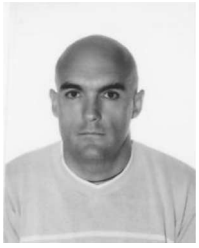
J. M. Alonso, V. Hernández, and G. Moltó are with the Department of Information Systems and Computation, Universidad Politécnica de Valencia, 46022 Valencia, Spain (e-mail: jmalonso,vhernand,gmolto@dsic.upv.es).

J. M. Ferrero, Jr., J. Saiz, and B. Trenor are with the Department of Electronic Engineering, Universidad Politécnica de Valencia, 46022 Valencia, Spain, and also with the Cardiac Modelling Group, Institute for Research and Innovation in Bioengineering, Universidad Politécnica de Valencia, 46022 Valencia, Spain (e-mail: cferrero, jsaiz, btrenor@eln.upv.es).

Color versions of one or more of the figures in this paper are available online at http://ieeexplore.ieee.org.

Digital Object Identifier 10.1109/TITB.2007.907982

[24] M. Janse, F. van Capelle, H. Morsink, A. Kleber, F. Wilms-Schopman, R. Cardinal, C. d' Alnoncourt, and D. Durrer, "Flow of "injury" current and patterns of excitation during early ventricular arrhythmias in acute regional myocardial ischemia in isolated porcine and canine hearts. Evidence for two different arrhythmogenic mechanisms," *Circ. Res.*, vol. 47, no. 2, pp. 151–165, 1980.



José M. Alonso received the M.Sc. degree in computer science from the Universidad Politécnica de Valencia (UPV), Valencia, Spain, in 1997. He is currently working toward the Ph.D. degree.

Since 1996, he is a member of the High-Performance Networking and Computing Group, UPV. Since 2000, he is an Assistant Lecturer in the Department of Information Systems and Computation, UPV. He has participated in different research projects concerning the application of parallel and grid computing techniques to several engineering areas. His current research interests include the field of parallel and grid computing in simulation of building structures.

José M. Ferrero, Jr. was born in Madrid, Spain, in 1966. He received the Ph.D. degree from the Universidad Politécnica de Valencia (UPV), Valencia, Spain, in 1995.

In 1990, he was an Electronic Engineer at the UPV. In 1995, he was a Research Trainee in the Department of Biomedical Engineering, The Johns Hopkins University, Baltimore, MD. Currently, he is a Full Professor in the Department of Electronic Engineering, UPV, where he is also the Co-Leader of the Cardiac Modelling Group, Institute for Research and Innovation in Bioengineering. His current research interests include cardiac electrophysiology, computer modeling of the cardiac electrical activity, biomedical signal processing, and bioelectronic instrumentation.

Vicente Hernández received the Ph.D. degree in mathematics from the Universidad de Valencia (UPV), Valencia, Spain, in 1979.

Since 1991, he is a Full Professor in the Department of Information Systems and Computation, UPV. He is a Leader of the High-Performance Networking and Computing Group, UPV. He is the author or coauthor of more than 200 papers published in international journals. He has supervised over 20 Ph.D. theses on computational science and applied mathematics. He has acted as Coordinator or Main Researcher in more than 30 projects funded by national and international agencies. His current research interests include numerical methods, parallel computing, and grid computing.

Germán Moltó received the M.Sc. degree in computer science from the Universidad Politécnica de Valencia (UPV), Valencia, Spain, in 2002. He is currently working toward the Ph.D. degree.

Since 2002, he has been a Researcher at the High-Performance Networking and Computing Group, UPV. In 2005, he became an Assistant Lecturer in the Department of Information Systems and Computation, UPV. His current research interests include the field of grid computing applied to biomedical applications, such as the cardiac electrical activity simulation and the design of proteins.

Javier Saiz received the Ph.D. degree from the Universidad Politécnica de Valencia (UPV), Valencia, Spain, in 1992.

In 1986, he was an Electronic Engineer at the UPV. In 1995, he was a Postdoctoral Research Fellow in the Department of Biomedical Engineering, The Johns Hopkins University, Baltimore, MD, where he was engaged in research on mathematical models of action potential propagation in heart tissue. Currently, he is a Full Professor in the Department of Electronic Engineering, UPV, where he is also the Co-Leader of the Cardiac Modelling Group, Institute for Research and Innovation in Bioengineering. His current research interests include cardiac electrophysiology, computer modeling of cardiac electrical activity, biomedical signal processing, and bioelectronic instrumentation.

Beatriz Trénor received the Ph.D. degree from the Universidad Politécnica de Valencia (UPV), Valencia, Spain, in 2001.

In 1997, she was an Electronic Engineer at the UPV. Currently, she is an Assistant Professor in the Department of Electronic Engineering, UPV, where she is also a Researcher in the Cardiac Modelling Group, Institute for Research and Innovation in Bioengineering. Her current research interests include cardiac electrophysiology and computer modeling of cardiac electrical activity.

5.1.1.5. A high-throughput application for the dynamic analysis of structures on a Grid environment

J. M. Alonso, V. Hernández, and G. Moltó, "A high-throughput application for the dynamic analysis of structures on a Grid environment," Adv. Eng. Softw., vol. 39, no. 10, pp. 839–848, Oct. 2008, doi: https://dx.doi.org/10.1016/j.advengsoft.2007.05.005

Base de datos de indexación	SCI
Índice de impacto	1.188
Año	2008
Categoría	Computer Science, Interdisciplinary Applications
Posición de la revista en el área	42 de 94
Tercil	T1
Cuartil	Q2
Número de citas en JCR	6
Número de citas totales	6

Comentario. Esta contribución es parte de los resultados del proyecto de Plan Nacional de I+D GRID-IT (TIC2003- 01318) donde se describe una novedosa arquitectura basada en servicios Grid para la metaplanificación de trabajos en infraestructuras distribuidas. El candidato participó en el proyecto en el proyecto y fue el desarrollador principal de la herramienta.

Available online at www.sciencedirect.com
ScienceDirect
Advances in Engineering Software 39 (2008) 839–848
ADVANCES IN ENGINEERING SOFTWARE
www.elsevier.com/locate/advengsoft

A high-throughput application for the dynamic analysis of structures on a Grid environment

J.M. Alonso *, V. Hernández, G. Moltó

Departamento de Sistemas Informáticos y Computación, Universidad Politécnica de Valencia, Camino de Vera s/n, 46022 Valencia, Spain

Available online 27 August 2007

Abstract

This paper describes a Grid Computing application for the 3D dynamic analysis of large dimension buildings. A previously developed software composed of parallel implementations of eight direct integration methods has been integrated on this application, in order to perform structural simulations on a Grid deployment. The GMarte software abstraction layer has been employed to couple the parallel simulator with the Grid infrastructure. Performing distributed executions has enabled a considerable reduction in the global execution time of structural dynamic studies composed of different design alternatives.

Keywords: Grid Computing technology; 3D structural dynamic analysis; Large dimension buildings; HPC techniques; Direct time integration methods; Grid middleware

1. Introduction

Three-dimensional dynamic analysis of large-scale buildings has been considered by engineers as a challenging problem, owing to its high-computational demand [1]. Nowadays, an analyst that uses a structural analysis program can be waiting a considerable time before achieving the dynamic response of a medium-sized building. Besides, most of the existing commercial codes are composed of debatable simplifications, because the computation involved in a realistic simulation can be too intensive for a traditional computer. Notwithstanding, these simplifications, although appropriate for single structures, have demonstrated to be completely inadequate for complex buildings.

Moreover, a structural designer usually works with different preliminary designs of a building, and a realistic 3D analysis is required for each of them. In addition, it is usual that a structure has to be simulated under the influence of different dynamic loads. Thereby, for example, the Spanish Earthquake-Resistant Construction Standards (NCSE-02) demands a building to be analysed at least by with five different representative earthquakes. Obviously, this number of simulations enlarges by several orders of magnitude the computational requirements of the problem.

Therefore, there is a pressing need to develop effective tools that allow us to simulate accurately and efficiently the dynamic behaviour of high-rise buildings. With the development of effective and reliable computing platforms, the application of high-performance computing techniques allows tackling in a realistic way large-scale structural problems. However, although cost-effective clusters of PCs can simulate large dimension structures in reasonable times, in practice, studios for engineering rarely own parallel platforms. They normally employ overloaded standard PCs, what limits the size of the problems to be treated, and they are not interested in investing in clusters, mainly because of the physical space required and the associated maintenance problems, despite their excellent ratio productivity/price.

In this paper, a Grid Computing application for the 3D dynamic analysis of large dimension buildings is presented. The tool is based on the GMarte framework and makes use

* Corresponding author.
E-mail address: jmalonso@disc.upv.es (J.M. Alonso).

0965-9978/$ - see front matter
doi:10.1016/j.advengsoft.2007.05.005

Acknowledgements

The authors wish to thank the financial support received from The Spanish Ministry of Science and Technology and the Generalitat Valenciana to develop the projects GRID-IT (TIC2003-0131) and Grid4Build (GV04B-424), respectively. The work developed under the GRID-IT project has been partially supported by the Structural Funds of the European Regional Development Fund (ERDF).

References

[1] Clough RW, Penzien J. Dynamics of structures. second ed. Computers and Structures, Inc.; 2004.
[2] Dolenc M, Turk Z, Katranuschkov P, Kurowski K, Hannus M. Towards a Grid enabled engineering collaboration environment. In: Topping BHV, editor. Proc of the Tenth Int Conf on Civil, Struct Environ Eng Comput (CC 2005), paper 69, Civil-Comp Press; 2005.
[3] Alonso JM, de Alfonso C, García G, Hernández V. Grid technology for structural analysis. Advances in Engineering Software 2007;38:738–49.
[4] Alonso JM, Hernández V. Three-dimensional structural dynamic analysis using parallel direct time integration methods. In: Topping BHV, editor. Proc of The Tenth Int Conf on Civil, Struct and Environ Eng Comput (CC 2005), paper 232, Civil-Comp Press; 2005.
[5] Fung TC. Numerical dissipation in time-step integration algorithms for structural dynamic analysis. Progr Struct Eng Mater 2003;5:167–80.
[6] Dokainish MA, Subbaraj K. A survey of direct time-integration methods in computational structural dynamics-I. Explicit methods. Comput Struct 1989;32:1371–86.
[7] Dokainish MA, Subbaraj K. A survey of direct time-integration methods in computational structural dynamics-II. Implicit methods. Comput Struct 1989;32:1387–401.
[8] Newmark NM. A method of computation for structural dynamics. J Eng Mech Division, ASCE 1959;85:67–94.
[9] Wilson EL. A computer program for the dynamic stress analysis of underground structures. SESM Report 68-1; Division of Structural Engineering and Structural Mechanics. Berkeley: University of California; 1968.
[10] Belytschko T, Mullen R. Explicit integration of structural problems. Finite Elements in Nonlinear Mech 1977;2:697–720.
[11] Chung J, Hulbert GM. A family of single-step Houbolt time integration algorithms for structural dynamics. Comput Methods Appl Mech Eng 1994;118(1–2):1–11.
[12] Hilber HM, Hughes TJR, Taylor RL. Improved numerical dissipation for time integration algorithms in structural dynamics. Earthquake Eng Struct Dynam 1977;5:283–92.
[13] Wood WL, Bossak M, Zienkiewicz OC. An alpha modification of Newmark's method. Int J Numer Methods Eng 1980;15:1562–6.
[14] Chung J, Hulbert GM. A time integration method for structural dynamics with improved numerical dissipation: the generalized-α method. J Appl Mech 1993;60:371–6.
[15] Owren B, Simonsen HH. Alternative integration methods for problems in structural dynamics. Comput Methods Appl Mech Eng 1995;22(1–2):1–10.
[16] Gropp WD, Lusk E. Users guide for MPICH, a portable implementation of MPI. Mathematics and Computer Science Division, Argonne National Laboratory; 1996.
[17] Thakur R, Gropp W, Lusk E. On implementing (MPI-IO) portably and with high performance, in: Proc of the Sixth Workshop of I/O in Parallel and Distributed Systems 1999. pp. 23–32.
[18] Gupta A, Joshi M, Kumar A. WSMP: a high-performance shared- and distributed-memory parallel sparse linear equation solver. IBM Research Report RC 22038(98932), IBM, 2001.
[19] Amestoy P, Duff I, L'Excellent JY, Koster J. MUltifrontal Massively Parallel Solver (MUMPS version 4.6.3) users guide, 2006.
[20] Balay S, Buschelman K, Gropp WD, Kaushik D, Knepley M, Curfman-McInnes L, et al. PETSc users manual. Technical Report ANL-95/11 – Revision 2.3.2. Argonne National Laboratory; 2006.
[21] Foster I, Kesselman C. The GRID 2: Blueprint for a new computing infrastructure. second ed. Morgan-Kaufmann; 2004.
[22] von Laszewski G. The Grid-idea and its evolution. Journal of Information Technology 2005;47(6):319–29.
[23] Foster I, Kesselman C. Globus: A metacomputing infrastructure toolkit. Int J Supercomput Applicat 1997;11:115–28.
[24] Foster I. Globus Toolkit version 4: Software for service-oriented systems. In: IFIP Int Conf on Network and Parallel Comput. LNCS, vol. 3779. Springer-Verlag; 2005. p. 2–13.
[25] Alonso JM, Hernández V, Moltó G. An object-oriented view of Grid Computing technologies to abstract remote task execution, in: Proc of the 13th Euromicro Conf on Parallel, Distributed and Network-based Processing 2005. pp. 235–42.
[26] Alonso JM, Hernández V, Moltó G. GMarte: Grid Middleware to abstract remote task execution. Concurrency and Computation: Practice and Experience 2006;18(15):2021–36.
[27] von Laszewski G, Foster I, Gawor J, Lane P. A Java Commodity Grid kit. Concurrency Comput: Practice Experience 2001;13:643–62.
[28] Schopf JM. Ten actions when superscheduling. Scheduling Working Group, SchedWD 8.5, 2001.
[29] Seidel E, Allen G, Merzky A, Nabrzysky J. GridLab: A Grid application toolkit and testbed. Future Generation Comput Syst 2002;18:1143–53.
[30] Thain D, Wright D, Miller K, Livny M. Condor – A distributed job scheduler. In: Sterling T, editor. Beowulf Cluster Computing with Linux. MIT Press; 2001.
[31] Frey J, Tannenbaum T, Foster I, Livny M, Tuecke S. Condor-G: A computation management agent for multi-institutional Grids. J Cluster Comput 2002;5:237–46.
[32] Angulo D, Foster I, Liu C, Yang L. Design and evaluation of a resource selection framework for Grid applications, in: Proc of IEEE Int Symp on High Performance Distributed Computing (HPDC-11), 2002.

5.1.1.6. Automatic replication of WSRF-based Grid services via operation providers

G. Moltó, V. Hernández, and J. M. Alonso, "Automatic replication of WSRF-based Grid services via operation providers," Futur. Gener. Comput. Syst., vol. 25, no. 8, pp. 876–883, Sep. 2009, doi: https://dx.doi.org/10.1016/j.future.2009.03.004

Base de datos de indexación	SCI
Índice de impacto	2.229
Año	2009
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	12 de 92
Tercil	T1
Cuartil	Q1
Número de citas en JCR	2
Número de citas totales	8

Comentario. Esta contribución fue uno de los resultados del proyecto de Plan Nacional ngGrid (TIN2006-12890) en el que el candidato describe la creación de una librería de replicación automatizado para servicios Grid. El candidato participó en el proyecto, fue el principal desarrollador de la librería y el autor principal del artículo.

Future Generation Computer Systems 25 (2009) 876–883

Contents lists available at ScienceDirect

Future Generation Computer Systems

journal homepage: www.elsevier.com/locate/fgcs

Automatic replication of WSRF-based Grid services via operation providers☆

G. Moltó *, V. Hernández, J.M. Alonso

Departamento de Sistemas Informáticos y Computación, Universidad Politécnica de Valencia, Camino de Vera S/N, 46022 Valencia, Spain

ARTICLE INFO

Article history:
Received 14 November 2008
Received in revised form
6 March 2009
Accepted 19 March 2009
Available online 27 March 2009

Keywords:
Grid computing
Replication
Globus Toolkit
WSRF
Service-oriented architectures

ABSTRACT

The advent of service-oriented architectures in Grid environments has fostered the development of applications in distributed deployments. The Globus Toolkit 4 (GT4) and its implementation of stateful Web services, via the WS-Resource Framework (WSRF), is a suitable platform to develop these Grid services. This way, its increased usage in many scientific areas reveals new scenarios where fault-tolerance and high availability should be considered. This paper describes a library that manages the automatic replication of WSRF-based Grid services. This functionality can be plugged to existing Grid services, by means of minimal changes in its source code, to achieve state replication through WS-Resources. The architecture of the library and its performance evaluation are described. In particular, two different replica topologies are addressed: ring-based and leaf-to-root complete binary tree, in order to achieve resource state update in logarithmic time with respect to the number of replicas. Finally, the paper describes the integration of the replication library into a service-oriented metascheduler to enhance fault-tolerance and to guarantee service availability.

1. Introduction

During the last years, Grid Computing has proved to be a suitable technology to support the execution of computationally intensive applications in distributed deployments. The Globus Toolkit (GT) version 2 [1] was considered to be the de facto standard in Grid middlewares. It provided a set of services and protocols to ease sharing both computational power and storage capacity within the context of virtual organizations. With the release of GT version 4 (GT4) [2], the move towards service-oriented architectures enlightened a new computing paradigm. Machines in a Grid were no longer dedicated exclusively to computing but they could also implement and offer a whole new catalog of services through standard web-based interfaces. These functionality required stateful Web services and the Grid service term was thus coined.

Since then, the development of Grid services has been growing in order to enrich the functionality of Grid deployments. As Grid services become a key factor in distributed infrastructures, topics such as fault-tolerance and high availability turn into requirements in order to maintain service availability regardless of software and hardware failures. This way, replication allows to improve reliability, fault-tolerance and accessibility by providing the user with different replicas of the same Grid service, all of them with a coherent state.

The fault-tolerance topic in Grid computing has been extensively addressed in the literature, where it typically focuses on reliable job management and execution on distributed deployments [3,4]. Achieving high availability through replication has also been studied, but mainly related to data Grids [5,6]. However, the area of building reliable replicated Grid services is still very new. In [7], the problem of fault-tolerant management of a set of Grid services is addressed. For that, a hierarchical system comprised of statically configured bootstrap services is proposed. These are responsible of reinstantiating the failed components. There also exist service managers attached to the replicated services responsible for managing their state. It is a generic approach for the scalable management of Grid services, but loosely related to WSRF-based Grid services.

In [8], the problem of building highly available Grid services is addressed by using primary-backup replication implemented in GT3. With this approach, a single replica processes all the requests and keeps the backup services consistent in case the primary fails. Therefore, the main bottleneck resides at the primary replica. In [9], fault tolerant concepts for stateful Web services are applied to a specific Grid middleware designed for monitoring and migrating high-performance applications. Implemented in GT4, the authors developed a ring replication protocol to provide total message ordering and group membership.

This paper describes a library for the replication of GT4-based Grid services through WS-Resource state management. This

☆ The authors wish to thank the financial support received from the Spanish Ministry of Science and Technology to develop the project ngGrid: New Generation Components for the Efficient Exploitation of eScience Infrastructures (TIN2006-12890). This work has been partially supported by the Structural Funds of the European Regional Development Fund (ERDF).

* Corresponding author. Tel.: +34 963877356; fax: +34 963877359.
E-mail address: gmolto@dsic.upv.es (G. Moltó).

0167-739X/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.future.2009.03.004

References

[1] I. Foster, C. Kesselman, Globus: A metacomputing infrastructure toolkit, International Journal of Supercomputer Applications and High Performance Computing 11 (2) (1997) 115–128.

[2] I. Foster, Globus toolkit version 4: Software for service-oriented systems, in: IFIP International Conference on Network and Parallel Computing, in: LNCS, vol. 3779, 2005, pp. 2–13.

[3] E. Huedo, R.S. Montero, I.M. Llorente, Evaluating the reliability of computational grids from the end user's point of view, Journal of Systems Architecture 52 (12) (2006) 727–736.

[4] E. Byun, S. Choi, M. Baik, J. Gil, C. Park, C. Hwang, MJSA: Markov job scheduler based on availability in desktop grid computing environment, Future Generation Computer Systems 23 (4) (2007) 616–622.

[5] P. Kunszt, E. Laure, H. Stockinger, K. Stockinger, File-based replica management, Future Generation Computer Systems 21 (1) (2005) 115–123.

[6] M. Lei, S.V. Vrbsky, X. Hong, An on-line replication strategy to increase availability in data grids, Future Generation Computer Systems 24 (2) (2008) 85–98.

[7] H. Gadgil, G. Fox, S. Pallickara, M. Pierce, Scalable, fault-tolerant management in a service oriented architecture, in: HPDC'07: Proceedings of the 16th International Symposium on High Performance Distributed Computing, ACM, New York, NY, USA, 2007, pp. 235–236.

[8] X. Zhang, D. Zagorodnov, M. Hiltunen, K. Marzullo, R. Schlichting, Fault-tolerant grid services using primary-backup: Feasibility and performance, in: IEEE International Conference on Cluster Computing, 2004, 2004, pp. 105–114.

[9] A. Luckow, B. Schnor, Service replication in grids: Ensuring consistency in a dynamic, failure-prone environment, in: IEEE International Symposium on Parallel and Distributed Processing, 2008. IPDPS 2008, 2008.

[10] I. Foster, et al. The Open Grid Services Architecture, version 1.5 (March 2006).

[11] B. Sotomayor, L. Childers, Globus Toolkit 4: Programming Java Services, Morgan Kaufmann, 2005.

[12] WSRF — The WS-Resource Framework, URL: http://www.globus.org/wsrf.

[13] T.H. Cormen, C.E. Leiserson, R.L. Rivest, C. Stein, Introduction to Algorithms, MIT Press, 2001.

[14] G. Moltó, V. Hernández, J.M. Alonso, A service-oriented WSRF-based architecture for metascheduling on computational grids, Future Generation Computer Systems (International Journal of Grid Computing) 24 (4) (2008) 317–328.

[15] J.M. Alonso, V. Hernández, G. Moltó, GMarte: Grid middleware to abstract remote task execution, Concurrency and Computation: Practice and Experience 18 (15) (2006) 2021–2036.

[16] J.M. Alonso, J.M. Ferrero (Jr.), V. Hernández, G. Moltó, J. Saiz, B. Trenor, A grid computing-based approach for the acceleration of simulations in cardiology, IEEE Transactions on Information Technology in Biomedicine 12 (2) (2008) 138–144.

[17] Data replication service, The Globus Toolkit Documentation. http://www.globus.org/toolkit/docs/4.2/4.2.0/data/datarep/index.html.

[18] D. Zhang, P. Coddington, A. Wendelborn, Binary data transfer performance over high-latency networks using web service attachments, in: E-SCIENCE'07: Proceedings of the Third IEEE International Conference on e-Science and Grid Computing, IEEE Computer Society, Washington, DC, USA, 2007, pp. 261–269.

G. Moltó received the B.Sc. and Ph.D. degrees in computer science from the Universidad Politécnica de Valencia (UPV) in 2002 and 2007. In 2002 he joined the Grid and High Performance Computing research group, at UPV. Since 2005, he is also an assistant lecturer at the same university. His current interests include Grid Computing, Service-Oriented Architectures, metascheduling and its usage in different scientific fields, such as biomedical applications and protein design.

V. Hernández obtained the Ph.D. degree in Mathematics from the Universidad de Valencia, Spain, in 1979. From 1991 he is full Professor in the Department of Information Systems and Computation, Universidad Politécnica de Valencia, Spain. Leader of the Grid and High Performance Computing, he has written over 220 journal and conference papers on Numerical Methods, Parallel Computing, Grid Computing and their Applications on different fields. He has supervised over 20 Ph.D. thesis on Computational Science and Applied Mathematics.

He has acted as coordinator or main researcher in more than 30 projects funded by national and international programmes.

J.M. Alonso obtained the M.Sc. degree in Computer Science from the Universidad Politécnica de Valencia (UPV), Spain, in 1997. He is member of the Grid and High Performance Computing group of UPV since 1996. Since 2000, he is an assistant lecturer in the same university. He is currently working towards the Ph.D. degree in the field of parallel and grid computing in simulation of building structures. He has also participated in different research projects about the application of parallel and grid computing techniques to several areas of engineering. Other fields of interest include neural networks and evolutionary computation.

5.1.1.7. Protein Design Based on Parallel Dimensional Reduction

G. Moltó, M. Suárez, P. Tortosa, J. M. Alonso, V. Hernández, and A. Jaramillo, "Protein design based on parallel dimensional reduction," J. Chem. Inf. Model., vol. 49, no. 5, pp. 1261–71, May 2009, doi: https://dx.doi.org/10.1021/ci8004594

Base de datos de indexación	Web of Science (JCR)
Índice de impacto	3.882
Año	2009
Categoría	Computer Science, Interdisciplinary Applications
Posición de la revista en el área	2 de 95
Tercil	T1
Cuartil	Q1
Número de citas en JCR	3
Número de citas totales	4

Comentario. Esta contribución fue uno de los resultados del proyecto de Plan Nacional ngGrid (TIN2006-12890) y describe la implementación paralela de un sistema de simulación de proteínas mediante métodos de Monte Carlo desarrollado completamente por el candidato en el marco de su tesis doctoral. La revista es la segunda mejor de la categoría COMPUTER SCIENCE, INTERDISCIPLINARY APPLICATIONS.

Protein Design Based on Parallel Dimensional Reduction

Germán Moltó,[†] María Suárez,[‡,§] Pablo Tortosa,[‡] José M. Alonso,[†] Vicente Hernández,[†] and Alfonso Jaramillo*[,‡,§]

Departamento de Sistemas Informáticos y Computación, Universidad Politécnica de Valencia, 46022 Valencia, Spain, Epigenomics Project, Genopole-Université d'Évry Val d'Essonne-CNRS UPS 3201, 91034 Évry, France, and Laboratoire de Biochimie, École Polytechnique-CNRS UMR 7654, 91128, Palaiseau, France

Received December 17, 2008

The design of proteins with targeted properties is a computationally intensive task with large memory requirements. We have developed a novel approach that combines a dimensional reduction of the problem with a High Performance Computing platform to efficiently design large proteins. This tool overcomes the memory limits of the process, allowing the design of proteins whose requirements prevent them to be designed in traditional sequential platforms. We have applied our algorithm to the design of functional proteins, optimizing for both catalysis and stability. We have also studied the redesign of dimerization interfaces, taking simultaneously into account the stability of the subunits of the dimer. However, our methodology can be applied to any computational chemistry application requiring combinatorial optimization techniques.

INTRODUCTION

Computational protein design has achieved remarkable breakthroughs[1] by considering the inverse folding problem: the identification of sequences able to fold on a predetermined three-dimensional structure and that exhibit high activity or stability.[2] Furthermore, the use of physicochemical inspired models has advanced our knowledge on the biophysical interactions governing processes such as protein structure,[3−6] protein−protein interactions,[7,8] or DNA−protein interactions.[9] In addition, the computational design of new biocatalysts,[10−14] the design of biosensors for non-natural molecules,[15] the redesign of improved protein binding affinity,[16] and the redesign of protein binding specificity[17,18] have opened new avenues for biotechnological and biomedical applications.[19,20]

The common approach to the inverse folding problem[21−23] relies on the precomputation of the interaction energies among the amino acids, in their different conformations, forming the possible sequences. We may compute different energies and use them as scoring functions (i.e., folding free energies, binding free energies, etc.), according to the goal of the designing procedure: thermostability, ligand binding affinity, protein−protein interaction, or DNA−protein binding specificity. Once we have computed the energies, we collect them into energy matrices for their optimization through different techniques: Monte Carlo Simulated Annealing (MCSA),[24] Dead End Elimination,[25] Branch and Bound,[26] or Genetic Algorithms.[27] The best suited methods to treat combinatorial problems of an ever increasing size are those based in heuristic approaches such as MCSA.

Protein design methodologies rely on the assumption that we will be able to perform a suitable exploration of the space of sequences, through the use of adequate combinatorial optimization methods, to find the optimal sequences. Nevertheless, whenever we are confronting the problem of designing functional proteins, our optimization problem will have two objectives since we want our protein to be both stable and functional. As a result, we will have to consider at least two scoring functions: one representing stability and another scoring function to account for the desired functionality of the protein.

Multiobjective searches are thus required to treat more complex problems (specificity design, improvement of binding affinity, or introduction of a new enzymatic activity) while maintaining the overall foldability of the considered protein. The development of multiobjective algorithms,[28,29] able to consider more than one interaction matrix at the same time, has led to an increase of the computational memory requirements. Moreover, the CPU time requirements of the optimization phase grow accordingly with the size of the designed protein. Therefore, Grid based projects (folding@home, rosetta@home[30,31]) have been developed to face this computational complexity. Nevertheless, these approaches still have to deal with the fact that each node must have enough available memory to load the complete matrices in order to perform the optimization.

In this paper, we propose a High Performance Computing approach that can benefit the protein optimization procedure to overcome these two difficulties. First of all, the memory requirements are distributed among different processors, thus allowing the tackling of larger proteins which, at the moment, cannot be optimized in a sequential platform. In addition, multiple processes can collaboratively optimize a single protein to increase the exploration of the search space. Our approach enables each different process to optimize part of the global problem: each one works with all the protein

* Corresponding author e-mail: alfonso.jaramillo@polytechnique.edu.
[†] Universidad Politécnica de Valencia.
[‡] École Polytechnique.
[§] Epigenomics Project.

10.1021/ci8004594 CCC: $40.75
Published on Web 05/07/2009

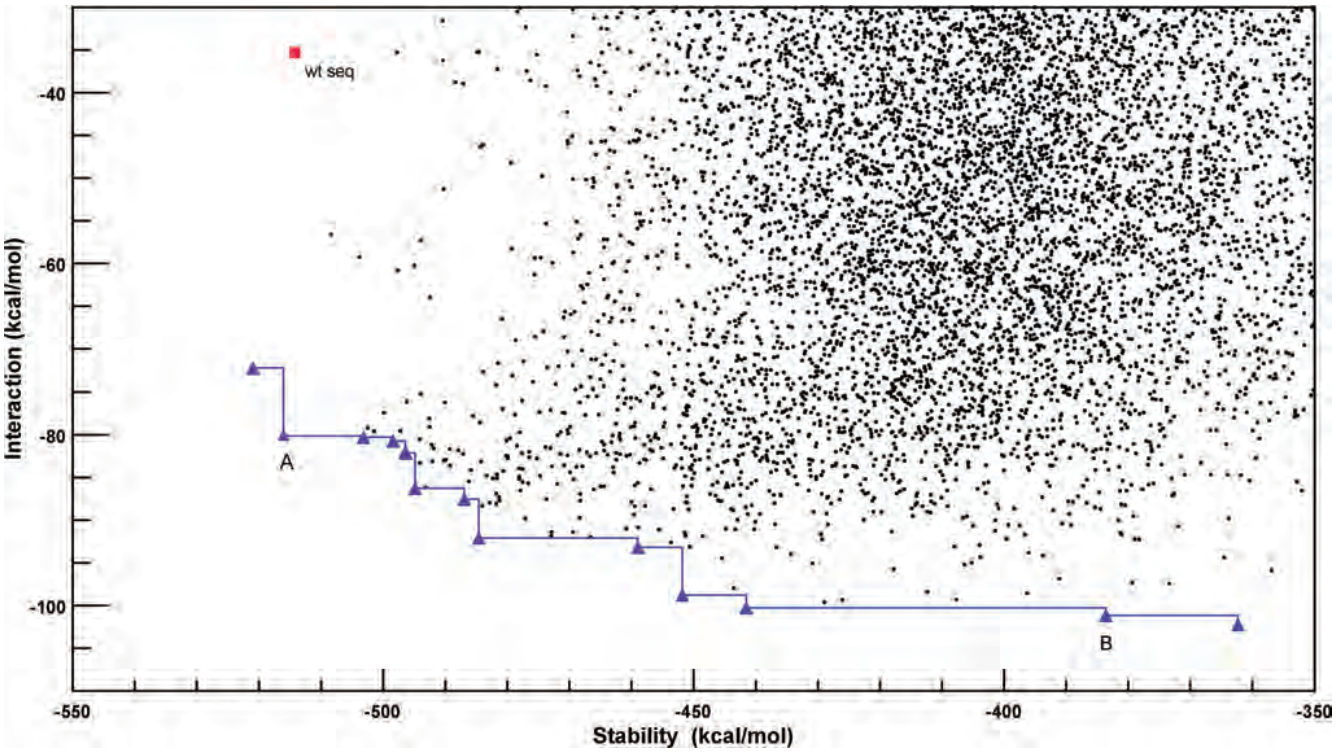


Figure 9. Dimerization interface redesign. Sequences explored in the optimization process. We have signaled (triangles) the nondominated sequences, and together with the frontiers of the regions they dominate (blue lines). These sequences form an approximation to the Pareto Set of sequences. The point (−514.24, −35.31) corresponds to the wild type sequence. Details of the structure of the marked sequences are shown in Figure 10. The complete structures of these sequences can be accessed in the Supporting Information.

the final optimized sequences and the intermediate lowest total energy solutions obtained at each iteration. Then we kept all nondominated ones, since they represent the best trade-off between the objectives. The intermediate sequences as well as the obtained PS are represented in Figure 9, together with the naturally occurring (wild type) sequence. We find that the optimization has increased the performance in both objectives, although the algorithm has been able to explore solutions exploring a broader range of binding affinity.

Sequences forming the PS show, in general, a decrease of the binding energy corresponding to interactions across the interface of about 40 kcal/mol with respect to the native sequence. On the other hand, the wild type sequence is among the most stable sequences obtained (note that the lower the folding energy the more stable a sequence is and the lower the binding energy the higher binding affinity a sequence has). Evolution has presumably optimized this protein for stability but also to form hexamers and homodimers. In our design, both units are no longer identical, and our designed sequences will not likely be able to form hexamers. The release of these two constraints may explain the fact that the wild type sequence is well away from the set of nondominated solutions.

Among the sequences in our PS, we have chosen to analyze two extreme cases, sequences A and B. Sequence A is one of the most stable sequences and has stability and interaction scores of −517.056 and −80.1374 kcal/mol, respectively. In Figure 10 A we can see a detail of the model of the structure corresponding to this sequence. We have focused on the dimerization interfaced formed by the two α helix. Almost no H-bonds involving side chains in this region have been produced in the designing process (those corresponding to the fixed backbone have been maintained, although they are not shown in the figures). On the other hand the side chain modeling has increased the stability of each of the monomers. As an example, the mutations K6D, F8Q, Q45D, and L12N have succeeded in constructing a triple H-bond stabilizing the interaction between the α-helix and the neighbor loop within a monomer. For sequence B (Figure 10 B) we have the opposite situation, where almost all the intradomain H-bonds involving only side chains have been lost, but the number of interactions across the dimerization interface has been greatly increased. This sequence has folding energy = −383.588 kcal/mol and binding energy = −101.165 kcal/mol. Mutations L32E (chain A) and L12K and I5K (in chain B) can be seen to increase the binding affinity of the monomers, through the formation of the interchain H-bonds. On the other hand, mutations L12K and I5K destabilize the protein, since they introduce polar groups into the protein core. These are two of the most extreme examples of the interplay between these competing objectives. Parts A and B show the α helix interface of the modeled structures, but the whole structures show a higher degree of interaction among the monomers than the wild type, as can be seen in the structures provided as Supporting Information.

CONCLUSIONS AND PERSPECTIVES

This paper describes the design of proteins with targeted properties using High Performance Computing. This approach allows a group of processors to collaborate in the optimization of the protein, thus increasing the quality of the obtained solutions through a more exhaustive exploration of the space of sequences and conformations. In addition,

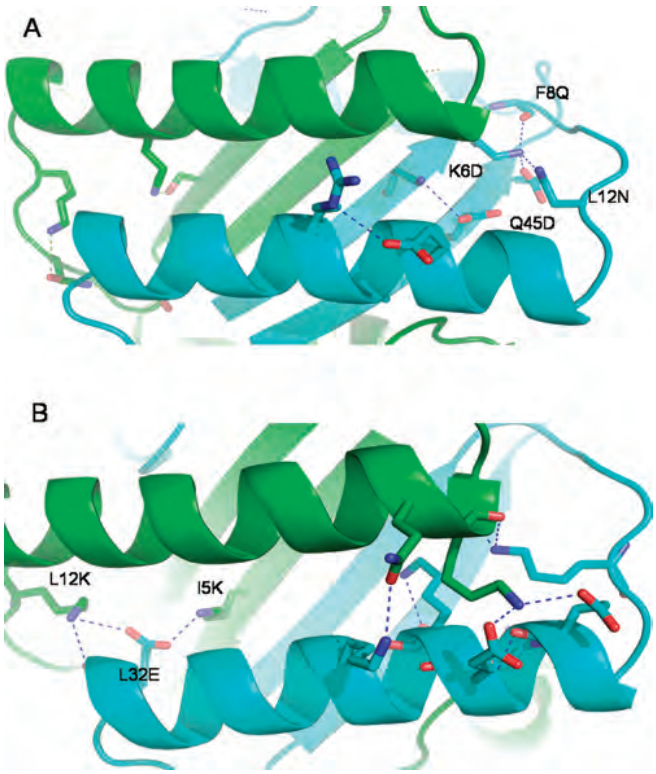


Figure 10. A) Dimerization interface of one of the most stable designed sequences. H-bonds involving side chains of residues in the same monomer have been marked as well as some selected mutations. B) Dimerization interface of one of the sequences with the highest interaction value, H-bonds across the interface have been marked. In both cases only H-bonds involving side chains have been depicted, since those only involving the main chain are kept fixed due to our fixed backbone assumption.

the proposed algorithm includes a dimensional reduction approach, that allows each processor to work with a subset of rotamers at each position of the protein. The subset of rotamers a given processor considers dynamically changes according to a probability distribution that considers the rate of appearance of rotamers in the partial solutions.

We have tested the algorithm with both virtual and real proteins, and we have detailed its performance under different parameter sets (i.e., dimensional reduction factor, number of processors, and number of global iterations). Our results show that it is possible to retrieve the global minimum with a reduced amount of memory. This paves the way to the optimization of larger proteins whose memory requirements represent a serious handicap when using a traditional computer.

In the near future, we plan to automatically compute the number of rotamers to be used for each processor. This value could be self-adjusted in order to fully take advantage of the available memory in the execution platform. This way, the optimization process would adapt its execution to the computational capacities available.

Additionally, the SA performed by each of the jobs to determine the rotamers probability distribution may be suboptimal since this distribution is constructed during the exploration of the different ranges of temperatures. Perhaps it would be well worth constructing this profile after the system has reached a fixed temperature T_{f_p}. To construct this profile we would let the system evolve using SA from T_0 to T_{f_p}, and then, keeping T fixed to T_{f_p}, the algorithm could explore the space of solutions following a Metropolis algorithm to accept or reject solutions. This modification would mean inclusion of additional local iterations to explore this region.

A natural extension of our algorithm to tackle multiobjective optimization problems is the use of the Weighted Sums Method[28,44] to assign different weights to each objective and to analyze the trade-off between the objectives. Nowadays, our method is implemented in such a way that the MCSA accepts/rejects solutions considering only the sum of both objectives, but we could extend it to keep also the solutions that are found to be nondominated and thus candidates for the Pareto Set.

Finally, eq 3 averages the old global probability and the new local probability to obtain the new global probability. In this equation both the local and global probabilities are equally treated. Perhaps the best way to obtain the new global probability would be to introduce a varying weighting factor, in such a way that initially a higher weight is given to the local probability, to erase the effect of the random initial distribution and, as the algorithm proceeds, a higher weight is given to the global probability distribution to not endanger the long-run quality of the global probabilities.

ACKNOWLEDGMENT

A.J. acknowledges financial support from the EU grants BioModularH2 (FP6-NEST contract 043340) and EMERGENCE (FP6-NEST contract 043338) and the ATIGE Genopole/UEVE CR-A3405. A.J., G.M., V.H., and J.M.A. wish to thank the Spanish Ministry of Science and Technology for the financial support received to develop the project ngGrid: New Generation Components for the Efficient Exploitation of eScience Infrastructures (TIN2006-12890). This work has been partially supported by the Structural Funds of the European Regional Development Fund (ERDF).

Supporting Information Available: Files in the Protein Data Bank format containing the atomic coordinates corresponding to sequences A and B from Figure 10. This material is available free of charge via the Internet at http://pubs.acs.org.

REFERENCES AND NOTES

(1) Lippow, S. M.; Tidor, B. *Curr. Opin. Biotech.* **2007**, *18*, 305–311.
(2) Bowie, J. U.; Lthy, R.; Heisenberg, D. *Science* **1991**, *253*, 164–170.
(3) Kuhlman, B.; Dantas, G.; Ireton, G. C.; Varani, G.; Stoddard, B. L.; Baker, D. *Science* **2003**, *302*, 1364–1368.
(4) Dantas, G.; Kuhlman, B.; Callender, D.; Wong, M.; Baker, D. *J. Mol. Biol.* **2003**, *332*, 449–460.
(5) Jaramillo, A.; Wernisch, L.; Héry, S.; Wodak, S. J. *Proc. Natl. Acad. Sci. U. S. A.* **2002**, *99*, 13554–13559.
(6) López de la Paz, M.; Serrano, L. *Proc. Natl. Acad. Sci. U. S. A.* **2004**, *101* (1), 87–92.
(7) Joachimiak, L. A.; Kortemme, T.; Stoddard, B. L.; Baker, D. *J. Mol. Biol.* **2006**, *361*, 195–208.
(8) Bolon, D. N.; Grant, R. A.; Baker, T. A.; Sauer, R. T. *Proc. Natl. Acad. Sci. U. S. A.* **2005**, *102*, 12724–12729.
(9) Ashworth, J.; Havranek, J. J.; Duarte, C. M.; Sussman, D.; Monnat, R. J.; Stoddard, B. L.; Baker, D. *Nature* **2006**, *41*, 656–659.
(10) Jiang, L.; Althoff, E. A.; Clemente, F. R.; Doyle, L.; Rothlisberger, D.; Zanghellini, A.; Gallaher, J. L.; Betker, J. L.; Tanaka, F.; Barbas, C. F.; Hilvert, D.; Houk, K. N.; Stoddard, B. L.; Baker, D. *Science* **2008**, *319*, 1387–1391.

(11) Röthlisberger, D.; Khersonsky, O.; Wollacott, A. M.; Jiang, L.; DeChancie, J.; Betker, J.; Gallaher, J. L.; Althoff, E. A.; Zanghellini, A.; Dym, O.; Albeck, S.; Houk, K. N.; Tawfik, D. S.; Baker, D. *Nature* **2008**, *06879*, 1–6.
(12) Suárez, M.; Tortosa, P.; García-Mira, M. M.; Rodríguez-Larrea, D.; Godoy-Ruiz, R.; Ibarra-Moreno, B.; Sánchez Ruiz, J.; Jaramillo, A. manuscript in preparation, 2008.
(13) Bolon, D. N.; Mayo, S. L. *Proc. Natl. Acad. Sci. U. S. A.* **2001**, *98*, 14274–14279.
(14) Kaplan, J.; DeGrado, W. F. *Proc. Natl. Acad. Sci. U. S. A.* **2004**, *101*, 11566–11570.
(15) Looger, L. L.; Dwyer, M. A.; Smith, J. J.; Hellinga, H. W. *Nature* **2003**, *423*, 185–190.
(16) Lazar, G. A.; Dang, W.; Karki, S.; Vafa, O.; Peng, J. S.; Hyun, L.; Chan, C.; Chung, H. S.; Eivazi, A.; Yoder, S. C.; Vielmetter, J.; Carmichael, D. F.; Hayes, R. J.; Dahiyat, B. I. *Proc. Natl. Acad. Sci. U. S. A.* **2006**, *103*, 4005–4010.
(17) Ogata, K.; Jaramillo, A.; Cohen, W.; Briand, J. P.; Connan, F.; Choppin, J.; Muller, S.; Wodak, S. J. *J. Biol. Chem.* **2002**, *278*, 1281–1290.
(18) Cochran, F. V.; Wu, S. P.; Wang, W.; Nanda, V.; Saven, J. G.; Therien, M. J.; DeGrado, W. F. *J. Am. Chem. Soc.* **2005**, *127*, 1346–1347.
(19) Kazlauskas, R. J. *Curr. Opin. Chem. Biol.* **2005**, *9*, 195–201.
(20) Jürgens, C.; Strom, A.; Wegener, D.; Hettwer, S.; Wilmanns, M.; Sterner, R. *Proc. Natl. Acad. Sci. U. S. A.* **2000**, *97*, 9925–9930.
(21) Chowdry, A. B.; Reynolds, K. A.; Hanes, M. S.; Vorhies, M.; Pokala, N.; Handel, T. M. *J. Comput. Chem.* **2007**, *28* (14), 2378–2388.
(22) Archontis, G.; Simonson, T. *J. Phys. Chem. B* **2005**, 22667–22673.
(23) Huang, A.; Stultz, C. M. *Biophys. J.* **2007**, 34–45.
(24) Hellinga, H. W.; Richards, F. M. *Proc. Natl. Acad. Sci. U. S. A.* **1994**, *91*, 5803–5807.
(25) Dahiyat, B.; Mayo, S. L. *Science* **1997**, *278* (5335), 82–87.
(26) Wernisch, L.; Hery, S.; Wodak, S. J. *J. Mol. Biol.* **2000**, *301* (3), 713–736.
(27) Jones, D. T. *Protein Sci.* **1994**, *3*, 567–574.
(28) Suárez, M.; Tortosa, P.; Carrera, J.; Jaramillo, A. *J. Comput. Chem.* **2008**, *29*, 2704–2711.
(29) Humphris, E. L.; Kortemme, T. *PLoS Comput. Biol.* **2007**, *3*, e164+.
(30) Zagrovic, B.; Sorin, E. J.; Pande, V. *J. Mol. Biol.* **2001**, *313*, 151–169.
(31) Rohl, C. A.; Strauss, C. E.; Misura, K. M.; Baker, D. *Methods Enzymol.* **2004**, *383*, 66–93.
(32) Katti, S. K.; Le Master, D. M.; Eklund, H. *J. Mol. Biol.* **1990**, *212*, 167.
(33) Almrud, J. J.; Kern, A. D.; Wang, S. C.; Czerwinski, R. M.; Johnson, W. H., Jr.; Murzin, A. G.; Hackert, M. L.; Whitman, C. P. *Biochemistry* **2002**, *41*, 12010–1202.
(34) Suárez, M.; Jaramillo, A. J. R. *Soc. Interface*, in press, 2009.
(35) Dunbrack, R. L.; Karplus, M. *J. Mol. Biol.* **1993**, *230*, 543–547.
(36) Brooks, B. R.; Bruccoleri, R. E.; Olafson, B. D.; States, D. J.; Swaminathan, S.; Karplus, M. *J. Comput. Chem.* **1983**, *4*, 187–217.
(37) Ooi, T.; Oobatake, M.; Némethy, G.; Scheraga, H. A. *Proc. Natl. Acad. Sci. U. S. A.* **1987**, *84*, 3086–3090.
(38) Jaramillo, A.; Wodak, S. J. *Biophys. J.* **2005**, *88*, 156–171.
(39) Saad, Y. *Iterative methods for sparse linear systems*; Society for Industrial and Applied Mathematics (SIAM): Philadelphia, PA, U.S.A., 2003.
(40) Gardiner, V.; Hoffman, J. G.; Metropolis, N. *J. Natl. Cancer Inst.* **1956**, *17*, 175–188.
(41) Hörmann, W.; Leydold, J.; Derflinger, G. *Automatic Nonuniform Random Variate Generation*; Springer: Berlin, 2004.
(42) MPI Forum. *MPI: A Message-Passing Interface Standard*, *version 2.0*; 1995.
(43) Whitman, C. P *Arch. Biochem. Biophys.* **2002**, *402* (1), 1–13.
(44) Papalambros, P. Y.; Wilde, D. J. *Principles of Optimal Design*; Cambridge University Press: New York, 2000.

CI8004594

5.1.1.8. Exploring the role of pH in modulating the effects of lidocaine in virtual ischemic tissue

.

K. Cardona, B. Trenor, G. Moltó, M. Martínez, J.M. Ferrero *Jr.*, F. Starmer, J. Saiz. "Exploring the role of pH in modulating the effects of lidocaine in virtual ischemic tissue," AJP Hear. Circ. Physiol., vol. 299, no. 5, pp. H1615-H1624, Nov. 2010, doi: https://dx.doi.org/10.1152/ajpheart.00425.2010

Base de datos de indexación	Web of Science (JCR)
Índice de impacto	3.712
Año	2009
Categoría	Cardiac & Cardiovascular Systems
Posición de la revista en el área	17 de 94
Tercil	T1
Cuartil	Q1
Número de citas en JCR	8
Número de citas totales	9

Comentario. Esta contribución supone un resultado posterior del proyecto de Plan Nacional TEC2005-04199 pues dicho simulador de la actividad eléctrica cardiaca desarrollado por el candidato se aplicó para el estudio de los efectos de la lidocaína en los tejidos cardiacos (en proyectos posteriores), dando lugar a una colaboración internacional con el profesor Frank Starmer de la Duke University

Am J Physiol Heart Circ Physiol 299: H1615–H1624, 2010.
First published August 13, 2010; doi:10.1152/ajpheart.00425.2010.

Exploring the role of pH in modulating the effects of lidocaine in virtual ischemic tissue

Karen Cardona,[1] Beatriz Trénor,[1] Germán Moltó,[2] Miguel Martínez,[3] José María Ferrero, Jr.,[1] Frank Starmer,[4] and Javier Saiz[1]

[1]*Instituto de Investigación Interuniversitario en Bioingeniería y Tecnología Orientada al Ser Humano,* [2]*Departamento de Sistemas Informáticos y Computación, and* [3]*Instituto Universitario de Automática e Informática Industrial, Universidad Politécnica de Valencia, Valencia, Spain; and* [4]*Biostatistics and Bioinformatics, Duke University, Singapore*

Submitted 3 May 2010; accepted in final form 10 August 2010

Cardona K, Trénor B, Moltó G, Martínez M, Ferrero JM Jr, Starmer F, Saiz J. Exploring the role of pH in modulating the effects of lidocaine in virtual ischemic tissue. *Am J Physiol Heart Circ Physiol* 299: H1615–H1624, 2010. First published August 13, 2010; doi:10.1152/ajpheart.00425.2010.—Lidocaine is a class I antiarrhytmic drug that blocks Na^+ channels and exists in both neutral and charged forms at a physiological pH. In this work, a mathematical model of pH and the frequency-modulated effects of lidocaine has been developed and incorporated into the Luo-Rudy model of the ventricular action potential. We studied the effects of lidocaine on Na^+ current, maximum upstroke velocity, and conduction velocity and demonstrated that a decrease of these parameters was dependent on pH, frequency, and concentration. We also tested the action of lidocaine under pathological conditions. Specifically, we investigated its effects on conduction block under acute regional ischemia. Our results in one-dimensional fiber simulations showed a reduction of the window of block in the presence of lidocaine, thereby highlighting the role of reduced conduction velocity and safe conduction. This reduction may be related to the antifibrillatory effects of the drug by hampering wavefront fragmentation. In bidimensional acute ischemic tissue, lidocaine increased the vulnerable window for reentry and exerted proarrhythmic effects. In conclusion, the present simulation study used a newly formulated model of lidocaine, which considers pH and frequency modulation, and revealed the mechanisms by which lidocaine facilitates the onset of reentries. The results of this study also help to increase our understanding of the potential antifibrillatory effects of the drug.

antiarrhythmic drug; sodium channel; guarded receptor theory; rate dependence

LIDOCAINE is a class I antiarrhythmic drug that exerts its effect by blocking inward Na^+ current (I_{Na}) in a use-dependent manner and is more effective for high stimulation frequencies (11). The block of I_{Na} by lidocaine leads to a decrease in the maximal action potential (AP) upstroke (dV/dt_{max}) (16, 37) and conduction velocity (CV) (1).

Lidocaine is a tertiary amine, and at a physiological pH, the drug exists in both neutral and charged forms (5, 24). Lidocaine is ionized with a pKa value in the range of 7.5–8.2 to give an equilibrium mixture of charged and neutral forms. The charged form predominates at low pH (6.4) due to the protonation of the neutral form with hydrogen molecules. Experimental data have confirmed that lidocaine is more effective and recovery from block is slowed (5, 35, 57) under acidosis. Therefore, the pH value plays an extremely important role in the effects of lidocaine.

The substantial fall in external pH during some pathologies, such as myocardial ischemia, changes the kinetics of the drug binding to Na^+ channels and may partially explain the heightened depressant effect of this drug during myocardial ischemia (13, 54).

Currently, lidocaine is one of the most controversial pharmacological agents among the antiarrhythmic drugs. The mechanism by which lidocaine suppresses or exerts arrhythmic effects is still not well understood. Experimental studies have shown that the reduction of excitability provoked by lidocaine promotes proarrhythmic effects, especially under ischemic conditions. This is because the level of external pH decreases and the action of lidocaine on the Na^+ channel increases, leading to a higher dispersion of conduction in the tissue (46, 60). However, other studies (7, 62) have supported the antifibrillatory effects of lidocaine in hampering wavefront fragmentation. By modeling the effects of lidocaine on I_{Na}, computer simulations can be conducted at cellular, tissue, and organ levels. The resultant studies will definitely shed light into the mechanisms of action of this drug and its role in arrhythmogenic processes.

The goal of the present work was to study the effect of pH on the action of lidocaine in the ventricular myocardium under normal and pathological conditions. A mathematical model of the effect of lidocaine on the Na^+ channel was proposed and incorporated into a ventricular AP model. The effects of lidocaine on AP characteristics for different pH values and concentrations of the drug were analyzed. Furthermore, we also conducted a theoretical investigation focusing on the mechanism by which lidocaine exerts controversial effects under ischemic conditions.

METHODS

Formulation of the lidocaine model. To formulate the model of the effects of lidocaine on Na^+ channels, it was important to consider that drugs such as lidocaine have two specific accesses to the Na^+ channel receptor, i.e., through hydrophobic and hydrophilic pathways, depending on the local pH (26).

The model of lidocaine-I_{Na} interactions formulated in this work takes into account the modulatory effect of pH on Na^+ channel block. The mathematical model was based on the guarded receptor theory proposed by Starmer (48). In our formulation, three main processes were considered: the hydrophobic pathway, the hydrophilic pathway, and coupling between blocked channels by charged and neutral forms using a proton exchange process.

It is widely known that the hydrophobic pathway is available at all times to lipid-soluble molecules (35). Several experimental studies

Address for reprint requests and other correspondence: J. Saiz, Instituto de Investigación Interuniversitario en Bioingeniería y Tecnología Orientada al Ser Humano (I3BH), Universidad Politécnica de Valencia, Camino de Vera s/n, Valencia 46022, Spain (e-mail: jsaiz@gbio.i3bh.es).

Furthermore, it has been experimentally observed that when the degree of myocardial injury increased, lidocaine facilitated the generation of reentrant circuits (6, 9). In examining this effect, we observed an important decrease in the lower limit of the VW. In the absence of the drug, and for low CIs, bidirectional block occurred, whereas reentry and thus unidirectional block occurred in the presence of the drug for the same CIs. In this way, lidocaine increased the probability of unidirectional block and prevented bidirectional block. This observation is in accordance with our one-dimensional results, as lidocaine favors conduction and prevents the retrograde block in the distal zone, thereby giving rise to the reentrant circuit. The reduction in CV also allows the distal zone of the tissue to recover from refractoriness when reached by the retrograde wavefront.

Clinical implications. Lidocaine is classified as a class Ib antiarrhythmic agent used to suppress arrhythmias. However, classification is a difficult task since many of the antiarrhythmic agents have multiple modes of action. The use of lidocaine is generally accepted in antiarrhythmic therapies during the acute phase of myocardial infarction. However, there is ample evidence that this drug exerts proarrhythmic effects by slowing conduction, facilitating the formation of reentries under ischemic conditions. This observation has been supported by experimental and clinical studies undertaken by several authors (9, 31, 43, 46, 62) and also by the present work.

The possible effectiveness of lidocaine under ischemic conditions is related to the termination of wavefront fragmentation into multiple wavelets and microreentrant circuits, exerting antifibrillatory effects. This effect has been proven by Yin (62) and by our results using one-dimensional fibers. To analyze the effects of lidocaine under such situations, further theoretical investigations should be undertaken in two- or three-dimensional tissues prone to fibrillation.

Other authors (2, 18) have investigated the action of lidocaine after 10–15 min of coronary occlusion. In such studies, an important finding was that lidocaine mainly prevented Na^+ loading, thus preventing Ca^{2+} overload and reducing cardiac damage. In this way, lidocaine exerts antiarrhythmic effects under ischemic conditions.

Limitations of the study. Some difficulties were encountered regarding the model of lidocaine. Specifically, data reflecting the use- and pH-dependent effects were scarce in the experimental scientific literature. Data published in 1977 by Schwarz were used to fit the model parameters. However, the experimentally observed effects of lidocaine were reproduced by our model with a high degree of fidelity.

In this work, we used experimental data from the frog because guinea pig data for pH- and use-dependent block by lidocaine were not available. Yet, the model was validated against data from the guinea pig and accurately reproduced the action of the drug under normal and pathologic conditions.

The most relevant electrophysiological changes have been in the model of ischemia. However, it is well documented that other mechanisms are altered, such as the depression of the Na^+-K^+ pump or other alterations in ionic currents. Furthermore, although regional heterogeneity in the tissue was considered, the contribution of transmural heterogeneity in the tissues, which was not considered in our case, may have an important role in the genesis of reentries and in arrithmogenesis when lidocaine is applied. Despite these limitations, our simulations rigorously reproduced the action of lidocaine under normal and ischemic conditions. The similarities between the results obtained from our simulations and experimental observations support the robustness of our model. Our model can be regarded as a new tool to study the mechanism of the action of lidocaine under different pathologies.

Conclusions. In this study, we proposed a model to characterize the behavior of both neutral and charged forms of lidocaine in the cellular electrical activity of guinea pig ventricles. The model is based on experimental results and takes into account the experimental evidence that suggests an interaction with the channel in a pH-, concentration-, and use-dependent manner. Simulations of the effects of lidocaine were conducted, and a higher reduction of I_{Na}, dV/dt_{max}, and CV was obtained at lower pH and BCL values. Under ischemic conditions, the effect of lidocaine on conduction block was investigated. In a one-dimensional fiber, our simulations showed a decrease in the WB for the different concentrations of lidocaine as a result of the reduction of I_{Na} and CV, with I_{CaL} supporting conduction, leading to slower but safer conduction. Thus, lidocaine could hamper wavefront fragmentation and exert antifibrillatory effects. In a bidimensional tissue, lidocaine exerts a proarrhythmic effect by increasing the vulnerability to reentries as a consequence of slow conduction and the enhancement of conduction dispersion.

GRANTS

This work was partially supported by European Commission preDiCT Grant DG-INFSO-224381 through the National Plan for Scientific Research, Development, and Technological Innovation of the Spanish Ministry of Science and Innovation (TEC2008-02090 and TIN2004-03602), by the Research and Development Support Plan (PAID-06-09-2843) of the Universidad Politécnica de Valencia, and by the Directorate-General for Scientific Policy of the Valencian Regional Government (GV/2010/078) and by the Generalitat Valenciana (BEST/2010/102). The work of K. Cardona is fully supported by the Spanish Ministry of Science and Education (TIC2001-2686).

DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

REFERENCES

1. **Anderson KP, Walker R, Lux RL, Ershler PR, Menlove R, Williams MR, Krall R, Moddrelle D.** Conduction velocity depression and drug-induced ventricular tachyarrhythmias. Effects of lidocaine in the intact canine heart. *Circulation* 81: 1024–1038, 1990.
2. **Barrett TD, Hayes ES, Yong SL, Zolotoy AB, Abraham S, Walker MJ.** Ischaemia selectivity confers efficacy for suppression of ischaemia-induced arrhythmias in rats. *Eur J Pharmacol* 398: 365–374, 2000.
3. **Bean BP, Cohen CJ, Tsien RW.** Lidocaine block of cardiac sodium channels. *J Gen Physiol* 81: 613–642, 1983.
4. **Biktasheva IV, Simitev RD, Suckley R, Biktashev VN.** Asymptotic properties of mathematical models of excitability. *Philos Transact A Math Phys Eng Sci* 364: 1283–1298, 2006.
5. **Broughton A, Grant AO, Starmer CF, Klinger JK, Stambler BS, Strauss HC.** Lipid solubility modulates pH potentiation of local anesthetic block of V_{max} reactivation in guinea pig myocardium. *Circ Res* 55: 513–523, 1984.
6. **Campbell TJ, Hemsworth PD.** Selective depression of maximum rate of depolarization of guinea-pig ventricular action potentials by amiodarone and lignocaine in simulated ischaemia: comparison with encainide. *Clin Exp Pharmacol Physiol* 17: 135–145, 1990.
7. **Canyon SJ, Dobson GP.** Protection against ventricular arrhythmias and cardiac death using adenosine and lidocaine during regional ischemia in the in vivo rat. *Am J Physiol Heart Circ Physiol* 287: H1286–H1295, 2004.
8. **Cardinal R, Janse MJ, van E, I, Werner G, d'Alnoncourt CN, Durrer D.** The effects of lidocaine on intracellular and extracellular potentials,

activation, and ventricular arrhythmias during acute regional ischemia in the isolated porcine heart. *Circ Res* 49: 792–806, 1981.
9. **Chang MG, Zhang Y, Chang CY, Xu L, Emokpae R, Tung L, Marban E, Abraham MR.** Spiral waves and reentry dynamics in an in vitro model of the healed infarct border zone. *Circ Res* 105: 1062–1071, 2009.
10. **Cimponeriu A, Starmer CF, Bezerianos A.** Ischemic modulation of vulnerable period and the effects of pharmacological treatment of ischemia-induced arrhythmias: a simulation study. *IEEE Trans Biomed Eng* 50: 168–177, 2003.
11. **Clarkson CW, Matsubara T, Hondeghem LM.** Evidence for voltage-dependent block of cardiac sodium channels by tetrodotoxin. *J Mol Cell Cardiol* 20: 1119–1131, 1988.
12. **Comtois P, Sakabe M, Vigmond EJ, Munoz M, Texier A, Shiroshita-Takeshita A, Nattel S.** Mechanisms of atrial fibrillation termination by rapidly unbinding Na^+ channel blockers: insights from mathematical models and experimental correlates. *Am J Physiol Heart Circ Physiol* 295: H1489–H1504, 2008.
13. **Coronel R, Wilms-Schopman FJ, Dekker LR, Janse MJ.** Heterogeneities in $[K^+]_o$ and TQ potential and the inducibility of ventricular fibrillation during acute regional ischemia in the isolated perfused porcine heart. *Circulation* 92: 120–129, 1995.
14. **Courtney KR.** Mechanism of frequency-dependent inhibition of sodium currents in frog myelinated nerve by the lidocaine derivative GEA. *J Pharmacol Exp Ther* 195: 225–236, 1975.
15. **Drolet B, Simard C, Mizoue L, Roden DM.** Human cardiac potassium channel DNA polymorphism modulates access to drug-binding site and causes drug resistance. *J Clin Invest* 115: 2209–2213, 2005.
16. **Ehring GR, Moyer JW, Hondeghem LM.** Quantitative structure activity studies of antiarrhythmic properties in a series of lidocaine and procainamide derivatives. *J Pharmacol Exp Ther* 244: 479–492, 1988.
17. **Faber GM, Rudy Y.** Action potential and contractility changes in $[Na^+]_i$ overloaded cardiac myocytes: a simulation study. *Biophys J* 78: 2392–2404, 2000.
18. **Farkas A, Curtis MJ.** Limited antifibrillatory effectiveness of clinically relevant concentrations of class I antiarrhythmics in isolated perfused rat hearts. *J Cardiovasc Pharmacol* 39: 412–424, 2002.
19. **Fazekas T, Scherlag BJ, Mabo P, Patterson E, Lazzara R.** Facilitation of reentry by lidocaine in canine myocardial infarction. *Acta Physiol Hung* 82: 201–213, 1994.
20. **Fernandez M, Caballero J, Fernandez L, Sarai A.** Genetic algorithm optimization in drug design QSAR: Bayesian-regularized genetic neural networks (BRGNN) and genetic algorithm-optimized support vectors machines (GA-SVM). *Mol Divers*. In press.
21. **Ferrero JM, Trénor B, Rodriguez B, Sáiz J.** Electrical activity and reentry during acute regional myocardial ischemia: insights from simulations. *Int J Bifurc Chaos* 13: 3703–3715, 2003.
22. **Ferrero JM Jr, Saiz J, Ferrero JM, Thakor NV.** Simulation of action potentials from metabolically impaired cardiac myocytes. Role of ATP-sensitive K^+ current. *Circ Res* 79: 208–221, 1996.
23. **Furukawa T, Koumi S, Sakakibara Y, Singer DH, Jia H, Arentzen CE, Backer CL, Wasserstrom JA.** An analysis of lidocaine block of sodium current in isolated human atrial and ventricular myocytes. *J Mol Cell Cardiol* 27: 831–846, 1995.
24. **Grant AO, Strauss LJ, Wallace AG, Strauss HC.** The influence of pH on th electrophysiological effects of lidocaine in guinea pig ventricular myocardium. *Circ Res* 47: 542–550, 1980.
25. **Hamamoto T, Ichiyama M, Takahashi Y, Ban T.** Modelling of frequency-dependent effects of lignocaine homologues on the maximum upstroke velocity of action potentials in guinea-pig papillary muscles. *Clin Exp Pharmacol Physiol* 19: 457–468, 1992.
26. **Hille B.** Local anesthetics: hydrophilic and hydrophobic pathways for the drug-receptor reaction. *J Gen Physiol* 69: 497–515, 1977.
27. **Houck C, Joines J, Kay M.** A genetic algorithm for optimization: a Matlab implementation. *Report NCSU-IE TR*: 95–109, 1995.
27a. **Irvine LA.** *Models of the Cardiac Sodium Channel and the Action of Lidocaine* (Dissertation). Baltimore, MD: The Johns Hopkins Univ., 1998.
28. **Jia H, Furukawa T, Singer DH, Sakakibara Y, Eager S, Backer C, Arentzen C, Wasserstrom JA.** Characteristics of lidocaine block of sodium channels in single human atrial cells. *J Pharmacol Exp Ther* 264: 1275–1284, 1993.
29. **Kagiyama Y, Hill JL, Gettes LS.** Interaction of acidosis and increased extracellular potassium on action potential characteristics and conduction in guinea pig ventricular muscle. *Circ Res* 51: 614–623, 1982.
30. **Li GR, Ferrier GR.** Effects of lidocaine on reperfusion arrhythmias and electrophysiological properties in an isolated ventricular muscle model of ischemia and reperfusion. *J Pharmacol Exp Ther* 257: 997–1004, 1991.
31. **Lin JW, Garber L, Qi YR, Chang MG, Cysyk J, Tung L.** Region [corrected] of slowed conduction acts as core for spiral wave reentry in cardiac cell monolayers. *Am J Physiol Heart Circ Physiol* 294: H58–H65, 2008.
33. **Liu H, Atkins J, Kass RS.** Common molecular determinants of flecainide and lidocaine block of heart Na^+ channels: evidence from experiments with neutral and quaternary flecainide analogues. *J Gen Physiol* 121: 199–214, 2003.
34. **Luo CH, Rudy Y.** A dynamic model of the cardiac ventricular action potential. I. Simulations of ionic currents and concentration changes. *Circ Res* 74: 1071–1096, 1994.
35. **Moorman JR, Yee R, Bjornsson T, Starmer CF, Grant AO, Strauss HC.** pKa does not predict pH potentiation of sodium channel blockade by lidocaine and W6211 in guinea pig ventricular myocardium. *J Pharmacol Exp Ther* 238: 159–166, 1986.
37. **Nawada T, Tanaka Y, Hirai S, Hisatome I, Hasegawa J, Kotake H, Mashiba H.** Evaluation of negative inotropic and antiarrhythmic effects of class 1 antiarrhythmic drugs. *Int J Clin Pharmacol Ther* 32: 347–355, 1994.
38. **Pasek M, Simurda J.** Quantitative modelling of interaction of propafenone with sodium channels in cardiac cells. *Med Biol Eng Comput* 42: 151–157, 2004.
39. **Quinteiro RA, Biagetti MO, de Forteza E.** Effects of lidocaine on V_{max} and conduction velocity in uniform anisotropic canine ventricular muscle: possible role of its binding-rate constants. *J Cardiovasc Pharmacol* 15: 29–36, 1990.
40. **Romero L, Trenor B, Alonso JM, Tobon C, Saiz J, Ferrero JM Jr.** The relative role of refractoriness and source-sink relationship in reentry generation during simulated acute ischemia. *Ann Biomed Eng* 37: 1560–1571, 2009.
41. **Saiz J, Monserrat M, Gomis-Tena J, Torres V, Ferrero JM, Nitish T.** Reflection and ectopic activity induced by early afterdepolarizations. A computer modeling study. *Proc XIX Int Conf IEEE/EMBS* 20: 390–393, 1998.
42. **Schwarz W, Palade PT, Hille Local anesthetics B.** Effect of pH on use-dependent block of sodium channels in frog muscle. *Biophys J* 20: 343–368, 1977.
43. **Shah M, Akar FG, Tomaselli GF.** Molecular basis of arrhythmias. *Circulation* 112: 2517–2529, 2005.
44. **Shaw RM, Rudy Y.** Electrophysiologic effects of acute myocardial ischemia. A mechanistic investigation of action potential conduction and conduction failure. *Circ Res* 80: 124–138, 1997.
45. **Shaw RM, Rudy Y.** Ionic mechanisms of propagation in cardiac tissue. Roles of the sodium and L-type calcium currents during reduced excitability and decreased gap junction coupling. *Circ Res* 81: 727–741, 1997.
46. **Sims JJ, Miller AW, Ujhelyi MR.** Electrical heterogeneity and arrhythmogenesis: importance of conduction velocity dispersion. *J Cardiovasc Pharmacol* 41: 795–803, 2003.
47. **Sivapathasekaran C, Mukherjee S, Ray A, Gupta A, Sen R.** Artificial neural network modeling and genetic algorithm based medium optimization for the improved production of marine biosurfactant. *Bioresour Technol* 101: 2884–2887, 2010.
48. **Starmer CF, Courtney KR.** Modeling ion channel blockade at guarded binding sites: application to tertiary drugs. *Am J Physiol Heart Circ Physiol* 251: H848–H856, 1986.
49. **Starmer CF, Grant AO, Colatsky TJ.** What happens when cardiac Na channel function is compromised? 2. Numerical studies of the vulnerable period in tissue altered by drugs. *Cardiovasc Res* 57: 1062–1071, 2003.
50. **Starmer CF, Grant AO, Strauss HC.** Mechanisms of use-dependent block of sodium channels in excitable membranes by local anesthetics. *Biophys J* 46: 15–27, 1984.
51. **Starmer CF, Nesterenko VV, Undrovinas AI, Grant AO, Rosenshtraukh LV.** Lidocaine blockade of continuously and transiently accessible sites in cardiac sodium channels. *J Mol Cell Cardiol* 23, *Suppl* 1: 73–83, 1991.
52. **Syed Z, Vigmond E, Leon L.** Suitability of genetic algorithm generated models to simulate atrial fibrillation and K^+ channel blockades. *Conf Proc IEEE Eng Med Biol Soc* 7: 7087–7090, 2005.
53. **Tan JH, Saint DA.** Interaction of lidocaine with the cardiac sodium channel: effects of low extracellular pH are consistent with an external blocking site. *Life Sci* 67: 2759–2766, 2000.

54. **ten HM, Jansen MA, Nederhoff MG, Van Echteld CJ.** Combined blockade of the Na^+ channel and the Na^+/H^+ exchanger virtually prevents ischemic Na^+ overload in rat hearts. *Mol Cell Biochem* 297: 101–110, 2007.
55. **Trenor B, Ferrero JM Jr, Rodriguez B, Montilla F.** Effects of pinacidil on reentrant arrhythmias generated during acute regional ischemia: a simulation study. *Ann Biomed Eng* 33: 897–906, 2005.
56. **Trenor B, Romero L, Ferrero JM Jr, Saiz J, Molto G, Alonso JM.** Vulnerability to reentry in a regionally ischemic tissue: a simulation study. *Ann Biomed Eng* 35: 1756–1770, 2007.
57. **Wendt DJ, Starmer CF, Grant AO.** pH dependence of kinetics and steady-state block of cardiac sodium channels by lidocaine. *Am J Physiol Heart Circ Physiol* 264: H1588–H1598, 1993.
58. **Wendt DJ, Starmer CF, Grant AO.** pH dependence of kinetics and steady-state block of cardiac sodium channels by lidocaine. *Am J Physiol Heart Circ Physiol* 264: H1588–H1598, 1993.
59. **Wu J, Zipes DP.** Transmural reentry during acute global ischemia and reperfusion in canine ventricular muscle. *Am J Physiol Heart Circ Physiol* 280: H2717–H2725, 2001.
60. **Wyse KR, Ye V, Campbell TJ.** Effects of hyperkalaemia on the depression of maximum rate of depolarization by class I antiarrhythmic agents in guinea-pig myocardium. *Br J Pharmacol* 108: 255–261, 1993.
61. **Yeh JZ, Tanguy J.** Na channel activation gate modulates slow recovery from use-dependent block by local anesthetics in squid giant axons. *Biophys J* 47: 685–694, 1985.
62. **Yin H, el Sherif N, Caref EB, Ndrepepa G, Levin R, Isber N, Stergiopolus K, Assadi MA, Gough WB, Restivo M.** Actions of lidocaine on reentrant ventricular rhythms in the subacute myocardial infarction period in dogs. *Am J Physiol Heart Circ Physiol* 272: H299–H309, 1997.

5.1.1.9. A replicated information system to enable dynamic collaborations in the Grid

E. Torres, G. Moltó, D. Segrelles, I. Blanquer, and Vicente Hernández, "A replicated information system to enable dynamic collaborations in the Grid," Concurr. Comput. Pract. Exp., vol. 24, no. 14, pp. 1668–1683, Sep. 2012, doi: https://dx.doi.org/10.1002/cpe.1915

Base de datos de indexación	Web of Science (JCR)
Índice de impacto	0.79
Año	2012
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	42 de 100
Tercil	T1
Cuartil	Q2
Número de citas en JCR	3
Número de citas totales	7

Comentario. Esta contribución fue uno de los resultados del proyecto de Plan Nacional ngGrid (TIN2006-12890), en el que participó el candidato. El mecanismo de replicación ideado por el candidato en la publicación "Automatic Replication of WSRF-based Grid Services via Operation Providers" fue integrado para permitir la replicación del sistema de información en una infraestructura distribuida Grid.

CONCURRENCY AND COMPUTATION: PRACTICE AND EXPERIENCE
Concurrency Computat.: Pract. Exper. 2012; **24**:1668–1683
Published online 2 February 2012 in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/cpe.1915

A replicated information system to enable dynamic collaborations in the Grid

Erik Torres*,†, Germán Moltó, Damià Segrelles, Ignacio Blanquer and Vicente Hernández

Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC – Universitat Politècnica de València – CIEMAT, Camino de Vera s/n, 46022 Valencia, Spain

SUMMARY

The main advantage of Grid computing over other distributed computing paradigms is its capability to coordinate the access to data and resources in a virtual multi-institutional environment. To this end, the information system plays a decisive role in selecting the services that meet the applications' needs. This paper presents an information system for the Grid that provides transparent and scalable group communication services to standard Grid applications, with the objective of supporting dynamic collaborations that could help address problems that involve only some participants of a virtual organization. In particular, it enables more flexible delivery mechanisms, which allows applications to select the appropriate services before sending their data to the information system. This significantly enhances the protection of data from unauthorized access, and avoids the transmission of unnecessary messages over the network. The proposed information system is based on the use of XML technologies and replication. It introduces several new advanced features that are not currently supported as a whole by any Grid middleware, such as: several entry points to the information, persistent capabilities, support for advanced queries based on XQuery, and support for the industrial standard WS-Policy. The information system has been stress tested under realistic workloads in a Grid infrastructure with 50 sites. Scalability has been evaluated in up to 1000 messages that can be up to 10 KB in size each, updated with a frequency of 5 min. Copyright © 2012 John Wiley & Sons, Ltd.

Received 28 April 2011; Revised 7 November 2011; Accepted 12 November 2011

KEY WORDS: Grid; information systems; service-oriented architectures; replication

1. INTRODUCTION

Computational Grids are currently used to tackle major challenges in scientific research. For example, the Worldwide LHC Computing Grid [1] distributes and analyzes hundreds of terabytes of data, serving a community of several thousands of users around the world. To this end, different tools have been developed, enabling users to execute applications in ubiquitous distributed computational resources, and providing transparent and secure access to distributed data. gLite [2], Globus Toolkit [3], and UNICORE [4] are examples of open-source Grid middlewares that are widely used in various fields of science and engineering.

The main advantage of Grid over other distributed computing paradigms is its capability to coordinate the access to data and resources across different administrative domains, in a virtual multi-institutional environment. Grid supports virtual organizations (VO) created to address the problems of a particular area. For example, the Spanish National Grid Initiative [5] provides a virtual, distributed computing infrastructure that uses Grid technologies to interconnect approximately 20 computational resource centers in Spain. A special characteristic for the Spanish National Grid

*Correspondence to: Erik Torres, Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC – Universitat Politècnica de València – CIEMAT, Camino de Vera s/n, 46022 Valencia, Spain.

†E-mail: ertorser@upv.es

Applications that can benefit from the approach proposed in this paper are those that require execution times in the order of tens of minutes to days or weeks. These are typical high-throughput Grid applications. For example, this is the case of medical image processing, which is frequently used in biomedicine as part of wider research, such as pharmacokinetic studies.

In contrast, this approach is not recommended for applications that require execution times in the order of seconds to a few minutes. These are typical short-running tasks that are executed as part of a multi-step procedure. For example, the comparison of biological sequences to find the best matched sequence within a group of sequences stored in a database, which is generally performed during the initial steps of a research project.

Future works include further experimentation and optimization of the proposed approach. There are plans to evaluate the applicability of the information system to other problems, such as the monitoring of resource utilization. In this particular case, the performance of the system needs to be adapted to deal with information that is much more dynamic.

ACKNOWLEDGEMENTS

The authors wish to thank the financial support received from The Spanish Ministry of Education and Science to develop the project "ngGrid - New Generation Components for the Efficient Exploitation of eScience Infrastructures", with reference number TIN2006-12890. This work has been partially supported by the Generalitat Valenciana and the Structural Funds of the European Regional Development Fund (ERDF).

REFERENCES

1. Shiers J. The Worldwide LHC Computing Grid (worldwide LCG). *Computer Physics Communications* 2007; **177**(1–2):219–223. DOI: 10.1016/j.cpc.2007.02.021.
2. GLite. The EGEE middleware for Grid computing. Available from: http://glite.cern.ch [November 24, 2011].
3. Foster I. Globus Toolkit Version 4: software for service-oriented systems. *Lecture Notes in Computer Science* 2005; **3779**:2–13. DOI: 10.1007/11577188_2.
4. Erwin DW. UNICORE - a Grid computing environment. *Concurrency and Computation: Practice and Experience* November 2002; **14**(13–15):1395–1410. DOI: 10.1002/cpe.691.
5. Kranzlmüller D, Lucas JM, Öster P. The European Grid Initiative (EGI). In *Remote Instrumentation and Virtual Laboratories*, Davoli F, Pugliese R, Meyer N, Zappatore S (eds). Springer: US, 2010; 61–66, DOI: 10.1007/978-1-4419-5597-5_6.
6. EGI. European Grid Infrastructure. Available from: http://www.egi.eu [November 24, 2011].
7. Alfieri R, Cecchini R, Ciaschini V, DellAgnello L, Frohner A, Lorentey K, Spataro F. From gridmap-file to VOMS: managing authorization in a Grid environment. *Future Generation Computer Systems* 2005; **21**(4):549–558. DOI: 10.1016/j.future.2004.10.006.
8. Schopf JM, Raicu I, Pearlman L, Miller N, Kesselman C, Foster I, DArcy M. Monitoring and Discovery in a Web Services Framework: Functionality and Performance of Globus Toolkit MDS4, 2006.
9. BDII. Berkeley Database Information Index. Available from: https://twiki.cern.ch/twiki/bin/view/EGEE/BDII [November 24, 2011].
10. Blanquer I, Hernandez V, Segrelles D, Torres E. TRENCADIS - secure architecture to share and manage DICOM objects in a ontological framework based on OGSA. *Studies in Health Technology and Informatics* 2007; **126**:115–124.
11. Blanquer I, Hernández V, Meseguer FJ, Segrelles JD. Content-based organisation of virtual repositories of DICOM objects. *Future Generation Computer Systems* 2009; **25**(6):627–637. DOI: 10.1016/j.future.2008.12.004.
12. CIBERSAM. Centro de Investigación Biomédica en Red de Salud Mental. Available from: http://www.cibersam.es [November 24, 2011].
13. W3C Web Services Policy Working Group. Web Services Policy 1.5 - Framework, 2007. URL http://www.w3.org/TR/ws-policy/.
14. Jayasinghe D. *Quickstart Apache Axis2: A Practical Guide to Creating Quality Web Services*. Packt Publishing: Birmingham, United Kingdom, 2008.
15. Thai TL, Lam H. *.Net Framework Essentials*, 3rd Edition. O'Reilly Media: Sebastopol, California, United States, 2003.
16. Alfonso C, Caballer M, Hernández V. DIDA, a Distributed Discovery Architecture for Grid Environments. In *Proceedings of the Cracow 05 Grid Workshop*. Druk i Oprawa EKODRUK: Cracow, Poland, 2005; 106–113.
17. Cooke A, Gray AJG, Ma L, Nutt W, Magowan J, Oevers M, Taylor P, Byrom R, Field L, Hicks S, Leake J, Soni M, Wilson A. R-GMA: An Information Integration System for Grid Monitoring, 2003.
18. Gagliardi F, Jones B, Grey F, Bégin ME, Heikkurinen M. Building an infrastructure for scientific Grid computing: status and goals of the EGEE project. *Philosophical transactions. Series A, Mathematical, physical, and engineering sciences* 2005; **363**(1833):1729–1742. DOI: 10.1098/rsta.2005.1603.

19. Howes TA, Smith MC, Good GS. *Understanding and Deploying LDAP Directory Services*, 2nd Edition. Addison-Wesley Professional: Boston, United States, 2003.
20. Laure E, Gr C, Fisher S, Frohner A, Kunszt P, Krenek A, Mulmo O, Pacini F, Prelz F, White J, Barroso M, Buncic P, Byrom R, Cornwall L, Craig M, Meglio AD, Djaoui A, Giacomini F, Hahkala J, Hemmer F, Hicks S, Edlund A, Maraschini A, Middleton R, Sgaravatto M, Steenbakkers M, Walk J, Wilson A. Programming the Grid with gLite, 2006.
21. Open Grid Forum. GLUE Specification v.2.0. *Technical Report*, 2009. Open Grid Forum URL http://www.ogf.org/documents/GFD.147.pdf.
22. Chaudhri AB, Rashid A, Zicari R. *XML Data Management: Native XML and XML-Enabled Database Systems*. Addison-Wesley Professional: Boston, United States, 2003.
23. Cohen F. *Fast SOA: The Way to use Native XML Technology to Achieve Service Oriented Architecture Governance, Scalability, and Performance*. Morgan Kaufmann: Waltham, Massachusetts, United States, 2006.
24. Marco C, Fabio C, Alvise D, Antonia G, Francesco G, Alessandro M, Moreno M, Salvatore M, Fabrizio P, Luca P, Francesco P. The gLite Workload Management System. In *Proceedings of the 4th International Conference on Advances in Grid and Pervasive Computing*, GPC '09. Springer-Verlag: Berlin, Heidelberg, 2009; 256–268, DOI: 10.1007/978-3-642-01671-4_24.
25. Huedo E, Montero RS, Llorente IM. The GridWay framework for adaptive scheduling and execution on grids. *Scalable Computing - Practice and Experience* 2005; **6**(3):1–8.
26. Torres E, Segrelles JD, Blanquer I, Hernández V. Service monitoring and differentiation techniques for resource allocation in the grid, on the basis of the level of service. *Future Generation Computer Systems* 2011; **27**(8):1152–1142. DOI: 10.1016/j.future.2011.03.005.
27. OSAIS. Web Services Resource Framework (WSRF), 2006. URL http://www.oasis-open.org/specs/#wsrfv1.2.
28. Sotomayor B, Childers L. *Globus Toolkit 4: Programming Java Services*. Morgan Kaufmann: Waltham, Massachusetts, United States, 2005.
29. Open Grid Forum. The Open Grid Services Architecture (OGSA), Version 1.5, 2006. URL http://www.ogf.org/documents/GFD.80.pdf.
30. The Globus Alliance. The Crux Toolkit, 2010. URL http://confluence.globus.org/display/whi/Crux+Toolkit+-.
31. OASIS Web Services Composite Application Framework (WS-CAF) Technical Committee. Web Services Context Specification (WS-Context) Version 1.0, 2007. Available from: http://docs.oasis-open.org/ws-caf/ws-context/v1.0/wsctx.html [November 24, 2011].
32. Aktas MS, Fox GC, Pierce M. Managing dynamic metadata as context. *The 2005 Istanbul International Computational Science and Engineering Conference ICCSE2005 Istanbul Turkey*, IEEE, 2005.
33. Pallickara S, Fox GC, Aktas M, Gadgil H, Yildiz B, Oh S, Patel S, Pierce M, Yemme D. A retrospective on the development of Web service specifications. In *Securing Web Services Practical Usage of Standards and Specifications*, Panos P (ed.). chap. 2, IGI Global, 2007; 22–49.
34. Moltó G, Hernández V, Alonso J. Automatic replication of WSRF-based Grid services via operation providers. *Future Generation Computer Systems* September 2009; **25**(8):876–883. DOI: 10.1016/j.future.2009.03.004.
35. Seltzer M, Bostic K, Berkeley DB. *The Architecture of Open Source Applications* (Brown A, Wilson G, eds), 2011. chap. 4.
36. Gosling J, Joy B, Steele G, Bracha G. *The Java Language Specification*, 3rd Ed. Addison Wesley: Boston, United States, 2005.
37. Hunt C, John B. *Java Performance*. Prentice Hall: Upper Saddle River, New Jersey, United States, 2011. chap. 5.

5.1.1.10. An economic and energy-aware analysis of the viability of outsourcing cluster computing to a cloud

C. de Alfonso, M. Caballer, F. Alvarruiz, and G. Moltó, "An economic and energy-aware analysis of the viability of outsourcing cluster computing to a cloud," Futur. Gener. Comput. Syst., vol. 29, no. 3, pp. 704–712, Mar. 2013, doi: https://dx.doi.org/10.1016/j.future.2012.08.014

Base de datos de indexación	Web of Science (JCR)
Índice de impacto	2.639
Año	2013
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	8 de 102
Tercil	T1
Cuartil	Q1
Número de citas en JCR	23
Número de citas totales	33

Comentario. Esta contribución fue uno de los resultados del proyecto de Plan Nacional CodeCloud (TIN2010-17804), en el que participó el candidato y donde se realizó un análisis económico de la viabilidad de usar tecnologías Cloud para la computación de tipo HPC (High Performance Computing).

Future Generation Computer Systems 29 (2013) 704–712

Contents lists available at SciVerse ScienceDirect

Future Generation Computer Systems

journal homepage: www.elsevier.com/locate/fgcs

An economic and energy-aware analysis of the viability of outsourcing cluster computing to a cloud

Carlos de Alfonso *, Miguel Caballer, Fernando Alvarruiz, Germán Moltó

Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC – Universitat Politècnica de València – CIEMAT, camino de Vera s/n, 46022 Valencia, Spain

ARTICLE INFO

Article history:
Received 27 March 2012
Received in revised form
17 August 2012
Accepted 27 August 2012
Available online 8 September 2012

Keywords:
Cloud computing
Cluster computing
Green computing
Cost analysis

ABSTRACT

This paper compares the total cost of ownership of a physical cluster with the cost of a virtual cloud-based cluster. For that purpose, cost models for both a physical cluster and a cluster on a cloud have been developed. The model for the physical cluster takes into account previous works and incorporates a more detailed study of the costs related to energy consumption and the usage of energy-saving strategies. The model for the cluster on a cloud considers pricing options offered by Amazon EC2, such as reserving instances on a long-term basis, and also considers using tools for powering nodes on and off on demand, in order to avoid the costs associated to keeping idle nodes running. Using these cost models, a comparison is made of physical clusters with cloud clusters of a similar size and performance. The results show that cloud clusters are an interesting option for start-ups and other organizations with a high degree of uncertainty with respect to the computational requirements, while physical clusters are still more economically viable for organizations with a high usage rate.

1. Introduction

One of the main problems faced when deploying a cluster of PCs relates to the high total cost of ownership (TCO). This cost involves not only the purchase and installation of the equipment (computational nodes, network components, cables, hard disks, etc.), but also the operating costs. The latter includes the salaries of the personnel in charge of the installation and maintenance, the electricity consumed, and the costs related to rent appropriate housing and its associated cooling systems. The problem is that the usage patterns of these machines are highly dynamic, where peak loads are often restricted to the context of specific experiments or deadlines. In addition to this, the prices of clusters of PCs is rapidly decreasing (due to technology obsolescence), thus reducing the value of the initial investment in hardware.

As an alternative, researchers might access the resources at the computing centers of national or international institutions. This is the case of the *Spanish Supercomputing Network*, which aggregates several supercomputing centers in Spain. The access to this equipment is supervised by an access committee that grants limited resource access according to the scientific merit of the proposals. Another example is the not-for-profit organization *Partnership for Advanced Computing in Europe* (PRACE), which provides access to a world-class computing and data management infrastructure [1].

Another alternative is to use *cloud computing*, a model for enabling convenient on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [2]. This is the case of Infrastructure as a Service (IaaS), which performs on-demand resource provision of computational resources, storage capacity, network access, etc. This is achieved by means of virtual machines that run on the cloud provider's computing center. In the case of public cloud providers, a pay-per-use pricing model is typically employed, where users are only charged for the resources that they have consumed.

Virtualization was not considered a feasible approach for high performance computing (HPC), due to the penalties involved mainly in the I/O. However, many applications running on PC clusters are CPU-bound, and thus their performance is hardly affected by virtualization [3]. In addition, certain public cloud providers, such as Amazon, offer low-latency links among instances, thus leveraging the idea of using virtual clusters on the cloud. Having a virtual cluster infrastructure on a public cloud provider has a large number of advantages for the end user, since no hardware costs are involved. However, the sustainability of this infrastructure in the long term might represent a high cost, since the pay-as-you-go model offered by the cloud providers implies that a running virtual machine costs money regardless of it being used for computations or not.

Due to the increase of the use of virtualization and cloud technologies, some initiatives to create HPC clusters over cloud infrastructures are emerging. One of the first approaches, described

* Corresponding author. Tel.: +34 963877007x88254.
E-mail address: caralla@upv.es (C. de Alfonso).

0167-739X/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.future.2012.08.014

resources can be provisioned and released on demand, in order to satisfy unexpected peak workloads.

Another aspect to be considered is that one might think that a usage rate of 20% or 40% (73 or 146 days in a year) in a cluster is significantly low. Even though there are scientific applications that require sustained computing power for weeks or months, not many applications used in clusters have usage patterns over that usage ratio. This represents a total of 224,256 and 439,296 CPU hours for a 128-node cluster. For example, a node that our research group dedicates as part of the Spanish NGI (National Grid Initiative) has a usage rate of 33%.

One of the target users of a cluster in a cloud would be a start-up (an enterprise with a high degree of uncertainty with respect to the computing requirements) or an organization whose workloads match a high level rate during medium or small time periods (e.g., without exceeding a 20–40% sustained usage rate across the year). In these cases, the organizations avoid upfront investment, reduce the time to market (TTM), and can postpone the decision of investing in a physical infrastructure, possibly depending on the ROI of the business activity. Such organizations could objectively map the cloud costs to the price charged to the customers, and adjust the use of reserved instances according to the changing needs.

6. Conclusions

Nowadays, there are several IaaS public cloud providers, which represent an alternative to the traditional purchase of computing infrastructure. However, the users of computer clusters have traditionally relied on physical clusters. This article has focused on the convenience of outsourcing cluster-based computations (HPC, HTC, MTC, etc.) to a cloud.

For that purpose, a cost model of a physical cluster has been developed, which considers the different aspects studied in the literature, but also includes the cost related to energy consumption and the usage of energy-saving strategies. We have used the pricing options of Amazon EC2 to create a cost model of a cluster in a cloud. This model considers the reserved instances approach offered by the provider and it also considers the usage of tools to power on and off instances on demand, in order to avoid idle nodes on the cloud and its associated cost.

A comparison has been made of the cost of physical clusters and their virtual counterparts, with the same number of nodes and similar performance. The result is that from the point of view of a data center, which expects a high usage rate for their clusters, it is still economically preferable to purchase a physical cluster hosted on its facilities. The fact is that these centers expect a ROI related to the usage and renting of their equipment and, therefore, can benefit from the economies of scale to turn themselves into infrastructure providers. But if the goal is obtaining high performance computing, and the sustained usage rate is moderate or low, a cloud can provide similar equipment at a competitive price. Having a good estimation of the workload is necessary in order to select the correct number of reserved instances. We have also obtained an expression to help us decide whether the option of reserving nodes is economically preferrable, depending on the estimated usage rate of the cluster.

Our cost model does not include additional features such as spot instances, which enable the user to bid for unused Amazon EC2 capacity, since their cost is not deterministic. However, it could be an interesting option when performing HTC computations. A scenario could be envisaged in which the cluster grows and shrinks opportunistically according to the instance prices.

Acknowledgments

The authors are grateful for the financial support received from both the Spanish Ministry of Economy and Competitiveness to develop project TIN2010-17804, and the Generalitat Valenciana for project GV/2012/076.

References

[1] PRACE Research Infrastructure. URL http://www.prace-ri.eu.
[2] P. Mell, T. Grance, The NIST Definition of Cloud Computing. NIST Special Publication 800-145 (Final), Tech. rep., 2011. URL http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf.
[3] L. Nussbaum, F. Anhalt, O. Mornard, J. Gelas, Linux-based virtualization for HPC clusters, in: Proceedings of the Linux Symposium, 2009.
[4] A. Bialecki, M. Cafarella, D. Cutting, O. O'Malley, Hadoop: a framework for running applications on large clusters built of commodity hardware, Tech. rep., 2005. URL http://hadoop.apache.org.
[5] P. Marshall, K. Keahey, T. Freeman, Elastic site: using clouds to elastically extend site resources, in: 10th IEEE/ACM International Conference on Cluster, Cloud and Grid Computing, IEEE Computer Society, 2010, pp. 43–52.
[6] G. Juve, E. Deelman, K. Vahi, Scientific workflow applications on Amazon EC2, in: Workshop on Cloud-based Services and Applications (5th IEEE International Conference on e-Science (e-Science 2009) (2010) 59–66. URL http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5408002.
[7] E. Deelman, G. Singh, M. Livny, B. Berriman, J. Good, The cost of doing science on the cloud: the montage example, in: 2008 ACM/IEEE conference on Supercomputing, Austin, Texas, 2008.
[8] M. De Assuncao, A. Di Costanzo, R. Buyya, Evaluating the cost-benefit of using cloud computing to extend the capacity of clusters, in: Proceedings of the 18th ACM international symposium on High performance distributed computing, ACM, Garching, Germany, 2009, pp. 141–150. URL http://portal.acm.org/citation.cfm?id=1551635.
[9] D. Kondo, B. Javadi, P. Malecot, F. Cappello, D.P. Anderson, Cost-benefit analysis of cloud computing versus desktop grids, in: 2009 IEEE International Symposium on Parallel & Distributed Processing, 2009.
[10] X. Li, Y. Li, T. Liu, J. Qiu, F. Wang, The method and tool of cost analysis for cloud computing, in: IEEE International Conference on Cloud Computing, 2009, 2009, pp. 93–100.
[11] M. Armbrust, A. Fox, R. Griffith, A. Joseph, Above the clouds: a Berkeley view of cloud computing, Tech. rep., UC Berkeley Reliable Adaptive Distributed Systems Laboratory, 2009. URL http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.149.7163\&rep=rep1\&type=pdf.
[12] Amazon, User Guide: Amazon EC2 Cost Comparison Calculator. URL http://awsmedia.s3.amazonaws.com/User_Guide_Amazon_EC2_Cost_Comparison_Calculator.pdf.
[13] M. Woitaszek, H. Tufo, Developing a cloud computing charging model for high-performance computing resources, in: IEEE 10th International Conference on Computer and Information Technology (CIT), 2010, pp. 210–217.
[14] M. Witkowski, A. Oleksiak, T. Piontek, J. Weglarz, Practical power consumption estimation for real life HPC applications, Future Generation Computer Systems 29 (1) (2013) 208–217. URL http://www.sciencedirect.com/science/article/pii/S0167739X12001392.
[15] A. Beloglazov, J. Abawajy, R. Buyya, Energy-aware resource allocation heuristics for efficient management of data centers for cloud computing, Future Generation Computer Systems 28 (5) (2012) 755–768. Special Section: Energy efficiency in large-scale distributed systems. URL http://www.sciencedirect.com/science/article/pii/S0167739X11000689.
[16] J. Koomey, K. Brill, P. Turner, J. Stanley, B. Taylor, A simple model for determining true total cost of ownership for data centers, Tech. rep., 2008. URL http://www.uptimeinstitute.org/wp_pdf/(TUI3011C)SimpleModelDetermingTrueTCO.pdf.
[17] C. Belady, A. Rawson, Green grid data center power efficiency metrics: PUE and DCiE, Tech. rep., The Green Grid (2008).
[18] C. De Alfonso, M. Caballer, V. Hernández, Efficient power management in high performance computer clusters, in: Proceedings of the International Conference on Green Computing 2010 (ICGreen 2010), 2010.
[19] Amazon, Amazon EC2 Pricing. URL http://aws.amazon.com/ec2/pricing/.
[20] Amazon, The Economics of the AWS Cloud vs. Owned IT Infrastructure, Tech. rep. URL http://aws.amazon.com/economics.
[21] U.E.I. Administration, Electricity Explained: Factors Affecting Electricity Prices. URL http://www.eia.gov/energyexplained/index.cfm?page=electricity_factors_affecting_prices.
[22] Energy Price in Spain. URL http://www.boe.es/boe/dias/2011/12/31/pdfs/BOE-A-2011-20650.pdf.
[23] J. Dongarra, LINPACK: users' guide, SIAM, 1979.
[24] R.R. Expósito, G.L. Taboada, S. Ramos, J. Touriño, R. Doallo, Performance analysis of hpc applications in the cloud, Future Generation Computer Systems 29 (1) (2013) 218–229. URL http://www.sciencedirect.com/science/article/pii/S0167739X12001458.
[25] J. Mahvi, A. Zarfaty, Using TCO to Determine PC Upgrade Cycles, Tech. rep., Intel (2009). URL http://communities.intel.com/docs/DOC-3172/version/1.
[26] W. Pitt, K. Brill, Cost model: dollars per kW plus dollars per square foot of computer floor, Tech. rep., Uptime Institute, 2008.
[27] K. Vermeersch, A Broker for Cost-efficient QoS aware Resource Allocation in EC2, Tech. rep., University of Antwerp, 2011.

Carlos de Alfonso obtained his B.Sc. degree in Computer Science from the Universidad Politécnica de Valencia (UPV), Spain, in 2000. In 2000, he joined the Grid and High Performance Computing research group, at UPV. Since 2007, he has been a Technician for the Support of Research at UPV, with a profile of grid and cloud computing. He has been part of several national, European, and international projects and contracts in the fields of grid computing. In recent years, he has oriented his activity mainly to cloud computing and green computing.

Miguel Caballer obtained his B.Sc. and M.Sc degrees in Computer Science from the Universidad Politécnica de Valencia (UPV), Spain, in 2000 and 2012, respectively. He has been a member of the Grid and High Performance Computing group of UPV since 2001. He has participated in different research projects concerning the application of grid and cloud computing techniques to several areas of engineering. Other fields of interest include green computing.

Fernando Alvarruiz obtained his M.Sc. degree in Computer Science from the Universidad Politécnica de Valencia (UPV), Spain, in 1995. In 1996, he joined the Grid and High Performance Computing research group at UPV. Since 2003, he has been an assistant lecturer at UPV. His research interests include green and cloud computing, and he has participated in projects on the adaptation of cloud environments for the execution of scientific applications. Other areas of interest include the application of high performance computing techniques in different engineering fields.

Germán Moltó received his B.Sc. and Ph.D. degrees in Computer Science from the Universidad Politécnica de Valencia (UPV) in 2002 and 2007, respectively. He is a member of the Grid and High Performance Computing research group. He is also associate professor, lecturing at the School of Engineering in Computer Science at UPV. His current research interests include cloud computing and service-oriented architectures, and their use in scientific and engineering fields.

5.1.1.11. EC3: Elastic Cloud Computing Cluster

M. Caballer, C. de Alfonso, F. Alvarruiz, and G. Moltó, "EC3: Elastic Cloud Computing Cluster," J. Comput. Syst. Sci., vol. 79, no. 8, pp. 1341–1351, Dec. 2013, doi: https://dx.doi.org/10.1016/j.jcss.2013.06.005

Base de datos de indexación	Web of Science (JCR)
Índice de impacto	1.091
Año	2013
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	33 de 102
Tercil	T1
Cuartil	Q2
Número de citas en JCR	19
Número de citas totales	45

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional CodeCloud (TIN2010-17804), en el que participó el candidato y supone la introducción de la herramienta EC3: https://www.grycap.upv.es/ec3, una herramienta de código abierto para el despliegue de clusters virtuales. EC3 ha sido una herramienta que ha ido evolucionando en los últimos años mediante su adopción por parte de numerosos proyectos Europeos como INDIGO-DataCloud, DEEP Hybrid- DataCloud, EOSC-HUB y EOSC-SYNERGY, en los que ha participado el candidato. La herramienta se encuentra actualmente integrada en el catálogo de servicios de Applications on Demand de EGI (https://www.egi.eu/services/applications-on-demand/) y se utiliza en producción para que científicos puedan desplegarse sus propios clusters virtuales elásticos sobre la infraestructura Cloud federada Europea (EGI Federated Cloud).

Journal of Computer and System Sciences 79 (2013) 1341–1351

Contents lists available at SciVerse ScienceDirect

Journal of Computer and System Sciences

www.elsevier.com/locate/jcss

EC3: Elastic Cloud Computing Cluster

Miguel Caballer *, Carlos de Alfonso, Fernando Alvarruiz, Germán Moltó

Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC – Universitat Politècnica de València – CIEMAT, Camino de Vera s/n, 46022 Valencia, Spain

ARTICLE INFO

Article history:
Received 25 September 2012
Received in revised form 12 April 2013
Accepted 20 June 2013
Available online 1 July 2013

Keywords:
Cloud computing
Service-oriented architectures
IaaS
Virtualization

ABSTRACT

This paper introduces Elastic Cloud Computing Cluster (EC3), a tool that creates elastic virtual clusters on top of Infrastructure as a Service (IaaS) Clouds. The clusters are self-managed entities that scale out to a larger number of nodes on demand, up to a maximum size specified by the user. Whenever idle resources are detected, the clusters automatically scale in, according to some predefined policies, in order to cut down the costs in the case of using a public Cloud provider. This creates the illusion of a real cluster without requiring an investment beyond the actual usage. Two different case studies are presented to assess the effectiveness of an elastic virtual cluster. The results show that the usage of self-managed elastic clusters represents an important economic saving when compared both to physical clusters and to static virtual clusters deployed on an IaaS Cloud, with a reduced penalty in the elasticity management.

1. Introduction

The usage of clusters of PCs as a computing facility is currently widespread in the scientific community. In the last years, the success of this computing platform, either for High Performance Computing (HPC) or for High Throughput Computing (HTC) has been unparalleled. However, one of the main drawbacks of these computing platforms is the relatively large upfront investment together with the maintenance cost. For small and medium-sized research groups or organizations the purchase of such an equipment might represent an important cost.

Traditionally, virtualization was not considered as a viable option for HPC, mainly due to the overhead costs in I/O and network devices. However, the major improvements in hypervisor technologies have paved the way for Cloud computing to rise as a paradigm where resources (in the shape of Virtual Machines (VM), network, storage capacity, etc.) can be dynamically provisioned and released on a pay-as-you-go basis [1]. This is the case of public Infrastructure as a Service (IaaS) Cloud providers such as Amazon Elastic Compute Cloud (EC2) or Rackspace.

In a previous work [2] we concluded that, in some cases, it is interesting to deploy a virtual cluster instead of a physical one. A virtual cluster in an IaaS provider is able to get a competitive performance per price rate, but also gets important benefits from the Cloud provider such as reducing the administration costs (both personnel costs and maintenance of equipments), avoiding hiring or buying the physical building to host the infrastructure, avoiding the upfront investments in hardware, cooling systems, etc. Therefore, deploying a cluster in the Cloud can also inherit these advantages.

However, clusters are generally not used at 100% of its capacity during their lifetime [3]. The total lifetime of a cluster can be divided into two parts: the time while the cluster is calculating (T_c) and the time when the system is idle (T_i). In a Cloud environment it would be adequate to stop the VMs while they are not being used and pay only for T_c. The idea is similar to what is currently done with energy saving techniques in a datacenter, where physical nodes are dynamically powered

* Corresponding author.
E-mail address: micafer1@upv.es (M. Caballer).

0022-0000/$ – see front matter
http://dx.doi.org/10.1016/j.jcss.2013.06.005

impact in the time required to have the VMs up and running. However, in private infrastructures some factors may affect this time such as the size of the Cloud deployment, the number of running VMs, the usage of the network, the policy used to balance the workload, etc. For example, launching a set of VMs to start simultaneously has an important impact in this time. Therefore, if the block size selected to add nodes to the cluster is large, and the Cloud infrastructure is relatively small, then the time may have an important increase.

5. Conclusion and future work

This article has introduced Elastic Cloud Computing Cluster (EC3), a tool to create HPC clusters on top of Cloud infrastructures that, using Green computing concepts, creates a self-managed system that dynamically scales to adapt to the workload of users.

The tool builds on top of CLUES, an energy manager system for cluster-like infrastructures, enabling the cluster to gain elastic capabilities on a Cloud deployment. For that, a Cloud connector has been developed to manage the interaction with the infrastructure manager in charge of starting and terminating the virtual machines that correspond to the internal nodes. Moreover the CLUES scheduler has been modified to adapt its policies to be able to manage elasticity to create virtual elastic clusters.

EC3 enables end users to deploy elastic clusters of a given maximum size in a matter of minutes with just a command line tool. Besides, the policies to start and shutdown nodes have been contributed back in order to enhance CLUES enabling more possibilities in order to consider the tradeoff between minimizing the impact in the waiting time for the user (which implies having a larger number of nodes started) and the reduction of the Cloud costs (which implies having a reduced number of running virtual machines).

Future works include several research lines. In the case of commercial Clouds it is crucial to incorporate cost-aware schedulers that consider not only the number of nodes but also the cost of the instances in order to better manage the budget without surpassing the specified limits (daily, monthly, etc.) specified by the user. Concerning the costs, it is important to consider deploying multi-core virtual machines that can share the execution of several jobs. This would enable reduced prices per execution unit. Finally, it is important to consider the case for heterogeneous cluster computing, where each node could exhibit different capabilities (more storage space, different CPU type, support for GPUs, etc.).

Acknowledgments

The authors would like to thank the financial support received from the Generalitat Valenciana for the project GV/2012/076 and to the Ministerio de Ciencia e Innovación for the project CodeCloud (TIN2010-17804).

References

[1] P. Mell, T. Grance, The NIST definition of cloud computing, NIST Special Publication 800-145 (Final), Tech. rep., 2011, http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf.
[2] C. de Alfonso, M. Caballer, F. Alvarruiz, G. Moltó, An economic and energy-aware analysis of the viability of outsourcing cluster computing to a cloud, Future Generation Computer Systems 29 (3) (2013) 704–712, http://dx.doi.org/10.1016/j.future.2012.08.014, http://www.sciencedirect.com/science/article/pii/S0167739X12001720.
[3] M. Armbrust, A. Fox, R. Griffith, A. Joseph, Above the clouds: A Berkeley view of cloud computing, Tech. rep., UC Berkeley Reliable Adaptive Distributed Systems Laboratory, 2009, http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.149.7163&rep=rep1&type=pdf.
[4] R.S. Montero, R. Moreno-Vozmediano, I.M. Llorente, An elasticity model for high throughput computing clusters, Journal of Parallel and Distributed Computing 71 (6) (2011) 750–757, http://dx.doi.org/10.1016/j.jpdc.2010.05.005, http://dl.acm.org/citation.cfm?id=1975006.1975198.
[5] X. Wei, H. Wang, H. Li, L. Zou, Dynamic deployment and management of elastic virtual clusters, in: 2011 Sixth Annual Chinagrid Conference, IEEE, 2011, pp. 35–41, http://dx.doi.org/10.1109/ChinaGrid.2011.31, http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&arnumber=6051755&contentType=Conference+Publications.
[6] F. Liu, X. Dong, A novel elastic resource allocation strategy of virtual cluster, in: 2011 Fourth International Symposium on Parallel Architectures, Algorithms and Programming, IEEE, 2011, pp. 168–173, http://dx.doi.org/10.1109/PAAP.2011.28, http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&arnumber=6128497&contentType=Conference+Publications.
[7] P. Marshall, K. Keahey, T. Freeman, Elastic site: Using clouds to elastically extend site resources, in: 10th IEEE/ACM International Conference on Cluster, Cloud and Grid Computing, IEEE Computer Society, 2010, pp. 43–52.
[8] P. Marshall, H. Tufo, K. Keahey, D. Labissoniere, M. Woitaszek, Architecting a large-scale elastic environment: Recontextualization and adaptive cloud services for scientific computing, in: 7th International Conference on Software Paradigm Trends (ICSOFT), Rome, Italy, 2012.
[9] M. De Assuncao, A. Di Costanzo, R. Buyya, Evaluating the cost-benefit of using cloud computing to extend the capacity of clusters, in: Proceedings of the 18th ACM International Symposium on High Performance Distributed Computing, ACM, Garching, Germany, 2009, pp. 141–150, http://portal.acm.org/citation.cfm?id=1551635.
[10] A. Bialecki, M. Cafarella, D. Cutting, O. O'Malley, Hadoop: A framework for running applications on large clusters built of commodity hardware, Tech. rep., 2005, http://hadoop.apache.org.
[11] F. Doelitzscher, M. Held, C. Reich, ViteraaS: Virtual Cluster as a Service, Technology and Science, http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6133210.
[12] MIT, StarCluster, http://web.mit.edu/stardev/cluster/.
[13] MIT, StarCluster Elastic Load Balancer, http://web.mit.edu/stardev/cluster/docs/0.92rc2/manual/load_balancer.html.
[14] IBM, IBM Platform Dynamic Cluster, http://www-03.ibm.com/systems/technicalcomputing/platformcomputing/products/lsf/dynamiccluster.html.
[15] CycleComputing, CycleCloud, http://www.cyclecomputing.com/cyclecloud.
[16] C. de Alfonso, M. Caballer, F. Alvarruiz, G. Moltó, V. Hernández, Infrastructure deployment over the cloud, in: 3rd IEEE International Conference on Cloud Computing Technology and Science (CloudCom 2011), 2011, pp. 517–521.

[17] AnsibleWorks, Ansible, http://ansible.cc.
[18] Cluster Resources Inc., Green Computing Powered by Moab, http://www.clusterresources.com/solutions/green-computing.php.
[19] Simple Linux Utility for Resource Management, Power Saving Guide, https://computing.llnl.gov/linux/slurm/power_save.html.
[20] C. de Alfonso, M. Caballer, V. Hernández, Efficient power management in high performance computer clusters, in: 1st International Multi-Conference on Innovative Developments in ICT, 2010, pp. 39–44.
[21] F. Alvarruiz, C. de Alfonso, M. Caballer, V. Hernandez, An energy manager for high performance computer clusters, in: 2012 IEEE 10th International Symposium on Parallel and Distributed Processing with Applications (ISPA), 2012, pp. 231–238.
[22] S. Ostermann, A. Iosup, N. Yigitbasi, A performance analysis of EC2 cloud computing services for scientific computing, in: Dimiter R. Avresky, Michel Diaz, Arndt Bode, Bruno Ciciani, Eliezer Dekel, Ozgur Akan, Paolo Bellavista, Jiannong Cao, Falko Dressler, Domenico Ferrari, Mario Gerla, Hisashi Kobayashi, Sergio Palazzo (Eds.), Cloud Computing, Springer, Berlin, Heidelberg, 2010, pp. 115–131, http://www.springerlink.com/index/T640753R2597524U.pdf.
[23] G. Moltó, M. Arevalillo-Herráez, C. Milián, M. Zacarés, V. Hernández, A. Ferrando, Optimization of supercontinuum spectrum using genetic algorithms on service-oriented grids, in: Proceedings of the 3rd Iberian Grid Infrastructure Conference (IberGrid 2009), 2009, pp. 137–147.
[24] J. Arabas, Z. Michalewicz, J. Mulawka, GAVaPS—A genetic algorithm with varying population size, in: Proceedings of the First IEEE Conference on Evolutionary Computation. IEEE World Congress on Computational Intelligence, IEEE, 1994, pp. 73–78, http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=350039.

5.1.1.12. CodeCloud: A platform to enable execution of programming models on the Clouds

M. Caballer, C. de Alfonso, G. Moltó, E. Romero, I. Blanquer, and A. García, "CodeCloud: A platform to enable execution of programming models on the Clouds," J. Syst. Softw., vol. 93, pp. 187–198, Jul. 2014, doi: https://dx.doi.org/10.1016/j.jss.2014.02.005

Base de datos de indexación	Web of Science (JCR)
Índice de impacto	1.485
Año	2014
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	31 de 102
Tercil	T1
Cuartil	Q2
Número de citas en JCR	10
Número de citas totales	21

Comentario. Esta contribución es el principal resultado del proyecto de Plan Nacional CodeCloud (TIN2010-17804), en el que participó el candidato, donde se describe la plataforma diseñada para ejecutar aplicaciones científicas bajo diferentes modelos de programación en infraestructuras Cloud. Supone también una contribución de la tesis doctoral de Andrés García García, co-dirigida por el candidato, titulada "SLA-Driven Cloud Computing Domain Representation and Management".

The Journal of Systems and Software 93 (2014) 187–198

Contents lists available at ScienceDirect

The Journal of Systems and Software

journal homepage: www.elsevier.com/locate/jss

CodeCloud: A platform to enable execution of programming models on the Clouds

Miguel Caballer*, Carlos de Alfonso, Germán Moltó, Eloy Romero, Ignacio Blanquer, Andrés García

Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC – Universitat Politècnica de València – CIEMAT, Camino de Vera s/n, 46022 Valencia, Spain

ARTICLE INFO

Article history:
Received 7 October 2013
Received in revised form 7 February 2014
Accepted 7 February 2014
Available online 17 February 2014

Keywords:
Cloud computing
Virtual infrastructures
Elasticity

ABSTRACT

This paper presents a platform that supports the execution of scientific applications covering different programming models (such as Master/Slave, Parallel/MPI, MapReduce and Workflows) on Cloud infrastructures. The platform includes (i) a high-level declarative language to express the requirements of the applications featuring software customization at runtime, (ii) an approach based on virtual containers to encapsulate the logic of the different programming models, (iii) an infrastructure manager to interact with different IaaS backends, (iv) a configuration software to dynamically configure the provisioned resources and (v) a catalog and repository of virtual machine images. By using this platform, an application developer can adapt, deploy and execute parallel applications agnostic to the Cloud backend.

1. Introduction

Scientific computing has long been devoted to close the gap between scientists, who require executing resource-starved models, and computer scientists, who can deliver the power required to solve challenging computational problems. In the last decades, different computing infrastructures have been used to provide computing power to the scientific community. Moreover with the commoditization of hardware, clusters of PCs became a suitable platform for scientists to execute their workloads. However, scientific problems required computational resources far beyond the capacity of a single cluster of PCs. The increase in network bandwidth made utility computing possible. Organizations started sharing computational power and storage (among other resources) in the so-called Grids, where scientific users could execute large experiments. Grid computing has proved to be a valuable tool not only to foster collaboration among research but also to aggregate enough computing power to tackle challenging problems that could not have been solved before (Jacq et al., 2008).

However, the Grid also exposed some drawbacks for scientists, since they had to adapt their applications to fit the requirements of the underlying computing platforms (in terms of Operating System, software libraries, etc.). Although the Scientific Gateways made progresses toward abstracting the usage of the Grid (Wilkins-Diehr et al., 2008), the diversity of platforms and software configurations made the approach a compile-once run-anywhere difficult. This hindered the massive adoption of the Grid out of the academic environment, which typically remained composed by Virtual Organizations with pre-configured environments and tools.

With the advent of Cloud computing, the idea of utility computing is reconsidered. The use of virtualization and its ability to customize the underlying infrastructure to the requirements of the applications (not the other way round, as in Grid computing) opened new opportunities. Cloud computing enabled users to migrate clustered based applications to Cloud-computing resources without modifying the existing resources. The usage of virtualized infrastructures on top of Cloud infrastructures enables to dynamically deploy suitable computing platforms, such as a virtual cluster. In this way users are provided with larger computing capabilities, but with the software and environment they are familiar. Therefore scientists can run their unmodified codes on modern computer resources without investing time in porting their applications to new computer designs.

For that, this paper describes an architecture and the implemented platform (called CodeCloud) to perform the execution of scientific applications on Cloud computing infrastructures, supporting different programming models (currently Master/Slave, Parallel/MPI, Workflow and MapReduce). The scientists just need to provide a high-level description of the jobs to be executed,

* Corresponding author. Tel.: +34 963877007x88254.
E-mail addresses: micafer1@upv.es (M. Caballer), caralla@upv.es (C. de Alfonso), elroal@upv.es (E. Romero), iblanque@dsic.upv.es (I. Blanquer).

http://dx.doi.org/10.1016/j.jss.2014.02.005
0164-1212/

features a declarative language of the requirements of applications and virtual infrastructures with an emphasis on software deployment and customization at runtime. It includes virtual containers which orchestrate the virtual infrastructure deployment and configurations for the different programming models. The automated configuration of the virtual infrastructures is achieved via the integration with Puppet.

The platform introduces high-level semantics to let the user focus on the requirements for their application and rely on the developed platform to automatically deploy the required virtual infrastructure and perform the execution of the jobs according to the programming model specified. Both vertical and horizontal elasticity are supported by the CodeCloud thus leveraging the inherent elasticity features of Cloud platforms. The platform hides the inner complexity of deploying and configuring virtual infrastructures on IaaS platforms to the user, who just define the features in a descriptive document. The platform exploits the parallel capabilities of different programming model and efficiently implements them as it can be observer in the experiments.

This represents a step forward in the usability of Cloud platforms for scientific computing. The support for multiple programming models for the Cloud featuring automatic deployment and configuration on multiple Clouds is unparalleled when compared to other Cloud frameworks.

Acknowledgements

The authors wish to thank the financial support received from both the Spanish Ministry of Economy and Competitiveness to develop the project "Servicios avanzados para el despliegue y contextualizacion de aplicaciones virtualizadas para dar soporte a modelos de programación en entornos cloud", with reference TIN2010-17804.

References

Altschul, S.F., Gish, W., Miller, W., Myers, E.W., Lipman, D.J., 1990. Basic local alignment search tool. Journal of Molecular Biology 215 (3), 403–410.
Bairoch, A., Apweiler, R., Wu, C.H., Barker, W.C., Boeckmann, B., Ferro, S., Gasteiger, E., Huang, H., Lopez, R., Magrane, M., Martin, M.J., Natale, D.A., O'Donovan, C., Redaschi, N., Yeh, L.-S.L., 2005. The Universal Protein Resource (UniProt). Nucleic Acids Research 33 (database issue), 154–159.
Bunch, C., Chohan, N., Krintz, C., Shams, K.,2011. Neptune. In: Proceedings of the 2nd International Workshop on Scientific Cloud Computing – ScienceCloud '11. ACM Press, New York, NY, p. 59.
Carrión, J.V., Moltó, G., De Alfonso, C., Caballer, M., Hernández, V., 2010. A generic catalog and repository service for virtual machine images. In: 2nd International ICST Conference on Cloud Computing CloudComp 2010.
Chohan, N., Bunch, C., Pang, S., Krintz, C., 2010. Appscale: scalable and open appengine application development and deployment. In: Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, pp. 57–70.
Curcin, V., Ghanem, M., 2008. Scientific workflow systems – can one size fit all? 2008 Cairo International Biomedical Engineering Conference 40, 1–9.
Dannert, T., Jenko, F., 2005. Gyrokinetic simulation of collisionless trapped-electron mode turbulence. Physics of Plasmas 12 (7).
de Alfonso, C., Caballer, M., Hernandez, V., 2008. WINGS: Versatile Workflow for the Grid. In: 2nd International Conference on Advanced Engineering Computing and Applications in Sciences, pp. 51–56.
de Alfonso, C., Caballer, M., Alvarruiz, F., Molto, G., Hernández, V.,2011. Infrastructure deployment over the cloud. In: 2011 IEEE Third International Conference on Cloud Computing Technology and Science. IEEE, pp. 517–521.
Dean, J., Ghemawat, S., 2008. MapReduce. Communications of the ACM 51 (1), 107.
Deelman, E., Gannon, D., Shields, M., Taylor, I., 2009. Workflows and e-Science: an overview of workflow system features and capabilities. Future Generation Computer Systems 25 (5), 528–540.
Goodale, T., Jha, S., Kaiser, H., Kielmann, T., Kleijer, P., Laszewski, G.V., Lee, C., Merzky, A., Rajic, H., Shalf, J., 2006. SAGA: a simple API for grid applications. High-level application programming on the grid. In: Computational Methods in Science and Technology, pp. 7–20.
Google, Google App Engine. URL: http://appengine.google.com/
Gropp, W., Lusk, E., Skjellum, A., 1999. Using MPI: Portable Parallel Programming with the Message-Passing Interface, 2nd ed. MIT Press, Cambridge, MA, USA.
Gu, Y., Grossman, R., 2009. Sector and sphere: the design and implementation of a high performance data cloud. Philosophical Transactions, Series A. Mathematical, Physical, and Engineering Sciences 367, 2429–2445.
Heroku, Cloud Application Platform. URL: http://www.heroku.com/
Jacq, N., Salzemann, J., Jacq, F., Legré, Y., Medernach, E., Montagnat, J., Maaß, A., Reichstadt, M., Schwichtenberg, H., Sridhar, M., Kasam, V., Zimmermann, M., Hofmann, M., Breton, V., 2008. Grid-enabled virtual screening against malaria. Journal of Grid Computing 6 (1), 29–43.
Keahey, K., Freeman, T., 2008. Contextualization: Providing one-click virtual clusters. In: Fourth IEEE International Conference on eScience, pp. 301–308.
Laure, E., Fisher, S., Frohner, A., Grandi, C., 2006. Programming the grid with gLite. Computational Methods in Science and Technology 12 (1), 33–45.
Marshall, P., Tufo, H.M., Keahey, K., Bissoniere, D.L., Woitaszek, M., 2012. Architecting a large-scale elastic environment – recontextualization and adaptive cloud services for scientific computing. In: 7th International Conference on Software Paradigm Trends, pp. 409–418.
Massie, M.L., Chun, B.N., Culler, D.E., 2004. The ganglia distributed monitoring system: design, implementation, and experience. Parallel Computing 30 (5–6), 817–840.
Miceli, C., Miceli, M., Jha, S., Kaiser, H., Merzky, A.,2009. Programming abstractions for data intensive computing on clouds and grids. In: 2009 9th IEEE/ACM International Symposium on Cluster Computing and the Grid. IEEE, pp. 478–483.
Microsoft, Windows Azure. URL: http://www.microsoft.com/windowsazure/
Miller, F.P., Vandome, A.F., McBrewster, J., 2010. Amazon Web Services. Alpha Press, ISBN:6131788367 9786131788369.
Moltó, G., Caballer, M., Romero, E., de Alfonso, C.,2013. Elastic memory management of virtualized infrastructures for applications with dynamic memory requirements. In: Proceedings of the International Conference on Computational Science (ICCS 2013). Elsevier, Amsterdam, pp. 159–168.
Oprescu, A.-M., Kielmann, T., 2010. Bag-of-tasks scheduling under budget constraints. In: IEEE Second International Conference on Cloud Computing Technology and Science CloudCom 2010, pp. 351–359.
Pierre, G., El Helw, I., Stratan, C., Oprescu, A., Kielmann, T., Schütt, T., Stender, J., Artač, M., Černivec, A.,2011. ConPaaS. In: Proceedings of the Workshop on Posters and Demos Track – PDT '11. ACM Press, New York, NY, USA, pp. 1–2.
Pivotal Software, Cloud Foundry. URL: http://www.cloudfoundry.com/
Shao, G., Berman, F., Wolski, R.,2000. Master/Slave Computing on the Grid. In: Proceedings of the 9th Heterogeneous Computing Workshop (HCW '00). IEEE Computer Society, Washington, DC, USA, pp. 3–16.
SNIA, CDMI: Cloud Data Management Interface. URL: http://www.snia.org/cdmi
Stonebraker, M., Çetintemel, U., Zdonik, S., 2005. The 8 requirements of real-time stream processing. ACM SIGMOD Record 34 (4), 42–47.
The SAGA Project, SAGA-Python: A Light-Weight Access Layer for Distributed Computing Infrastructure. URL: http://saga-project.github.io/saga-python/
Troger, P., Rajic, H., Haas, A., Domagalski, P.,2007. Standardization of an API for distributed resource management systems. In: 7th IEEE International Symposium on Cluster Computing and the Grid, 2007 (CCGRID 2007). IEEE, pp. 619–626.
University of Chicago, Nimbus Project. URL: http://www.nimbusproject.org
Vecchiola, C., Chu, X., Buyya, R., 2009. Aneka: A Software Platform for.NET based Cloud Computing. Advances in Parallel Computing: High Speed and Large Scale Scientific Computing. IOS Press, pp. 267–295.
Wilkins-Diehr, N., Gannon, D., Klimeck, G., Oster, S., Pamidighantam, S., 2008. TeraGrid Science Gateways and their impact on science. Computer 41 (11), 32–41.
Zhang, Q., Cheng, L., Boutaba, R., 2010. Cloud computing: state-of-the-art and research challenges. Journal of Internet Services and Applications 1 (1), 7–18.

Miguel Caballer obtained the B.Sc. and M.Sc. degree in Computer Science from the Universitat Politècnica de València (UPV), Spain, in 2000 and 2012. He is member of the Grid and High Performance Computing group of the Research institute of Instrumentation for Molecular Imaging (I3M) since 2001. He has participated in several European and National research projects about the application of Parallel, Grid and Cloud computing techniques to several areas of engineering. Other fields of interest include Green Computing.

Carlos de Alfonso obtained the B.Sc. degree in Computer Science from the Universitat Politècnica de València (UPV), Spain, in 2000. In 2000 he joined the Grid and High Performance Computing research group, at UPV. Since 2007 he is a Technician for the Support of Research at UPV, with a profile of Grid and Cloud computing. He has been part of several national, European and international projects and contracts in the fields of Grid. During the last years he has oriented his activity mainly to Cloud Computing and Green Computing.

Germán Moltó received the B.Sc. and Ph.D. degrees in computer science from the Universitat Politècnica de València (UPV) in 2002 and 2007. He is a member of the Grid and High Performance Computing research group (GRyCAP) at the Institute for Molecular Imaging (I3M) since 2002. He is also associate professor at the Department of Computer Systems and Computation (DSIC) at UPV. His research interests broadly lie in Cloud Computing, Grid Computing, High Performance Computing and Scientific Computing.

Eloy Romero obtained the M.Sc. and Ph.D. degrees in Computer Science from Universitat Politècnica de València in 2008 and 2012, working on the solution of large eigenvalue problems. Since 2006 he has been in the group of Grid and High Performance Computing (GRyCAP) as developer of the SLEPc library, and more recently of the CodeCloud project. His current interests include high performance computing, numerical lineal algebra and software engineering applied to scientific computing.

Ignacio Blanquer is an Assistant Professor in the Department of Information Systems and Computation (DSIC), Universitat Politècnica de València (UPV), since 1999. He has been involved in Parallel Computation and Medical Image processing since 15 years ago participating in more than 20 national and European Research Projects. He is a research fellow of the Institute for Molecular Imaging Instrumentation (I3M) and Network Centre for Biomedical Engineering (CRIB) and member of the board of directors of HealthGrid association.

Andrés García started working in the High Performance and Grid Computing Group (GRyCAP) in November 2007 as an undergraduated. Upon obtaining the bachelor in computer science by the Universitat Politècnica de València (UPV) in September, 2008, he joined the group as a graduate under a collaboration fellowship. He obtained the Master Degree in September 2010 with the Master Thesis Cloud Computing PaaS Platform – Cloud Compaas. Since then, he continued developing the Cloud Compaas platform specifically toward the field of Service Level Agreements as the subject of his Ph.D. Thesis.

5.1.1.13. Dynamic Management of Virtual Infrastructures

M. Caballer, I. Blanquer, G. Moltó, and C. de Alfonso, "Dynamic Management of Virtual Infrastructures," J. Grid Comput., vol. 13, no. 1, pp. 53–70, Mar. 2015, doi: https://dx.doi.org/10.1007/s10723-014-9296-5

Base de datos de indexación	Web of Science (JCR)
Índice de impacto	2.044
Año	2015
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	27 de 105
Tercil	T1
Cuartil	Q2
Número de citas en JCR	40
Número de citas totales	79

Comentario. Esta contribución es uno de los principales resultados del proyecto de Plan Nacional CodeCloud (TIN2010-17804) en el que se describe la herramienta Infrastructure Manager (IM) (https://www.grycap.upv.es/im). Esta herramienta fue pionera en la definición de Infraestructuras como Código (IaC), ha dado lugar al registro de software (R-17353-2015) y se ofrece a la comunidad como código abierto (https://github.com/grycap/im) y como servicio (en https://www.grycap.upv.es/im). La herramienta ha sido evolucionada en el marco de numerosos proyectos europeos entre los que destacamos INDIGO-DataCloud, DEEP Hybrid-DataCloud, EOSC-HUB y EOSC-SYNERGY, dando soporte a los casos de uso. IM ha sido adoptado como el orquestador de aplicaciones dentro de EGI y se usa actualmente en producción en el VMOps Dashboard (https://wiki.egi.eu/wiki/Federated_Cloud_AppDB_VMOps_Dashboard) para el despliegue de arquitecturas Cloud en la infraestructura Cloud federada.

IM fue adoptada por INDRA para su solución GIM de despliegue Cloud, se utiliza en el INFN para obtener el soporte multi-Cloud en el PaaS Orchestrator (https://marketplace.eosc-portal.eu/services/paas-orchestrator) y está integrada dentro del EOSC Portal (https://marketplace.eosc-portal.eu/services/infrastructure-manager-im), completamente alineado con la iniciativa europea EOSC (European Open Science Cloud). La herramienta, que ha alcanzado un TRL 8 (Technology Readiness Level), se utiliza a diario en producción en infraestructuras distribuidas Cloud para el soporte al despliegue de infraestructuras y supone una de las mayores contribuciones de nuestro grupo de investigación a la e-ciencia en abierto. Por último, se trata del principal resultado de la tesis doctoral de Miguel Caballer, titulada "Gestión de infraestructuras virtuales configuradas

dinámicamente", co-dirigida por el candidato.

J Grid Computing (2015) 13:53–70
DOI 10.1007/s10723-014-9296-5

Dynamic Management of Virtual Infrastructures

Miguel Caballer · Ignacio Blanquer · Germán Moltó · Carlos de Alfonso

Received: 16 September 2013 / Accepted: 25 February 2014 / Published online: 9 April 2014

Abstract Cloud infrastructures are becoming an appropriate solution to address the computational needs of scientific applications. However, the use of public or on-premises Infrastructure as a Service (IaaS) clouds requires users to have non-trivial system administration skills. Resource provisioning systems provide facilities to choose the most suitable Virtual Machine Images (VMI) and basic configuration of multiple instances and subnetworks. Other tasks such as the configuration of cluster services, computational frameworks or specific applications are not trivial on the cloud, and normally users have to manually select the VMI that best fits, including undesired additional services and software packages. This paper presents a set of components that ease the access and the usability of IaaS clouds by automating the VMI selection, deployment, configuration, software installation, monitoring and update of Virtual Appliances. It supports APIs from a large number of virtual platforms, making user applications cloud-agnostic. In addition it integrates a contextualization system to enable the installation and configuration of all the user required applications providing the user with a fully functional infrastructure. Therefore, golden VMIs and configuration recipes can be easily reused across different deployments. Moreover, the contextualization agent included in the framework supports horizontal (increase/decrease the number of resources) and vertical (increase/decrease resources within a running Virtual Machine) by properly reconfiguring the software installed, considering the configuration of the multiple resources running. This paves the way for automatic virtual infrastructure deployment, customization and elastic modification at runtime for IaaS clouds.

Keywords Cloud computing · Virtual Infrastructures · Contextualization

M. Caballer (✉) · I. Blanquer · G. Moltó · C. de Alfonso
Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC – Universitat Politècnica de València – CIEMAT Camino de Vera s/n, 46022 Valencia, Spain
e-mail: micafer1@upv.es

I. Blanquer
e-mail: iblanque@dsic.upv.es

G. Moltó
e-mail: gmolto@dsic.upv.es

C. de Alfonso
e-mail: caralla@upv.es

1 Introduction

With the advent of virtualization technologies and cloud infrastructures, scientists are exploring the usage of computational clouds for their research. Cloud computing technologies can offer: "ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources" [28]. Many scientific infrastructure providers are including IaaS as an added value [16] and [5] analyzes the use cases

(in beta version at the time of the work of this article) that provides a similar functionality to the IM, which could be analysed once it becomes stable. Another interesting issue is the selection of the "best" cloud provider. In this area further research is required to enable cloud-bursting and to include performance/price ratios or similar criteria.

Acknowledgments The authors would like to thank to thank the financial support received from the Ministerio de Economía y Competitividad for the project CodeCloud (TIN2010-17804).

References

1. de Alfonso, C., Caballer, M., Alvarruiz, F., Molto, G., Hernández, V.: Infrastructure deployment over the cloud. In: 2011 IEEE 3rd International Conference on Cloud Computing Technology and Science, pp. 517–521. IEEE. (2011). doi:10.1109/CloudCom.2011.77
2. Alvarruiz, F., De Alfonso, C., Caballer, M., Hernández, V.: An energy manager for high performance computer clusters. In: 2012 IEEE 10th International Symposium on Parallel and Distributed Processing with Applications, pp. 231–238. (2012). doi:10.1109/ISPA.2012.38
3. Amazon Web Services: AWS CloudFormation. (2013). http://aws.amazon.com/es/cloudformation/
4. Apache: Whirr (2013). http://whirr.apache.org/
5. Blanquer, I., Brasche, G., Lezzi, D.: Requirements of scientific applications in cloud offerings. In: Proceedings of the 2012 6th Iberian Grid Infrastructure Conference, IBERGRID '12, pp. 173–182 (2012)
6. Bresnahan, J., Freeman, T., LaBissoniere, D., Keahey, K.: Managing appliance launches in infrastructure clouds. In: Proceedings of the 2011 TeraGrid Conference: Extreme Digital Discovery, TG '11, pp. 12:1–12:7. ACM, New York (2011). doi:10.1145/2016741.2016755
7. Buyya, R., Ranjan, R., Calheiros, R.N.: InterCloud: utility-oriented federation of cloud computing environments for scaling of application services. Algoritm. Archit. Parallel Process. **6081**, 20 (2010)
8. Buyya, R., Yeo, C.S., Venugopal, S., Broberg, J., Brandic, I.: Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility. Futur. Gener. Comput. Syst. **25**(6), 599–616 (2009). doi:10.1016/j.future.2008.12.001
9. Caballer, M., De Alfonso, C., Alvarruiz, F., Moltó, G.: EC3: elastic cloud computing cluster. J. Comput. Syst. Sci. (2013). doi:10.1016/j.jcss.2013.06.005
10. Caballer, M., García, A., Moltó, G., de Alfonso, C.: Towards SLA-driven management of cloud infrastructures to elastically execute scientific applications. In: 6th Iberian Grid Infrastructure Conference (IberGrid), pp. 207–218 (2012)
11. Carrión, J.V., Moltó, G., De Alfonso, C., Caballer, M., Hernández, V.: A generic catalog and repository service for virtual machine images. In: 2nd International ICST Conference on Cloud Computing CloudComp 2010 (2010)
12. Cuomo, A., Modica, G., Distefano, S., Puliafito, A., Rak, M., Tomarchio, O., Venticinque, S., Villano, U.: An SLA-based broker for cloud infrastructures. J. Grid Comput **11**(1), 1–25 (2012). doi:10.1007/s10723-012-9241-4
13. DeHaan, M.: Ansible. http://ansible.cc/ (2013)
14. Distributed Management Task Force, Inc: Open Virtualization Format (OVF) (2010). http://dmtf.org/sites/default/files/standards/documents/DSP0243_1.1.0.pdf
15. Distributed Management Task Force, Inc: Cloud Infrastructure Management Interface (CIMI) Model and REST Interface over HTTP Specification (2012). http://dmtf.org/sites/default/files/standards/documents/DSP0263_1.0.1.pdf
16. EGI.eu: Seeking new horizons: EGI's role for 2020. Tech. rep. (2012). https://documents.egi.eu/public/RetrieveFile?docid=1098&version=4&filename=EGI-1098-D230-final.pdf
17. Elmroth, E., Tordsson, J., Hernández, F.: Self-management challenges for multi-cloud architectures. Towards a service-based internet. Lect. Notes Comput. Sci. **6994**, 38–49 (2011)
18. HashiCorp: Vagrant (2013). http://www.vagrantup.com/
19. Jacob, A.: Infrastructure in the cloud era. In: Proceedings of the 2009 International OReilly Conference Velocity (2009)
20. Juve, G., Deelman, E.: Automating application deployment in infrastructure clouds. In: Proceedings of the 2011 IEEE 3rd International Conference on Cloud Computing Technology and Science, CLOUDCOM '11, pp. 658–665. IEEE Computer Society, Washington DC (2011). doi:10.1109/CloudCom.2011.102
21. Keahey, K., Freeman, T.: Contextualization: providing one-click virtual clusters. In: 4th IEEE International Conference on eScience, pp. 301–308 (2008)
22. Keahey, K., Freeman, T.: Architecting a large-scale elastic environment: recontextualization and adaptive cloud services for scientific computing (2012)
23. Kecskemeti, G., Kertesz, A., Marosi, A., Kacsuk, P.: Interoperable resource management for establishing federated clouds. In: Achieving Federated and SelfManageable Cloud Infrastructures Theory and Practice, pp. 18–35 (2012). doi:10.4018/978-1-4666-1631-8.ch002
24. Kertesz, A., Kecskemeti, G., Oriol, M., Kotcauer, P., Acs, S., Rodríguez, M., Mercè, O., Marosi, A.C., Marco, J., Franch, X.: Enhancing federated cloud management with an integrated service monitoring approach. J. Grid Comput. **11**(4), 699–720 (2013). doi:10.1007/s10723-013-9269-0
25. Loutas, N., Kamateri, E., Bosi, F., Tarabanis, K.: Cloud computing interoperability: the state of play. 2011 IEEE 3rd International Conference on Cloud Computing Technology and Science, pp. 752–757 (2011). doi:10.1109/CloudCom.2011.116
26. Marshall, P., Keahey, K., Freeman, T.: Elastic site: using clouds to elastically extend site resources. In: Proceedings of the 2010 IEEE/ACM 10th International Conference on Cluster, Cloud and Grid Computing, CCGRID '10, pp. 43–52. IEEE Computer Society, Washington DC (2010). doi:10.1109/CCGRID.2010.80
27. Massie, M.L., Chun, B.N., Culler, D.E.: The ganglia distributed monitoring system: design, implementation, and experience. Parallel Comput. **30**(5-6), 817–840 (2004)
28. Mell, P., Grance, T.: The NIST definition of cloud computing. NIST Special Publication 800-145 (Final). Tech. rep.

(2011). http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf
29. Moltó, G., Caballer, M., Romero, E., Alfonso, C.D.: Elastic memory management of virtualized infrastructures for applications with dynamic memory requirements. In: Proceedings of the International Conference on Computational Science ICCS 2013, pp. 159–168. Elsevier (2013). doi:10.1016/j.procs.2013.05.179
30. Morfeo: Claudia (2013). http://claudia.morfeo-project.org/wiki/index.php/Main_Page
31. OASIS: Topology and Orchestration Specification for Cloud Applications Version 1.0 (2013). http://docs.oasis-open.org/tosca/TOSCA/v1.0/TOSCA-v1.0.html
32. OCCI working group within the Open Grid Forum: Open Cloud Computing Interface Infrastructure (2011). http://ogf.org/documents/GFD.184.pdf
33. Opscode: Chef (2013). http://www.opscode.com/chef/
34. Pawluk, P., Simmons, B., Smit, M., Litoiu, M., Mankovski, S.: Introducing STRATOS: a cloud broker service. In: 2012 IEEE 5th International Conference on Cloud Computing, pp. 891–898 (2012). doi:10.1109/CLOUD.2012.24
35. Puppet Labs: IT Automation Software for System Administrators (2013). http://www.puppetlabs.com/
36. Redl, C., Breskovic, I., Brandic, I., Dustdar, S.: Automatic SLA matching and provider selection in grid and cloud computing markets. In: Proceedings of the 2012 ACM/IEEE 13th International Conference on Grid Computing, GRID '12, pp. 85–94. IEEE Computer Society, Washington (2012). doi:10.1109/Grid.2012.18
37. Rodero-Merino, L., Vaquero, L.M., Gil, V., Galán, F., Fontán, J., Montero, R.S., Llorente, I.M.: From infrastructure delivery to service management in clouds. Futur. Gener. Comput. Syst. **26**(8), 1226–1240 (2010). doi:10.1016/j.future.2010.02.013
38. StratusLab: Claudia Platform (2013). http://stratuslab.eu/doku.php/claudia
39. Sundareswaran, S., Squicciarini, A., Lin, D.: A brokerage-based approach for cloud service selection. In: Proceedings of the 2012 IEEE 5th International Conference on Cloud Computing, CLOUD '12, pp. 558–565 (2012). doi:10.1109/CLOUD.2012.119
40. Telefónica Investigación y Desarrollo S.A. Unipersonal.: Telefónicas TCloud API Specification. (2010). http://www.tid.es/files/doc/apis/TCloud_API_Spec_v0.9.pdf
41. Yangui, S., Marshall, I.J., Laisne, J.P., Tata, S.: CompatibleOne: The open source cloud broker. J. Grid Comput. (2013). doi:10.1007/s10723-013-9285-0

5.1.1.14. Supercontinuum optimization for dual-soliton based light sources using genetic algorithms in a grid platform

F. R. Arteaga-Sierra, C. Milián, I. Torres-Gómez, M. Torres-Cisneros, G. Moltó, and A. Ferrando, "Supercontinuum optimization for dual-soliton based light sources using genetic algorithms in a grid platform," Opt. Express, vol. 22, no. 19, pp. 23686–23693, Sep. 2014, doi: https://dx.doi.org/10.1364/OE.22.023686

Base de datos de indexación	Web of Science (JCR)
Índice de impacto	3.488
Año	2014
Categoría	Optics
Posición de la revista en el área	10 de 87
Tercil	T1
Cuartil	Q1
Número de citas en JCR	18
Número de citas totales	23

Comentario. Este artículo es el resultado de la colaboración mantenida con los investigadores Francisco Arteaga Sierra, Carles Milián y Albert Ferrando durante la realización de la Tesis Doctoral del candidato, en la parte dedicada a la optimización de fibras de cristal fotónico. El candidato aportó las estrategias para ejecutar de forma óptima los múltiples trabajos computacionales que surgen para encontrar la mejor configuración de fibra usando algoritmos genéticos.

Supercontinuum optimization for dual-soliton based light sources using genetic algorithms in a grid platform

F. R. Arteaga-Sierra,[1,2,*] C. Milián,[2,3,6] I. Torres-Gómez,[1] M. Torres-Cisneros,[4] G. Moltó,[3] and A. Ferrando[2,5]

[1]*Centro de Investigaciones en Óptica, A.C., León Gto. 37150, Mexico*
[2]*Universidad Politécnica de Valencia, Grupo de Modelización Multidisciplinar Intertech, 46022, Valencia, Spain*
[3]*Instituto de Instrumentación para Imagen Molecular (I3M). Centro mixto CSIC-Universitat Politècnica de València-CIEMAT, camino de Vera s/n, 46022 Valencia, Spain*
[4]*NanoBioPhotonics Group, DICIS, Universidad de Guanajuato, Mexico*
[5]*Departament d'Òptica, Universitat de València, Burjassot (València). 46100, Spain*
[6]*Current address: Centre de Physique Théorique, École Polytechnique, CNRS, F-91128 Palaiseau, France*
[*]*arteaga@cio.mx*

Abstract: We present a numerical strategy to design fiber based dual pulse light sources exhibiting two predefined spectral peaks in the anomalous group velocity dispersion regime. The frequency conversion is based on the soliton fission and soliton self-frequency shift occurring during supercontinuum generation. The optimization process is carried out by a genetic algorithm that provides the optimum input pulse parameters: wavelength, temporal width and peak power. This algorithm is implemented in a Grid platform in order to take advantage of distributed computing. These results are useful for optical coherence tomography applications where bell-shaped pulses located in the second near-infrared window are needed.

OCIS codes: (190.4370) Nonlinear optics, fibers; (060.5530) Pulse propagation and temporal solitons; (230.6080) Sources; (110.2945) Illumination design; (170.4500) Optical coherence tomography.

References and links

1. J. P. Gordon, "Theory of the soliton self-frequency shift," Opt. Lett. **11,** 662–664 (1986).
2. F. M. Mitschke and L. F. Mollenauer, "Discovery of the soliton self-frequency shift," Opt. Lett. **11,** 659–661 (1986).
3. J. M. Dudley, G. Genty, and S. Coen, "Supercontinuum generation in photonic cristal fibers," Rev. Mod. Phys. **78,** 135–1184 (2006).
4. D. V. Skryabin and A. V. Gorbach, "Colloquium: looking at a soliton through the prism of optical supercontinuum," Rev. Mod. Phys. **82,** 1287–1299 (2010).
5. A. V. Gorbach and D. V. Skryabin, "Light trapping in gravity-like potentials and expansion of supercontinuum spectra in photonic-crystal fibres," Nat. Photonics **1,** 1749-4885 (2007).
6. A. Hause, T. X. Tran, F. Biancalana, A. Podlipensky, P. St.J. Russell, and F. Mitschke, "Understanding Raman-shifting multipeak states in photonic crystal fibers: two convergent approaches," Opt. Lett. **35,** 2167–2169 (2010).
7. A. Hause and F. Mitschke, "Soliton trains in motion," Phys. Rev. A **82,** 043838 (2010).
8. T. X. Tran, A. Podlipensky, P. St. J. Russell, and F. Biancalana, "Theory of Raman multipeak states in solid-core photonic crystal fibers," J. Opt. Soc. Am. B **27,** 1785–1791 (2010).
9. A. V. Gorbach and D. V. Skryabin, "Soliton self-frequency shift, non-solitonic radiation and self-induced transparency in air-core fibers," Opt. Express **16,** 4858–4865 (2008).

#217205 - $15.00 USD Received 17 Jul 2014; revised 29 Aug 2014; accepted 8 Sep 2014; published 19 Sep 2014

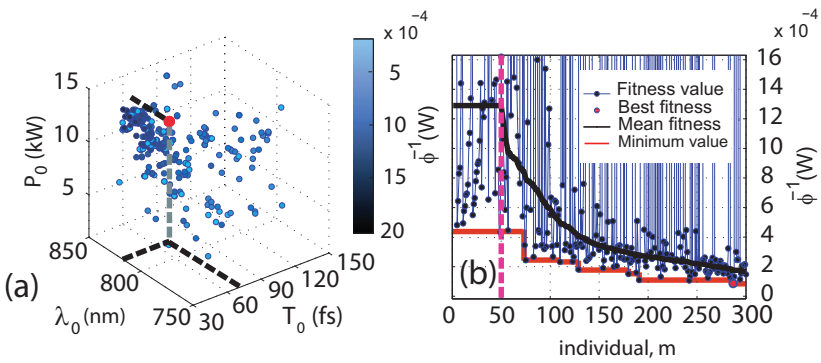


Fig. 4. (a) Parameter space cloud of the 300 individuals (and fitness) generated by the GA in the optimization yielding to the solution in Figs. 3 (b),(e). The best individual is marked in red and dashed mark its input parameters. (b) Fitness evolution versus generated individuals in chronological order. Dashed vertical line marks the threshold population $p_{th} = 50$ corresponding to the end of stage 1 (random generation). Best (at $m \approx 260$), Instantaneous minimum, and average fitness are also plotted (see legend).

curve in Fig. 4(b)]. However, the scattering ability of GOs often results in finding slightly better individuals in nearby regions presenting smaller agglomeration. An important reason for the convergence of our GA towards the optimal solutions is the fact that the operator $\hat{M}$ is given a lower probability of action than $\hat{X}$ (probabilities are $1/3$ and 0.95 respectively, see previous section). This combination gives both a good diversity and probability to conserve the properties of the best individuals during the execution of the GA.

4. Conclusions

We presented an efficient optimization procedure based on GAs deployed in the Grid platform, providing faster results and potential scalability of the computational resources. The optimization provides the optimum input pulse parameters required to control the SC dynamics in a way that the first two ejected Raman solitons are centered at two pre-defined wavelengths. The results are shown to be of interest for practical OCT applications in the NIR II region where dual frequency, pulsed sources enable in vivo imaging, and avoid spurious results.

Acknowledgments

F.R.A.S. thanks the Consejo Nacional de Ciencia y Tecnología (CONACyT). F.R.A.S. and M.T.C. acknowledge partial funding provided by the projects CONCyTEG (GTO-2012-C03-195247) and DAIP-UG 382/2014. I.T.G. acknowledges CONACyT for partial support, project: 106764 (CB-2008-1). The work of A.F. was supported by the MINECO under Grant No. TEC2010-15327. C.M. thanks Dr. Miguel Arevalillo Herráez for details on GAs. F.R.A.S thanks Dr. Daniel Ceballos for providing the numerical data for the fiber dispersion.

5.1.1.15. Automatic memory-based vertical elasticity and oversubscription on cloud platforms

G. Moltó, M. Caballer, and C. de Alfonso, "Automatic memory-based vertical elasticity and oversubscription on cloud platforms," Futur. Gener. Comput. Syst., vol. 56, pp. 1–10, Mar. 2016, doi: https://dx.doi.org/10.1016/j.future.2015.10.002

Base de datos de indexación	Web of Science (JCR)
Índice de impacto	3.997
Año	2016
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	10 de 104
Tercil	T1
Cuartil	Q1
Número de citas en JCR	24
Número de citas totales	36

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional CLUVIEM (TIN2013-44390-R), liderado por el candidato, donde se creó una herramienta de código abierto para escalado vertical automatizado de máquinas virtuales en plataformas Cloud, disponible bajo licencia abierta (Apache 2.0) en https://www.grycap.upv.es/cloudvamp. Supone también una contribución del proyecto Europeo H2020 INDIGO-DataCloud (653549) dado que se integraron técnicas de escalado automatizado en la plataforma Cloud diseñada en dicho proyecto.

Future Generation Computer Systems 56 (2016) 1–10

Contents lists available at ScienceDirect

Future Generation Computer Systems

journal homepage: www.elsevier.com/locate/fgcs

Automatic memory-based vertical elasticity and oversubscription on cloud platforms

Germán Moltó *, Miguel Caballer, Carlos de Alfonso

Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC – Universitat Politècnica de València – CIEMAT, camino de Vera s/n, 46022 Valencia, Spain

HIGHLIGHTS

- We describe a memory oversubscription framework for Cloud Management Platforms.
- Transient overcommitment of physical hosts increases consolidation.
- Automatic vertical elasticity is managed via memory ballooning and live migration.
- Horizontal and vertical elastic virtual clusters are used in production.

ARTICLE INFO

Article history:
Received 15 April 2015
Received in revised form
10 September 2015
Accepted 6 October 2015
Available online 22 October 2015

Keywords:
Cloud computing
Cloud Management platform
Virtualisation
Vertical elasticity
Memory overcommitment
Oversubscription

ABSTRACT

Hypervisors and Operating Systems support vertical elasticity techniques such as memory ballooning to dynamically assign the memory of Virtual Machines (VMs). However, current Cloud Management Platforms (CMPs), such as OpenNebula or OpenStack, do not currently support dynamic vertical elasticity. This paper describes a system that integrates with the CMP to provide automatic vertical elasticity to adapt the memory size of the VMs to their current memory consumption, featuring live migration to prevent overload scenarios, without downtime for the VMs. This enables an enhanced VM-per-host consolidation ratio while maintaining the Quality of Service for VMs, since their memory is dynamically increased as necessary. The feasibility of the development is assessed via two case studies based on OpenNebula featuring (i) horizontal and vertical elastic virtual clusters on a production Grid infrastructure and (ii) elastic multi-tenant VMs that run Docker containers coupled with live migration techniques. The results show that memory oversubscription can be integrated on CMPs to deliver automatic memory management without severely impacting the performance of the VMs. This results in a memory management framework for on-premises Clouds that features live migration to safely enable transient oversubscription of physical resources in a CMP.

1. Introduction

Elasticity [1], or the ability to rapidly provision and release resources, is one of the integral characteristics of Cloud Computing. Horizontal elasticity is commonly employed to provision additional computational nodes in order to sustain the quality of service delivered by an architecture deployed on a Cloud platform, specially after an increase in the number of users or workload. Horizontal elasticity has been extensively studied in the past, with services already available for public Clouds, such as Auto Scaling[1] for Amazon Web Services (AWS), and Heat[2] for OpenStack.

Instead, vertical elasticity enables to increase and decrease the number of resources allocated to a single Virtual Machine (VM). The increased support to techniques such as *memory ballooning* [2] and *CPU hot plugging* by popular hypervisors such as KVM, Xen or VMware paves the way for vertical elasticity to be adopted by Cloud platforms. However, popular open source CMPs such as OpenNebula and OpenStack do not currently support vertical elasticity without stopping the VMs. As an example, the

* Corresponding author.
E-mail address: gmolto@dsic.upv.es (G. Moltó).

http://dx.doi.org/10.1016/j.future.2015.10.002
0167-739X/

[1] Auto Scaling: http://aws.amazon.com/autoscaling.
[2] Heat: https://wiki.openstack.org/wiki/Heat.

6. Conclusion and future works

This paper has introduced CloudVAMP, a customisable system to safely enable transient memory oversubscription in on-premises Clouds via vertical elasticity without VM downtime and featuring live migration to prevent oversubscription scenarios. By leveraging the memory ballooning techniques and live migration capabilities available in the KVM hypervisor, CloudVAMP integrates with Cloud Management Platforms to dynamically reduce and increase the allocated memory to the VMs so that they fit the memory requirements of the applications running in the VMs.

We have introduced a generic architecture that can be deployed for different CMPs, and we have implemented a fully functional open-source proof-of-concept based on OpenNebula which is currently being used in production at our research centre.[10] The benefits of CloudVAMP have been assessed via a case study that uses horizontal and vertical elastic virtual clusters that run jobs from a production Grid infrastructure and a multi-tenant scenario based on Docker containers. The ability of CloudVAMP to reclaim unused memory from the VMs to enable temporary oversubscription for the CMPs has resulted in increased VM-per-host consolidation ratio with a reduced impact for the running applications. The usage of live migration has been beneficial to restore the level of service in memory overload scenarios.

Future works include adjusting the O percentage on a per-VM level considering the stability of each VM. For example, CloudVAMP could reclaim different percentages of free memory depending on the amount of time in which a VM's memory consumption has remained among a certain range. For VMs with long periods of stable memory consumption it might be safe to assume that the unused memory will not be used, and a greater percentage can be reclaimed by CloudVAMP to be used for additional VMs to be hosted on the same physical node. Also, we plan to evolve the CVEM to consider historical information of the memory consumption of the VMs to avoid unnecessary transient memory changes while maintaining the ability to rapidly react when memory consumption spikes are detected.

In addition, we plan to explore memory bursting, where a VM could temporarily allocate more memory than the one initially requested, much in the same way as CPU bursting is available for certain instance types (e.g. *t2.micro*) in Amazon EC2. This can be easily implemented by increasing the VM deployment memory request by a certain percentage, which would depend on the policies of the on-premises Cloud, and letting CloudVAMP to dynamically manage the memory consumption, which could temporarily exceed the amount of memory initially requested.

Finally, we plan to generalise our development to other CMPs (e.g. OpenStack). For that, one can use Ganglia as the memory reporting system and modify the monitoring system of OpenStack to integrate CloudVAMP.

Acknowledgements

The authors would like to thank the Spanish "Ministerio de Economía y Competitividad" for the project CLUVIEM (TIN2013-44390-R) and the European Commission for the project INDIGO-DataCloud with grant number 653549.

References

[1] G. Galante, L.C.E. de Bona, A Survey on Cloud Computing Elasticity, in: 2012 IEEE Fifth International Conference on Utility and Cloud Computing, IEEE, 2012, pp. 263–270. URL http://dl.acm.org/citation.cfm?id=2415689.2415736.
[2] C.A. Waldspurger, Memory resource management in VMware ESX server, ACM SIGOPS Oper. Syst. Rev. 36 (SI) (2002) 181. URL http://dl.acm.org/citation.cfm?id=844128.844146.
[3] G. Moltó, M. Caballer, E. Romero, C. de Alfonso, Elastic Memory Management of Virtualized Infrastructures for Applications with Dynamic Memory Requirements, in: Proceedings of the International Conference on Computational Science, ICCS 2013, Elsevier, 2013, pp. 159–168.
[4] L. Tomás, J. Tordsson, Improving cloud infrastructure utilization through overbooking, in: Proceedings of the 2013 ACM Cloud and Autonomic Computing Conference on - CAC '13, ACM Press, New York, New York, USA, 2013, p. 1. URL http://dl.acm.org/citation.cfm?id=2494621.2494627.
[5] R. Householder, S. Arnold, R. Green, On cloud-based oversubscription, Int. J. Eng. Trends Technol. 8 (8) (2014) 425–431.
[6] D. Williams, H. Jamjoom, Y.-H. Liu, H. Weatherspoon, Overdriver: handling memory overload in an oversubscribed cloud, ACM SIGPLAN Not. 46 (7) (2011) 205. URL http://dl.acm.org/citation.cfm?id=2007477.1952709.
[7] W. Dawoud, I. Takouna, C. Meinel, Elastic VM for Cloud Resources Provisioning Optimization, in: Advances in Computing and Communications, First International Conference, ACC 2011, Kochi, India, July 22–24, 2011, in: Proceedings, Part I, Vol. 190, 2011, pp. 431–445. URL http://www.springerlink.com/index/K75M2705443R2402.pdf.
[8] E. Tasoulas, H. r. Haugerund, K. Begnum, Bayllocator: a proactive system to predict server utilization and dynamically allocate memory resources using Bayesian networks and ballooning, in: Proceedings of the 26th International Conference on Large Installation System Administration: Strategies, Tools, and Techniques, USENIX Association, 2012, pp. 111–122. URL http://dl.acm.org/citation.cfm?id=2432523.2432532.
[9] M.R. Hines, A. Gordon, M. Silva, D. Da Silva, K. Ryu, M. Ben-Yehuda, Applications Know Best: Performance-Driven Memory Overcommit with Ginkgo, in: 2011 IEEE Third International Conference on Cloud Computing Technology and Science, IEEE, 2011, pp. 130–137. URL http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=6133136.
[10] T.-I. Salomie, G. Alonso, T. Roscoe, K. Elphinstone, Application level ballooning for efficient server consolidation, in: Proceedings of the 8th ACM European Conference on Computer Systems - EuroSys '13, ACM Press, New York, New York, USA, 2013, p. 337. URL http://dl.acm.org/citation.cfm?id=2465351.2465384.
[11] J. Hwang, A. Uppal, T. Wood, H. Huang, Mortar: Filling the gaps in data center memory, ACM SIGPLAN Not. 49 (7) (2014) 53–64. URL http://dl.acm.org/citation.cfm?id=2674025.2576203.
[12] Baset S. A., Wang L, Tang C, Towards an understanding of oversubscription in cloud (2012) 7. URL http://dl.acm.org/citation.cfm?id=2228283.2228293.
[13] KVM, Automatic Ballooning. URL http://www.linux-kvm.org/page/Projects/auto-ballooning.
[14] A. Litke, Manage Resources on Overcommitted KVM Hosts, Tech. Rep, 2011. URL http://www.ibm.com/developerworks/library/l-overcommit-kvm-resources/.
[15] A. Kivity, Y. Kamay, D. Laor, KVM: the Linux virtual machine monitor, in: Proceedings of the Linux Symposium, 2007, pp. 225–230. URL http://www.kernel.org/doc/ols/2007/ols2007v1-pages-225-230.pdf.
[16] R. Moreno-Vozmediano, I.M. Llorente, IaaS Cloud Architecture: From Virtualized Datacenters to Federated Cloud Infrastructures, in: IEEE Computer (Long. Beach. Calif), vol. 45, no. 12, 2012, pp. 65–72. URL http://doi.ieeecomputersociety.org/10.1109/MC.2012.76.
[17] P.J. Denning, Thrashing: Its causes and prevention, in: Proceedings of the December 9–11, 1968, Fall Joint Computer Conference, Part I on - AFIPS '68 (Fall, part I), ACM Press, New York, New York, USA, 1968, p. 915. URL http://dl.acm.org/citation.cfm?id=1476589.1476705.
[18] Miller L., Performance analysis of exponential backoff, IEEE/ACM Trans. Netw. 13 (2) (2005) 343–355. URL http://dl.acm.org/citation.cfm?id=1066626.1066636.
[19] C. Clark, K. Fraser, S. Hand, J.G. Hansen, E. Jul, C. Limpach, I. Pratt, A. Warfield, Live migration of virtual machines, in: NSDI'05 Proceedings of the 2nd Conference on Symposium on Networked Systems Design &Implementation, USENIX Association, 2005, pp. 273–286. URL http://dl.acm.org/citation.cfm?id=1251203.1251223.
[20] M. Caballer, C. de Alfonso, F. Alvarruiz, G. Moltó, EC3: Elastic cloud computing cluster, J. Comput. System Sci. 79 (2013) 1341–1351. URL http://authors.elsevier.com/sd/article/S0022000013001141.
[21] C. de Alfonso, M. Caballer, F. Alvarruiz, V. Hernández, An energy management system for cluster infrastructures, Comput. Electr. Eng. 39 (8) (2013) 2579–2590. URL http://www.sciencedirect.com/science/article/pii/S0045790613001365.
[22] D. Merkel, Docker: lightweight Linux containers for consistent development and deployment, Linux J. 2014 (239) (2014) 2. URL http://dl.acm.org/ft_gateway.cfm?id=2600241&type=html.

Germán Moltó received the B.Sc. and Ph.D. degrees in computer science from the Universitat Politècnica de València (UPV), Spain, in 2002 and 2007. He is a member of the Grid and High Performance Computing research group (GRyCAP) at the Institute for Molecular Imaging (I3M) since 2002. He is also associate professor at the Department of Computer Systems and Computation (DSIC) at UPV. He has participated in several European projects and led National research projects in the area of Cloud Computing. His research interests broadly lie in Cloud Computing, Grid Computing, High Performance Computing and Scientific Computing.

[10] CloudVAMP is available at https://github.com/grycap/cloudvamp.

Miguel Caballer obtained the B.Sc., M.Sc. and Ph.D. degrees in Computer Science from the Universitat Politècnica de València (UPV), Spain, in 2000, 2012 and 2014. He is a member of the Grid and High Performance Computing research group at the Institute for Molecular Imaging (I3M) since 2001. He has participated in several European and National research projects about the application of Parallel, Grid and Cloud computing techniques to several areas of engineering. Other fields of interest include Green Computing.

Carlos de Alfonso obtained the B.Sc., M.Sc. and Ph.D. degrees in Computer Science from the Universitat Politècnica de València (UPV), Spain, in 2000, 2013 and 2015. In 2000 he joined the Grid and High Performance Computing research group, at UPV. Since 2007 he is a Technician for the Support of Research at UPV, with a profile of Grid and Cloud computing. He has been part of several national, European and international projects and contracts in the fields of Grid. During the last years he has oriented his activity mainly to Cloud Computing and Green Computing.

5.1.1.16. Self-managed cost-efficient virtual elastic clusters on hybrid Cloud infrastructures

A. Calatrava, E. Romero, G. Moltó, M. Caballer, and J. M. Alonso, "Self-managed cost-efficient virtual elastic clusters on hybrid Cloud infrastructures," Futur. Gener. Comput. Syst., vol. 61, pp. 13–25, Aug. 2016, doi: https://dx.doi.org/10.1016/j.future.2016.01.018

Base de datos de indexación	Web of Science (JCR)
Índice de impacto	3.997
Año	2016
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	10 de 104
Tercil	T1
Cuartil	Q1
Número de citas en JCR	20
Número de citas totales	29

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional CLUVIEM (TIN2013-44390-R), liderado por el candidato, y supone la consolidación de la herramienta EC3 (https://www.grycap.upv.es/ec3) para el despliegue de clusters virtuales, adoptada en producción a nivel europeo como parte del catálogo de servicios de EGI dentro de "Applications on Demand - https://www.egi.eu/services/applications-on-demand/", la infraestructura de computación distribuida Europea. Es el principal resultado de la Tesis Doctoral de Amanda Calatrava, titulada "High Performance Scientific Computing over Hybrid Cloud Platforms" y dirigida por el candidato. La herramienta ha sido mejorada a lo largo de los años mediante su adopción por numerosos proyectos Europeos, entre los que destacamos INDIGO-DataCloud, EOSC-HUB y EOSC-SYNERGY. La herramienta se ofrece como código abierto (Apache 2.0) en *http://github.com/grycap/ec3* así como mediante servicio en *https://www.grycap.upv.es/ec3*.

Future Generation Computer Systems 61 (2016) 13–25

Contents lists available at ScienceDirect

Future Generation Computer Systems

journal homepage: www.elsevier.com/locate/fgcs

Self-managed cost-efficient virtual elastic clusters on hybrid Cloud infrastructures☆

Amanda Calatrava *, Eloy Romero, Germán Moltó, Miguel Caballer, Jose Miguel Alonso

Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC - Universitat Politècnica de València - CIEMAT, Camino de Vera s/n, 46022 Valencia, Spain

HIGHLIGHTS

- Cost-efficient hybrid elastic virtual clusters are deployed across clouds.
- Spot instances and checkpointing reduce the costs of execution.
- Hybrid clusters reduce the total execution time by employing cloud bursting.
- Computationally intensive applications are executed easily with EC3.

ARTICLE INFO

Article history:
Received 24 April 2015
Received in revised form
27 November 2015
Accepted 27 January 2016
Available online 15 February 2016

Keywords:
Checkpointing
Cloud bursting
Cloud computing
Cluster computing
Hybrid cluster
Spot instance

ABSTRACT

In this study, we describe the further development of Elastic Cloud Computing Cluster (EC3), a tool for creating self-managed cost-efficient virtual hybrid elastic clusters on top of Infrastructure as a Service (IaaS) clouds. By using spot instances and checkpointing techniques, EC3 can significantly reduce the total execution cost as well as facilitating automatic fault tolerance. Moreover, EC3 can deploy and manage hybrid clusters across on-premises and public cloud resources, thereby introducing cloud bursting capabilities. We present the results of a case study that we conducted to assess the effectiveness of the tool based on the structural dynamic analysis of buildings. In addition, we evaluated the checkpointing algorithms in a real cloud environment with existing workloads to study their effectiveness. The results demonstrate the feasibility and benefits of this type of cluster for computationally intensive applications.

1. Introduction

The successful use of clusters of PCs as a computing facility is widespread in the scientific community for both high performance computing (HPC) and high throughput computing (HTC). However, these computing platforms have several drawbacks, such as the requirement for a large upfront investment and maintenance costs, which have major economic effects in small and medium-sized organizations. Moreover, the size of a physical cluster cannot be adapted easily to the application workload and they cannot provide customized environments for executing each separate application. In recent years, the development of hypervisors and virtualization technologies have paved the way for cloud computing. This paradigm can address those problems with customizable virtual machines (VMs), which decouple the execution of the application from the underlying hardware, where they are dynamically provisioned and released [1]. Thus, depending on the resource usage and cost model, it might be convenient to deploy a virtual cluster instead of a physical one, as suggested in a previous study [2]. Virtual clusters in the cloud are highly beneficial for many computational workloads, but particularly for highly parallel tasks. These benefits include the on-demand provision of per-application customized clusters as well as the ability to dynamically increase and decrease the number of working nodes in the virtual cluster according to the current workload, as demonstrated in our previous study [3]. Our previous study led to the development of the Elastic Cloud Computing Cluster (EC3)[1] [3] as an open-source tool for the deployment of customized virtual elastic clusters on different on-premises

☆ All the software described in this study is available at https://github.com/grycap.

* Corresponding author. Tel.: +34 963877356; fax: +34 963877359.
E-mail address: amcaar@i3m.upv.es (A. Calatrava).

[1] EC3: http://www.grycap.upv.es/ec3.

http://dx.doi.org/10.1016/j.future.2016.01.018
0167-739X/

5. Conclusions and future work

In this study, we described the further development of EC3 as a tool that produces self-managed cost-efficient virtual hybrid elastic clusters from the computational resources provided by multiple IaaS clouds. In particular, we focused on two topics: (i) hybrid clusters across on-premises and public clouds; and (ii) using the spot instances provide by AWS to achieve reliable low cost cluster-based cloud computing. We performed a case study based on a scientific application for the nonlinear dynamic analysis of buildings, which we executed using a hybrid virtual elastic cluster across an on-premises OpenNebula cloud and AWS. We also assessed the threshold algorithm and other previously proposed algorithms using real workloads and real spot prices.

Our results demonstrated the ability of the clusters to adapt their size to the workload, as well as automatic cloud bursting to a public cloud, and significant savings due to the use of spot instances compared with on-demand instances, where the increased resilience was attributable to performing periodic and automatic checkpointing for the jobs. EC3 is open-source based on the Apache 2.0 License and hosted on GitHub,[4] and a web application is also available for free (Elastic Virtual Clusters as a Service) to the community.[5]

In future research, we aim to add migration capabilities to EC3. We plan to enable the migration of virtual clusters across cloud platforms, thereby introducing an unprecedented degree of flexibility for data centers, especially during planned outages where computing power can be outsourced temporarily to a public cloud. In addition, we may address the checkpointing of applications that also require the restoration of the file system's content at the time of checkpointing. We also intend to adapt the algorithms to other public cloud providers with similar features, which is the case for the preemptible VM instances provided by the Google Cloud Platform.

Acknowledgments

This study was supported by the program "Ayudas para la contratación de personal investigador en formación de carácter predoctoral, programa VALi+d" under grant number ACIF/2013/003 from the Conselleria d'Educació of the Generalitat Valenciana. We are also grateful for financial support received from The Spanish Ministry of Economy and Competitiveness to develop the project "CLUVIEM" under grant reference TIN2013-44390-R. Finally, we express our gratitude to D. David Ruzafa for support with the arduous task of analyzing the executions data.

References

[1] P. Mell, T. Grance, The NIST definition of cloud computing, Tech. Rep. 800-145, National Institute of Standards and Technology (NIST), Gaithersburg, MD, 2011, URL http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf.
[2] C. De Alfonso, M. Caballer, F. Alvarruiz, G. Moltó, An economic and energy-aware analysis of the viability of outsourcing cluster computing to a cloud, Future Gener. Comput. Syst. 29 (3) (2013) 704–712. http://dx.doi.org/10.1016/j.future.2012.08.014.
[3] M. Caballer, C. De Alfonso, F. Alvarruiz, G. Moltó, Ec3: Elastic cloud computing cluster, J. Comput. Syst. Sci. 79 (8) (2013) 1341–1351. http://dx.doi.org/10.1016/j.jcss.2013.06.005.
[4] B. Sotomayor, R.S. Montero, I.M. Llorente, I. Foster, Capacity leasing in cloud systems using the OpenNebula engine, in: Cloud Computing and Applications 2008, CCA08, 2009.
[5] OpenStack, OpenStack Cloud Software, http://openstack.org (accessed 01.12.14).
[6] Amazon, Amazon Web Services (AWS), http://aws.amazon.com (accessed 01.12.14).
[7] Amazon, Spot instances (amazon ec2), https://aws.amazon.com/ec2/purchasing-options/spot-instances/ (accessed 01.12.14).
[8] A. EC2, Spot instance termination notices, http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/spot-interruptions.html (accessed 13.01.15).
[9] MIT, Starcluster, http://web.mit.edu/stardev/cluster/ (accessed 01.12.14).
[10] CycleComputing, Cyclecloud, http://www.cyclecomputing.com/cyclecloud (accessed 01.12.14).
[11] U. of Zurich, Elasticluster. URL http://gc3-uzh-ch.github.io/elasticluster/.
[12] F. Doelitzscher, M. Held, C. Reich, A. Sulistio, Viteraas: Virtual cluster as a service, in: Proceedings of the 2011 IEEE Third International Conference on Cloud Computing Technology and Science, CLOUDCOM'11, IEEE Computer Society, Washington, DC, USA, 2011, pp. 652–657. http://dx.doi.org/10.1109/CloudCom.2011.101.
[13] IBM, IBM platform dynamic cluster, http://www-03.ibm.com/systems/technicalcomputing/platformcomputing/products/lsf/dynamiccluster.html (accessed 10.12.13).
[14] R.S. Montero, R. Moreno-Vozmediano, I.M. Llorente, An elasticity model for high throughput computing clusters, J. Parallel Distrib. Comput. 71 (6) (2011) 750–757. http://dx.doi.org/10.1016/j.jpdc.2010.05.005.
[15] R. Moreno-Vozmediano, R.S. Montero, I.M. Llorente, Elastic management of cluster-based services in the cloud, in: Proceedings of the 1st Workshop on Automated Control for Datacenters and Clouds, ACDC '09, ACM, New York, NY, USA, 2009, pp. 19–24. http://dx.doi.org/10.1145/1555271.1555277.
[16] R. Moreno-Vozmediano, R.S. Montero, I.M. Llorente, Multicloud deployment of computing clusters for loosely coupled MTC applications, IEEE Trans. Parallel Distrib. Syst. 22 (6) (2011) 924–930. http://dx.doi.org/10.1109/TPDS.2010.186.
[17] P. Marshall, K. Keahey, T. Freeman, Elastic site: Using clouds to elastically extend site resources, in: 10th IEEE/ACM International Conference on Cluster, Cloud and Grid Computing, CCGrid, 2010, pp. 43–52. http://dx.doi.org/10.1109/CCGRID.2010.80.
[18] P. Marshall, H.M. Tufo, K. Keahey, D.L. Bissoniere, M. Woitaszek, Architecting a large-scale elastic environment - recontextualization and adaptive cloud services for scientific computing, in: S. Hammoudi, M. van Sinderen, J. Cordeiro (Eds.), ICSOFT, SciTePress, 2012, pp. 409–418.
[19] D. Duplyakin, P. Marshall, K. Keahey, H. Tufo, A. Alzabarah, Rebalancing in a multi-cloud environment, in: Proceedings of the 4th ACM Workshop on Scientific Cloud Computing, Science Cloud'13, ACM, New York, NY, USA, 2013, pp. 21–28. http://dx.doi.org/10.1145/2465848.2465854.
[20] M.D. de Assuncao, A. di Costanzo, R. Buyya, Evaluating the cost-benefit of using cloud computing to extend the capacity of clusters, in: Proceedings of the 18th ACM International Symposium on High Performance Distributed Computing, HPDC'09, ACM, New York, NY, USA, 2009, pp. 141–150. http://dx.doi.org/10.1145/1551609.1551635.
[21] B. Javadi, R.K. Thulasiram, R. Buyya, Characterizing spot price dynamics in public cloud environments, Future Gener. Comput. Syst. 29 (4) (2013) 988–999. http://dx.doi.org/10.1016/j.future.2012.06.012.
[22] S. Tang, J. Yuan, X.-Y. Li, Towards optimal bidding strategy for Amazon EC2 cloud spot instance, in: Proceedings of the 2012 IEEE Fifth International Conference on Cloud Computing, CLOUD'12, IEEE Computer Society, Washington, DC, USA, 2012, pp. 91–98. http://dx.doi.org/10.1109/CLOUD.2012.134.
[23] Y. Song, M. Zafer, K.-W. Lee, Optimal bidding in spot instance market, in: 2012 Proceedings IEEE, INFOCOM, 2012, pp. 190–198. http://dx.doi.org/10.1109/INFCOM.2012.6195567.
[24] M. Mazzucco, M. Dumas, Achieving performance and availability guarantees with spot instances, in: 2011 IEEE 13th International Conference on High Performance Computing and Communications, HPCC, 2011, pp. 296–303. http://dx.doi.org/10.1109/HPCC.2011.46.
[25] O. Agmon Ben-Yehuda, M. Ben-Yehuda, A. Schuster, D. Tsafrir, Deconstructing Amazon EC2 spot instance pricing, in: Proceedings of the 2011 IEEE Third International Conference on Cloud Computing Technology and Science, CLOUDCOM'11, IEEE Computer Society, Washington, DC, USA, 2011, pp. 304–311. http://dx.doi.org/10.1109/CloudCom.2011.48.
[26] M. Mattess, C. Vecchiola, R. Buyya, Managing peak loads by leasing cloud infrastructure services from a spot market, in: Proceedings of the 2010 IEEE 12th International Conference on High Performance Computing and Communications, HPCC'10, IEEE Computer Society, Washington, DC, USA, 2010, pp. 180–188. http://dx.doi.org/10.1109/HPCC.2010.77.
[27] R.N. Calheiros, C. Vecchiola, D. Karunamoorthy, R. Buyya, The aneka platform and qos-driven resource provisioning for elastic applications on hybrid clouds, Future Gener. Comput. Syst. 28 (6) (2012) 861–870. http://dx.doi.org/10.1016/j.future.2011.07.005.
[28] Amazon, Amazon EC2 Spot Bid Price Limits, http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/using-spot-limits.html, (accessed 02.12.14).
[29] W. Voorsluys, S.K. Garg, R. Buyya, Provisioning spot market cloud resources to create cost-effective virtual clusters, in: Proceedings of the 11th International Conference on Algorithms and Architectures for Parallel Processing — Volume Part I, ICA3PP'11, Springer-Verlag, Berlin, Heidelberg, 2011, pp. 395–408.
[30] M. Taifi, J.Y. Shi, A. Khreishah, Spotmpi: A framework for auction-based HPC computing using Amazon spot instances, in: Proceedings of the 11th International Conference on Algorithms and Architectures for Parallel Processing — Volume Part II, ICA3PP'11, Springer-Verlag, Berlin, Heidelberg, 2011, pp. 109–120.
[31] MIT, Starcluster elastic load balancer, http://web.mit.edu/stardev/cluster/docs/0.92rc2/manual/load_balancer.html, (accessed 09.12.13).
[32] F. Alvarruiz, C. de Alfonso, M. Caballer, V. Hernández, An energy manager for high performance computer clusters, in: Proceedings of the 2012 IEEE 10th International Symposium on Parallel and Distributed Processing with Applications, ISPA'12, IEEE Computer Society, Washington, DC, USA, 2012, pp. 231–238. http://dx.doi.org/10.1109/ISPA.2012.38.

[4] EC3 at GitHub: https://github.com/grycap/ec3.
[5] EC3 web GUI, available at http://www.grycap.upv.es/ec3.

[33] C. de Alfonso, M. Caballer, F. Alvarruiz, G. Moltó, V. Hernández, Infrastructure deployment over the cloud, in: IEEE Third International Conference on Cloud Computing Technology and Science, CloudCom, 2011, pp. 517–521. http://dx.doi.org/10.1109/CloudCom.2011.77.
[34] J.V. Carrión, G. Moltó, C. De Alfonso, M. Caballer, V. Hernández, A generic catalog and repository service for virtual machine images, in: 2nd International ICST Conference on Cloud Computing, CloudComp 2010, 2010.
[35] A. Works, Ansible software, http://www.ansibleworks.com/ (accessed 04.12.14).
[36] M. Caballer, I. Blanquer, G. Moltó, C. de Alfonso, Dynamic management of virtual infrastructures, J. Grid Comput. 13 (1) (2015) 53–70. http://dx.doi.org/10.1007/s10723-014-9296-5.
[37] M.A. Jette, A.B. Yoo, M. Grondona, Slurm: Simple Linux utility for resource management, in: Lecture Notes in Computer Science: Proceedings of Job Scheduling Strategies for Parallel Processing, JSSPP, 2003, Springer-Verlag, 2002, pp. 44–60.
[38] AdaptiveComputing, Torque resource manager, http://www.adaptivecomputing.com/products/open-source/torque/ (accessed 12.01.15).
[39] J. Duell, The design and implementation of Berkeley Labs Linux checkpoint/restart, Tech. Rep., Lawrence Berkeley National Laboratory, 2002.
[40] OpenVPN, Open Source VPN, http://openvpn.net/ (accessed 11.12.14).
[41] S. Yi, D. Kondo, A. Andrzejak, Reducing costs of spot instances via checkpointing in the amazon elastic compute cloud, in: Proceedings of the 2010 IEEE 3rd International Conference on Cloud Computing, CLOUD'10, IEEE Computer Society, Washington, DC, USA, 2010, pp. 236–243. http://dx.doi.org/10.1109/CLOUD.2010.35.
[42] D. Jung, S. Chin, K. Chung, H. Yu, J. Gil, An efficient checkpointing scheme using price history of spot instances in cloud computing environment, in: E. Altman, W. Shi (Eds.), Network and Parallel Computing, in: Lecture Notes in Computer Science, vol. 6985, Springer, Berlin Heidelberg, 2011, pp. 185–200. http://dx.doi.org/10.1007/978-3-642-24403-2_16.
[43] S. Khatua, N. Mukherjee, A novel checkpointing scheme for Amazon EC2 spot instances, in: 2013 13th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing, CCGrid, 2013, pp. 180–181. http://dx.doi.org/10.1109/CCGrid.2013.71.
[44] A. Pérez-García, F. Gómez-Martínez, A. Alonso, V. Hernández, J.M. Alonso, P. de la Fuente, P. Lozano, Architrave: Advanced analysis of building structures integrated in computer-aided design, in: Construction and Building Research, Springer, Netherlands, 2014, pp. 123–130. http://dx.doi.org/10.1007/978-94-007-7790-3_17.
[45] A. Iosup, H. Li, M. Jan, S. Anoep, C. Dumitrescu, L. Wolters, D. Epema, The grid workloads archive, Future Gener. Comput. Syst. 24 (7) (2008) 672–686. http://dx.doi.org/10.1016/j.future.2008.02.003.
[46] NorduGrid dataset, The Grid Workloads Archive, http://gwa.ewi.tudelft.nl/datasets/gwa-t-3-nordugrid/report/ (accessed 24.09.15).

Amanda Calatrava received the BSc degree in computer science from the Universitat Politècnica de València (UPV) in 2010. In 2011, she joined the Grid and High Performance Computing research group as a graduate under a collaboration fellowship while she worked on her Master's Thesis. She obtained her Master's Degree in February 2012, in which she specialized in grid and cloud computing. In June 2013, she started working in the field of virtual elastic clusters over hybrid infrastructures as the subject of her PhD Thesis.

Eloy Romero Alcalde obtained MSc and PhD degrees in Computer Science from Universitat Politècnica de València in 2008 and 2012, respectively, working on the solution of large eigenvalue problems. Since 2006, he has been in the Grid and High Performance Computing (GryCAP) group as a developer of the SLEPc library, and more recently the CodeCloud project and EC3. His current interests include high performance computing, numerical lineal algebra, and software engineering applied to scientific computing.

Germán Moltó received BSc and PhD degrees in computer science from the Universitat Politècnica de València (UPV), Spain, in 2002 and 2007, respectively. He has been a member of the Grid and High Performance Computing research group (GRyCAP) at the Institute for Molecular Imaging (I3M) since 2002. He is also an associate professor in the Department of Computer Systems and Computation (DSIC) at UPV. He has participated in several European projects and led national research projects in the area of cloud computing. His broad research interests are cloud computing, grid computing, high performance computing, and scientific computing.

Miguel Caballer obtained BSc, MSc, and PhD degrees in Computer Science from the Universitat Politècnica de València (UPV), Spain, in 2000, 2012, and 2014, respectively. He has been a member of the Grid and High Performance Computing research group at the Institute for Molecular Imaging (I3M) since 2001. He has participated in several European and national research projects related to the application of parallel, grid, and cloud computing techniques to various areas of engineering. His other fields of interest include green computing.

J.M. Alonso obtained his MSc degree in Computer Science from the Universidad Politécnica de Valencia (UPV), Spain, in 1997. He has been a member of the Grid and High Performance Computing group at UPV since 1996. He has been an assistant lecturer at the same university since 2000. He is currently working toward the PhD degree in the field of advanced computing in the simulation of building structures. He has also participated in multiple research projects related to the application of HPC, grid, and cloud computing in different areas of engineering.

5.1.1.17. Container-based virtual elastic clusters

C. de Alfonso, A. Calatrava, and G. Moltó, "Container-based virtual elastic clusters," J. Syst. Softw., vol. 127, pp. 1–11, May 2017, doi: https://dx.doi.org/10.1016/j.jss.2017.01.007

Base de datos de indexación	Web of Science (JCR)
Índice de impacto	2.619
Año	2016
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	23 de 104
Tercil	T1
Cuartil	Q1
Número de citas en JCR	23
Número de citas totales	43

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional CLUVIEM (TIN2013-44390-R), liderado por el candidato y supone la aplicación de las técnicas de despliegue de clusters virtuales al ámbito de los contenedores. Se trata de un resultado de las tesis doctorales de Amanda Calatrava (titulada "High Performance Scientific Computing over Hybrid Cloud Platforms") y de Carlos de Alfonso (titulada "Efficient and elastic management of computing infrastructures"), ambas dirigidas por el candidato, que combina la experiencia en despliegue de clusters virtuales de la primera y la experiencia en elasticidad en infraestructuras virtuales del segundo. La herramienta fue liberada como código abierto (Apache 2.0) en GitHub: https://github.com/grycap/ec4docker y fue el origen de la herramienta ONEDock, también liberada como código abierto en GitHub: https://github.com/indigo-dc/onedock y que fue utilizada durante el proyecto INDIGO-DataCloud (653549) para soportar la ejecución de contenedores dentro de OpenNebula. Esto dio lugar a una contribución al ecosistema de OpenNebula descrita en: https://opennebula.io/opennebula-docker-driver-and-datastore/

The Journal of Systems and Software 127 (2017) 1–11

Contents lists available at ScienceDirect

The Journal of Systems and Software

journal homepage: www.elsevier.com/locate/jss

Container-based virtual elastic clusters

Carlos de Alfonso*, Amanda Calatrava, Germán Moltó

Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC - Universidad Politécnica de Valencia - CIEMAT, Camino de Vera s/n, 46022, Valencia, Spain

ARTICLE INFO

Article history:
Received 6 July 2016
Revised 12 December 2016
Accepted 18 January 2017
Available online 19 January 2017

Keywords:
Computing
Containers
Cluster computing
Elasticity

ABSTRACT

eScience demands large-scale computing clusters to support the efficient execution of resource-intensive scientific applications. Virtual Machines (VMs) have introduced the ability to provide customizable execution environments, at the expense of performance loss for applications. However, in recent years, containers have emerged as a light-weight virtualization technology compared to VMs. Indeed, the usage of containers for virtual clusters allows better performance for the applications and fast deployment of additional working nodes, for enhanced elasticity. This paper focuses on the deployment, configuration and management of Virtual Elastic computer Clusters (VEC) dedicated to process scientific workloads. The nodes of the scientific cluster are hosted in containers running on bare-metal machines. The open-source tool Elastic Cluster for Docker (EC4Docker) is introduced, integrated with Docker Swarm to create auto-scaled virtual computer clusters of containers across distributed deployments. We also discuss the benefits and limitations of this solution and analyse the performance of the developed tools under a real scenario by means of a scientific use case that demonstrates the feasibility of the proposed approach.

1. Introduction

eScience involves the execution of complex HTC (High Throughput Computing), HPC (High Performance Computing) applications and long-running workflows. This requires a significant amount of computing power and memory capacity that can be only obtained via distributed computing. Indeed, large-scale Distributed Computing Infrastructures (DCIs), such as the European Grid Infrastructure (EGI)[1] have been tremendously successful in supporting the computational requirements of many scientific communities across Europe (Vella et al., 2011; Camarasu-Pop et al., 2013). However, one of the main limitations of Grid infrastructures is that applications have to be ported to the execution environments provided by the machines involved, what results in a rigid structure composed by several Virtual Organizations (VOs) that support a set of applications. This inability to provide customized execution environments for applications is addressed by Cloud Computing by means of Virtual Machines (VMs) that encapsulate the Operating System (OS) together with the user application and its dependences in a Virtual Machine Image (VMI) that can be run on a physical machine by means of a hypervisor.

Indeed, the ability to provide ubiquitous, on-demand network access to a set of configurable computing resources, according to the NIST definition (Mell and Grance, 2011) of Cloud Computing, has paved the way for the rise of many public Cloud providers (such as Amazon Web Services (AWS),[2] Microsoft Azure[3] or Google Cloud Platform[4]), different Cloud Management Frameworks (such as OpenNebula or OpenStack) and even initiatives to create large-scale community Clouds (e.g. EGI Federated Cloud[5]). Cloud computing has provided researchers with access to unprecedented customizable computing resources, either on-premises or on public Clouds. However, these computing resources still require a coordinated use for applications to efficiently use them. For that, Local Resource Management Systems (LRMS) such as Torque, SLURM (Jette et al., 2002) or HTCondor (Thain et al., 2005) are job schedulers that are commonly used to dispatch jobs across nodes (Ahn et al., 2016). Indeed, computing clusters are still widely-used computing facilities to support the execution of many types of applications.

A scientific computing cluster is a type of parallel or distributed processing system, which consists of a collection of interconnected stand-alone computers working together as a single integrated

* Corresponding author.
E-mail address: caralla@upv.es (C. de Alfonso).

[1] European Grid Infrastructure: http://www.egi.eu.

[2] Amazon Web Services: https://aws.amazon.com.

[3] Microsoft Azure: https://azure.microsoft.com.

[4] Google Cloud Platform: https://cloud.google.com.

[5] EGI Federated Cloud: https://www.egi.eu/federation/egi-federated-cloud/.

http://dx.doi.org/10.1016/j.jss.2017.01.007
0164-1212/

It is important to point out that container-based elastic clusters improve the overall performance compared to VM-based elastic clusters. As demonstrated by the case study, the reduced footprint of the container images with respect to the virtual machine images enhances the ability of the elastic cluster to cushion the workload peaks. Booting the container-based virtual working nodes takes significant less time than the VM-based ones. Therefore, the average waiting time for a job to be running is considerably reduced.

Regarding the performance of the scientific computing clusters, containers executed in one host take profit from the fact that the computational resources are not allocated to a specific container. Instead, the default behaviour for the containers is to share the available resources, managed by the host OS. That means that if one container is executed in an 8-core host, the application running in the container will be able to use the 8 cores and the whole memory if there are no other competing containers. However, a VM deployed with a fixed number of cores and memory, will only be able to use that number of cores and amount of memory even if the rest of the physical host is idle.

5. Conclusions and future work

This paper has analyzed the feasibility of using Docker containers to support the creation of virtual elastic computer clusters for the execution of scientific applications. These clusters maintain the very same interfaces for end users but benefit from the reduced overheads introduced by containers. For this, we introduced the open-source EC4Docker tool to support the deployment of such clusters on a Container Orchestration Platform managed by Docker Swarm.

We have demonstrated the feasibility of adopting containers to execute scientific applications, introducing two main advantages when compared to traditional VMs: (i) the low deploying times for new working nodes, and (ii) potential reductions in the overhead caused by VMs in CPU, memory and storage, offering near-native performance. Moreover, from the discussed case study, we can conclude that container-based virtual clusters are an appropriate solution for the execution of short HTC tasks.

Future work involves the automatization of the generation of the container images that EC4Docker uses to deploy the cluster. Currently, the administrator or the users need to generate their own images including the Dockerfile provided with EC4Docker in order to deploy their own applications in the container cluster environment. A service will be implemented to facilitate this process for non-experienced users. Finally, a thorough scalability testing will be carried out to quantify the benefits of the container technology versus virtual machines for the processing of jobs on scientific computing virtual clusters.

Acknowledgement

This work has been developed under the support of the program “Ayudas para la contratación de personal investigador en formación de carácter predoctoral, programa VALi+d”, grant number ACIF/2013/003, from the Conselleria d’Educació of the Generalitat Valenciana. The authors wish to thank the financial support received form The Spanish Ministry of Economy and Competitiveness to develop the project “CLUVIEM”, with reference TIN2013-44390-R.

References

Adufu, T., Choi, J., Kim, Y., 2015. Is container-based technology a winner for high performance scientific applications? In: Network Operations and Management Symposium (APNOMS), pp. 507–510. doi:10.1109/APNOMS.2015.7275379. 2015 17th Asia-Pacific.

Ahn, S.U., Park, S.O., Kim, J., 2016. Profiling job activities of batch systems in the data center. In: 2016 International Conference on Platform Technology and Service (PlatCon). IEEE, pp. 1–5. doi:10.1109/PlatCon.2016.7456818.

Alvarruiz, F., de Alfonso, C., Caballer, M., Hernández, V., 2012. An energy manager for high performance computer clusters. In: Proceedings of the 2012 IEEE 10th International Symposium on Parallel and Distributed Processing with Applications, ISPA ’12. IEEE Computer Society, Washington, DC, USA, pp. 231–238. doi:10.1109/ISPA.2012.38.

Bernstein, D., 2014. Containers and cloud: From lxc to docker to kubernetes. Cloud Comput. IEEE 1 (3), 81–84. doi:10.1109/MCC.2014.51.

Buyya, R., 1999. High Performance Cluster Computing: Architectures and Systems. Prentice Hall PTR, Upper Saddle River, NJ, USA.

Caballer, M., de Alfonso, C., Alvarruiz, F., Moltó, G., 2013. EC3: elastic cloud computing cluster. J. Comput. Syst. Sci. 79, 1341–1351. doi:10.1016/j.jcss.2013.06.005. URL http://authors.elsevier.com/sd/article/S0022000013001141.

Calatrava, A., Romero, E., Moltó, G., Caballer, M., Alonso, J.M., 2016. Self-managed cost-efficient virtual elastic clusters on hybrid cloud infrastructures. Future Gener. Comput. Syst. 61, 13–25. doi:10.1016/j.future.2016.01.018. URL http://authors.elsevier.com/sd/article/S0167739X16300024 http://linkinghub.elsevier.com/retrieve/pii/S0167739X16300024.

Camarasu-Pop, S., Glatard, T., Benoit-Cattin, H., 2013. Simulating application workflows and services deployed on the European grid infrastructure. In: 2013 13th IEEE/ACM International Symposium on Cluster, Cloud, and Grid Computing. IEEE, pp. 18–25. doi:10.1109/CCGrid.2013.13. URL http://ieeexplore.ieee.org/document/6546054/.

Canonical, LXD, 2016. URL https://linuxcontainers.org/lxd/introduction/.

Chronos. https://mesos.github.io/chronos/, [Online; accessed 19-January-2016].

CoreOS, rkt, 2016. URL https://coreos.com/rkt/.

Docker. https://www.docker.com/, [Online; accessed 18-January-2016].

Duato, J., Pena, A.J., Silla, F., Mayo, R., Quintana-Orti, E.S., 2010. rCUDA: reducing the number of GPU-based accelerators in high performance clusters. In: 2010 International Conference on High Performance Computing & Simulation. IEEE, pp. 224–231. doi:10.1109/HPCS.2010.5547126.

U. of zurich, elasticluster. http://gc3-uzh-ch.github.io/elasticluster/, [Online; accessed 21-January-2016].

Felter, W., Ferreira, A., Rajamony, R., Rubio, J., 2015. An updated performance comparison of virtual machines and linux containers. In: Performance Analysis of Systems and Software (ISPASS), pp. 171–172. 2015 IEEE International Symposium on doi: 10.1109/ISPASS.2015.7095802.

Gerlach, W., Tang, W., Keegan, K., Harrison, T., Wilke, A., Bischof, J., D’Souza, M., Devoid, S., Murphy-Olson, D., Desai, N., Meyer, F., 2014. Skyport: container-based execution environment management for multi-cloud scientific workflows. In: Proceedings of the 5th International Workshop on Data-Intensive Computing in the Clouds, DataCloud ’14. IEEE Press, Piscataway, NJ, USA, pp. 25–32. doi:10.1109/DataCloud.2014.6.

Goecks, J., Nekrutenko, A., Taylor, J., Team, T.G., 2010. Galaxy: a comprehensive approach for supporting accessible, reproducible, and transparent computational research in the life sciences.. Genome Biol. 11 (8), R86.

Higgins, J., Holmes, V., Venters, C., 2015. Orchestrating docker containers in the HPC environment. In: High Performance Computing: 30th International Conference, ISC High Performance 2015, Frankfurt, Germany, July 12-16, 2015, Proceedings. Springer International Publishing, Cham, pp. 506–513. doi:10.1007/978-3-319-20119-1_36.

Hindman, B., Konwinski, A., Zaharia, M., Ghodsi, A., Joseph, A.D., Katz, R., Shenker, S., Stoica, I., 2011. Mesos: a platform for fine-grained resource sharing in the data center. In: Proceedings of the 8th USENIX Conference on Networked Systems Design and Implementation. NSDI’11, USENIX Association, Berkeley, CA, USA, pp. 295–308. URL http://dl.acm.org/citation.cfm?id=1972457.1972488.

Jette, M.A., Yoo, A.B., Grondona, M., 2002. Slurm: simple linux utility for resource management. In: Lecture Notes in Computer Science: Proceedings of Job Scheduling Strategies for Parallel Processing (JSSPP) 2003. Springer-Verlag, pp. 44–60.

Kubernetes. http://kubernetes.io/, [Online; accessed 7-March-2016].

Linux containers, lxc. https://linuxcontainers.org/, [Online; accessed 18-January-2016].

Luzzardi, A., Vieux, V.,. Swarm: a docker-native clustering system. https://docs.docker.com/swarm/, [Online; accessed 7-March-2016].

Marathon https://mesosphere.github.io/marathon/, [Online; accessed 19-January-2016].

Melia, I., Puri, S., Owens, K., Thirumalai, K., Yellumahanti, S., Herrmann, L., Coggin, M., Fernandes, J., Craven, K., Juengst, D., September 2014. Linux containers: Why They’re in Your Future and What has to Happen First. Tech. rep. CISCO and Redhat.

Mell, P., Grance, T., 2011. The NIST Definition of Cloud Computing. NIST Special Publication 800-145 (Final). Tech. rep.. URL http://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf.

Mrbayes: Bayesian inference of phylogeny. http://mrbayes.sourceforge.net/index.php, [Online; accessed 22-April-2016].

Openstack, openstack floating ips. http://docs.openstack.org/openstack-ops/content/floating_ips.html, [Online; accessed 21-May-2016].

Openvz. http://openvz.org/Main_Page, [Online; accessed 14-January-2016].

Pahl, C., Lee, B., 2015. Containers and clusters for edge cloud architectures – a technology review. In: Future Internet of Things and Cloud (FiCloud) 2015, 3rd International Conference on, pp. 379–386. doi:10.1109/FiCloud.2015.35.

Park, J.-W., Hahm, J., 2015. Container-based cluster management platform for distributed computing. In: Proceedings of the International Conference

on Parallel and Distributed Processing Techniques and Applications, pp. 34–40.

Peinl, R., Holzschuher, F., Pfitzer, F., 2016. Docker cluster management for the cloud - survey results and own solution. J. Grid Comput. 1–18. doi:10.1007/s10723-016-9366-y.

Petazzoni, J., Linux containers(lxc), docker, and security. http://www.slideshare.net/jpetazzo/linux-containers-lxc-docker-and-security/4-Fear_Uncertainty_and_DoubtLXC_is, [Online; accessed 18-January-2016].

Prabhu, C., 2008. GRID an Cluster Computing. PHI Learning. URL https://books.google.es/books?id=evcgB7Qlix4C.

Regola, N., Ducom, J.C., 2010. Recommendations for virtualization technologies in high performance computing. In: Cloud Computing Technology and Science (CloudCom), 2010 IEEE Second International Conference on, pp. 409–416. doi:10.1109/CloudCom.2010.71.

Scheepers, M., 2014. Virtualization and Containerization of Application Infrastructure: A Comparison, 21. University of Twente. URL http://referaat.cs.utwente.nl/conference/21/paper/7449/virtualization-and-containerization-of-application-infrastructure-a-comparison.pdf.

Slominski, A., Muthusamy, V., Khalaf, R., 2015. Building a multi-tenant cloud service from legacy code with docker containers. In: IC2E. IEEE, pp. 394–396.

Software, M., Cynmix dataset. http://mrbayes.sourceforge.net/wiki/index.php/Cynmix.nex, [Online; accessed 05-Jun-2016].

Soltesz, S., Pötzl, H., Fiuczynski, M.E., Bavier, A., Peterson, L., 2007. Container-based operating system virtualization: a scalable, high-performance alternative to hypervisors. SIGOPS Oper. Syst. Rev. 41 (3), 275–287. doi:10.1145/1272998.1273025.

MIT, starcluster. http://web.mit.edu/stardev/cluster/, [Online; accessed 1-December-2014].

Thain, D., Tannenbaum, T., Livny, M., 2005. Distributed computing in practice: the condor experience.. Concurrency - Pract. Experience 17 (2–4), 323–356.

Adaptivecomputing, torque resource manager. http://www.adaptivecomputing.com/products/open-source/torque/, [Online; accessed 12-January-2015].

Vella, F., Cefal, R.M., Costantini, A., Gervasi, O., Tanci, C., 2011. GPU computing in EGI environment using a cloud approach. In: 2011 International Conference on Computational Science and Its Applications. IEEE, pp. 150–155. doi:10.1109/ICCSA.2011.61. URL http://ieeexplore.ieee.org/document/5959549/.

Xavier, M.G., Neves, M.V., de Rose, C.A.F., 2014. A performance comparison of container-based virtualization systems for mapreduce clusters. In: Parallel, Distributed and Network-Based Processing (PDP), pp. 299–306. doi:10.1109/PDP.2014.78. 2014 22nd Euromicro International Conference on.

Xavier, M.G., Neves, M.V., Rossi, F.D., Ferreto, T.C., Lange, T., De Rose, C.A.F., 2013. Performance evaluation of container-based virtualization for high performance computing environments. In: Proceedings of the 2013 21st Euromicro International Conference on Parallel, Distributed, and Network-Based Processing, PDP '13. IEEE Computer Society, Washington, DC, USA, pp. 233–240. doi:10.1109/PDP.2013.41.

Zheng, C., Thain, D., 2015. Integrating containers into workflows: a case study using makeflow, work queue, and docker. In: Proceedings of the 8th International Workshop on Virtualization Technologies in Distributed Computing, VTDC '15. ACM, New York, NY, USA, pp. 31–38. doi:10.1145/2755979.2755984.

Carlos de Alfonso obtained the B.Sc., M.Sc. and Ph.D. degrees in Computer Science from the Universitat Politècnica de València (UPV), Spain, in 2000 and 2015. In 2000 he joined the Grid and High Performance Computing research group, at UPV. Since 2007 he is a Technician for the Support of Research at UPV, with a profile of Grid and Cloud computing. He has been part of several national, European and international projects and contracts in the fields of Grid. During the last years he has oriented his activity mainly to Cloud Computing and Green Computing.

Amanda Calatrava received the B.Sc. and Ph.D. degrees in computer science from the Universitat Politècnica de València (UPV) in 2010 and 2016. In 2011, she joined the Grid and High Performance Computing research group as a graduate under a collaboration fellowship while she worked on her Master's Thesis. She obtained her Master's Degree in February 2012, in which she specialized in grid and cloud computing. In November 2016, she obtained the Ph.D degree whose work was centred in the field of virtual elastic clusters over hybrid infrastructures. Currently, her research interests are focused in Virtualization, Cloud Computing and Scientific Computing.

Germán Moltó received the B.Sc. and Ph.D. degrees in computer science from the Universitat Politècnica de València (UPV) in 2002 and 2007. He is a member of the Grid and High Performance Computing research group (GRyCAP) at the Institute for Molecular Imaging (I3M) since 2002. He is also associate professor at the Department of Computer Systems and Computation (DSIC) at UPV. His research interests broadly lie in Cloud Computing, Grid Computing, High Performance Computing and Scientific Computing.

5.1.1.18. Orchestrating Complex Application Architectures in Heterogeneous Clouds

M. Caballer, S. Zala, Á. López García, G. Moltó, P. Orviz Fernández, and M. Velten, "Orchestrating Complex Application Architectures in Heterogeneous Clouds," J. Grid Comput., vol. 16, no. 1, pp. 3–18, Mar. 2018, doi: https://dx.doi.org/10.1007/s10723-017-9418-y

Base de datos de indexación	Web of Science (JCR)
Índice de impacto	2.8
Año	2018
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	17 de 103
Tercil	T1
Cuartil	Q1
Número de citas en JCR	15
Número de citas totales	23

Comentario. Esta contribución es uno de los resultados del proyecto Europeo H2020 INDIGO-DataCloud (Grant Agreement 653549), donde el candidato fue líder de la tarea T5.1 para el diseño y creación de una arquitectura PaaS (Plataforma como Servicio) para dar soporte a diferentes casos de uso científicos. Durante este proyecto se produjo la adaptación de la herramienta Infrastructure Manager (IM) para soportar el estándar TOSCA (Topology and Orchestration Specification for Cloud Applications). Esto precisó realizar contribuciones al proyecto tosca-parser de OpenStack y para la distribución "Newton" de OpenStack. De hecho, la UPV fue el tercer contribuyente más activo, por detrás de IBM y Nokia (ver: https://www.stackalytics.com/?module=tosca-parser&release=newton). A raíz de esta actividad, se creó un vínculo con el investigador de IBM Sahdev Zala en USA, involucrado en el proyecto tosca-parser. También en colaboración con Mathieu Velten, investigador del centro de reconocido prestigio CERN (Conseil Européen pour la Recherche Nucléaire), se produjo esta contribución para demostrar la posibilidad de usar TOSCA como mecanismo para el despliegue de clusters en múltiples Clouds usando la herramienta Infrastructure Manager (IM).

J Grid Computing
https://doi.org/10.1007/s10723-017-9418-y

Orchestrating Complex Application Architectures in Heterogeneous Clouds

Miguel Caballer · Sahdev Zala · Álvaro López García · Germán Moltó · Pablo Orviz Fernández · Mathieu Velten

Received: 12 April 2017 / Accepted: 24 October 2017

Abstract Private cloud infrastructures are now widely deployed and adopted across technology industries and research institutions. Although cloud computing has emerged as a reality, it is now known that a single cloud provider cannot fully satisfy complex user requirements. This has resulted in a growing interest in developing hybrid cloud solutions that bind together distinct and heterogeneous cloud infrastructures. In this paper we describe the orchestration approach for heterogeneous clouds that has been implemented and used within the INDIGO-DataCloud project. This orchestration model uses existing open-source software like OpenStack and leverages the OASIS Topology and Specification for Cloud Applications (TOSCA) open standard as the modeling language. Our approach uses virtual machines and Docker containers in an homogeneous and transparent way providing consistent application deployment for the users. This approach is illustrated by means of two different use cases in different scientific communities, implemented using the INDIGO-DataCloud solutions.

Keywords Cloud-computing · Heterogeneous-cloud · Multi-cloud · Open-source · TOSCA

Álvaro López García (✉) · Pablo Orviz Fernández
Instituto de Física de Cantabria, Centro Mixto CSIC - UC, Santander, Spain
e-mail: aloga@ifca.unican.es

Miguel Caballer · Germán Moltó
Instituto de Instrumentación para Imagen Molecular (I3M), Centro Mixto CSIC, Universitat Politècnica de València, Valencia, Spain

Sahdev Zala
IBM Raleigh, Raleigh, NC 27609, USA

Mathieu Velten
European Organization for Nuclear Research (CERN), Geneva, Switzerland

1 Introduction

The scientific exploitation of cloud resources is nowadays a reality. Large collaborations, small groups and individual scientists have incorporated the usage of cloud infrastructures as an additional way of obtaining computing resources for their research. However, in spite of this large adoption, cloud computing still presents several functionality gaps that make difficult to deliver its full potential, specially for scientific usage [74, 75]. One of the most prominent challenges is the lack of elasticity and transparent interoperability and portability across different cloud technologies and infrastructures [21, 47, 70]. It is absolutely needed to provide users with seamless dynamic elasticity over a large pool of computing resources across multiple cloud providers.

Commercial providers can create this illusion of infinite resources (limited by the amount of money that users can afford to pay), but this is not true in

Published online: 09 November 2017

6 Conclusions and Future Work

This paper has described the challenges of orchestrating computing resources in heterogeneous clouds and the approach carried out in the INDIGO-DataCloud project to overcome them, with discussion of real life use cases from scientific communities.

The TOSCA open standard has been adopted for the description of the application layouts. Different examples have been shown ranging from a simple single-node application to an elastic Apache Mesos cluster. For this, an orchestration approach based on prioritizing cloud sites with existing pre-configured Docker images is employed, while being able to dynamically deploy the applications on cloud sites supporting only vanilla VMs or Docker images. By adopting a configuration management solution based on Ansible roles to carry out both the deployment of the application and the creation of the pre-configured Docker images, a single consistent unified approach for application delivery is employed.

By using TOSCA to model the user's complex application architectures it is possible to obtain repeatable and deterministic deployments. User's can port their virtual infrastructures between providers transparenty obtaining the same expected topology.

The time required to deploy a virtual infrastructure is strictly dominated by the time required to provision the underlying computational resources and the time to configure them. Therefore, provisioning from a Cloud site that already supports the pre-configured Docker images requested by the user is considerably much faster than having to boot up the Virtual Machines from another Cloud site and perform the whole application installation and its dependencies. The overhead introduced by the PaaS layer is negligible compared to the time to deploy an infrastructure, since it just requires a reduced subset of invocations among the different microservices.

As it can be seen from the use cases described in Section 5, several non-normative TOSCA node types were introduced in the context of INDIGO-DataCloud project to support both different user applications and specific services to be used within the deployed applications. Indeed, the extensibility of the TOSCA language and the ability of the underlying TOSCA parser to process these new elements facilitates the procedure of adopting TOSCA as the definition language to perform the orchestration of complex infrastructures across multiple Clouds.

It is important to point out that a key contribution of the INDIGO-DataCloud Orchestration system, with respect to other orchestration platforms, is the implementation of hybrid orchestration to satisfy demands of dynamic or highly changeable workloads, such as the virtual elastic cluster use case presented.

The approach described here is being used by several user communities that have been engaged within the project [1, 11, 14, 19, 20, 41, 53, 68, 72]. The developed solutions have also resulted in community and upstream code contributions to major open source solutions like OpenStack and OpenNebula.

Future work includes supporting different complex application architectures used by scientific communities. For example, this work will include architectures for Big Data processing in order to automatically provision virtual computing clusters to process large volumes of data using existing frameworks such as Hadoop and Spark). Regarding the tools that have been described, the OpenStack Heat Translator is expected to evolve into a service that could be deployed along with the OpenStack Orchestration (Heat) service, enabling the direct submission of TOSCA documents to the endpoint that this service will provide.

Acknowledgements The authors want to acknowledge the support of the INDIGO-Datacloud (grant number 653549) project, funded by the European Commission's Horizon 2020 Framework Program.

References

1. Aguilar Gómez, F., de Lucas, J.M., García, D., Monteoliva, A.: Hydrodynamics and water quality forecasting over a cloud computing environment: indigo-datacloud. In: EGU General Assembly Conference Abstracts, vol. 19, p. 9684 (2017)
2. de Alfonso, C., Caballer, M., Alvarruiz, F., Hernández, V.: An energy management system for cluster infrastructures. Comput. Electr. Eng. **39**(8), 2579–2590 (2013). http://www.sciencedirect.com/science/article/pii/S0045790613001365
3. Amazon Web Services (AWS): Amazon Web Services (AWS). https://aws.amazon.com/ (2017)
4. Amazon Web Services (AWS): CloudFormation. https://aws.amazon.com/cloudformation/ (2017)
5. Apache Software Foundation: Apache Mesos. http://mesos.apache.org/ (2017)

6. ARIA, ARIA. http://ariatosca.incubator.apache.org/ (2017)
7. Bumpus, W.: NIST Cloud Computing Standards Roadmap. Tech. rep., National Institute of Standards and Technology (NIST). https://doi.org/10.6028/NIST.SP.500-291r2 (2013)
8. Caballer, M., Blanquer, I., Moltó, G., de Alfonso, C.: Dynamic management of virtual infrastructures. J Grid Comput. **13**(1), 53–70 (2015). https://doi.org/10.1007/s10723-014-9296-5
9. Campos Plasencia, I., Fernández-del Castillo, E., Heinemeyer, S., López García, Á., Pahlen, F., Borges, G.: Phenomenology tools on cloud infrastructures using OpenStack. Eur. Phys. J. C **73**(4), 2375 (2013). https://doi.org/10.1140/epjc/s10052-013-2375-0
10. Celar: Celar. http://www.cloudwatchhub.eu/celar (2017)
11. Chen, Y., de Lucas, J.M., Aguilar, F., Fiore, S., Rossi, M., Ferrari, T.: Indigo: building a datacloud framework to support open science. In: EGU General Assembly Conference Abstracts, vol. 18, p. 16610 (2016)
12. Chronos: Chronos. https://mesos.github.io/chronos/ (2017)
13. Cloudify: Cloudify. http://getcloudify.org (2017)
14. Davidović, D., Cetinić, E., Skala, K.: European research area and digital humanities
15. Distefano, S., Serazzi, G.: Performance driven WS orchestration and deployment in service oriented infrastructure. J Grid Comput. **12**(2), 347–369 (2014). https://doi.org/10.1007/s10723-014-9293-8
16. EGI FedCloud: EGI FedCloud. https://www.egi.eu/federation/egi-federated-cloud/ (2017)
17. Eucalyptus: Eucalyptus. https://www.eucalyptus.com/ (2017)
18. Fiore, S., D'Anca, A., Palazzo, C., Foster, I., Williams, D.N., Aloisio, G.: Ophidia: toward big data analytics for eScience. Procedia Comput. Sci. **18**, 2376–2385 (2013). https://doi.org/10.1016/j.procs.2013.05.409
19. Fiore, S., Palazzo, C., D'Anca, A., Elia, D., Londero, E., Knapic, C., Monna, S., Marcucci, N.M., Aguilar, F., Płóciennik, M., et al.: Big data analytics on large-scale scientific datasets in the indigo-datacloud project. In: Proceedings of the Computing Frontiers Conference, pp. 343–348. ACM (2017)
20. Fiore, S., Płóciennik, M., Doutriaux, C., Palazzo, C., Boutte, J., Żok, T., Elia, D., Owsiak, M., D'Anca, A., Shaheen, Z., et al.: Distributed and cloud-based multi-model analytics experiments on large volumes of climate change data in the earth system grid federation eco-system. In: 2016 IEEE International Conference on Big Data (Big Data), pp. 2911–2918. IEEE (2016)
21. Galante, G., Erpen de Bona, L.C., Mury, A.R., Schulze, B., da Rosa Righi, R.: An analysis of public clouds elasticity in the execution of scientific applications: a survey. J Grid Comput.,1–24. https://doi.org/10.1007/s10723-016-9361-3 (2016)
22. Google Cloud Platform (GCP): Google Cloud Platform (GCP). https://cloud.google.com/ (2017)
23. Hochstein, L. (ed.): Ansible: Up and Running, Automating Configuration Management and Deployment the Easy Way. O'Reilly Media (2014)
24. Idabc: European Interoperability Framework for pan-European eGovernment Services. European Commission version 1, 1–25. https://doi.org/10.1109/HICSS.2007.68 (2004)
25. IM: IM. http://www.grycap.upv.es/im (2017)
26. INDIGO-DataCloud: D1.8 - General Architecture. Tech. rep., INDIGO-DataCloud Consortium (2015)
27. INDIGO-DataCloud: Ansible Galaxy repository for INDIGO-DataCloud. https://galaxy.ansible.com/indigo-dc/ (2017)
28. INDIGO-DataCloud: Disvis/Powerfit Ansible Role in Ansible Galaxy. https://galaxy.ansible.com/indigo-dc/disvis-powerfit/ (2017)
29. INDIGO-DataCloud: INDIGO-DataCloud. https://www.indigo-datacloud.eu/ (2017)
30. INDIGO-DataCloud: INDIGO-DataCloud DockerHub application repository. https://hub.docker.com/u/indigodatacloudapps/ (2017)
31. INDIGO-DataCloud: INDIGO-DataCloud PaaS Orchestrator. https://github.com/indigo-dc/orchestrator (2017)
32. INDIGO-DataCloud: INDIGO-DataCloud RepoSync. https://github.com/indigo-dc/java-reposync (2017)
33. INDIGO-DataCloud: INDIGO-DataCloud TOSCA templates. https://github.com/indigo-dc/tosca-templates (2017)
34. INDIGO-DataCloud: TOSCA Across Clouds. https://github.com/indigo-dc/tosca-types/blob/master/examples/web_mysql_tosca_across_clouds.yaml (2017)
35. INDIGO-DataCloud: TOSCA template for deploying an Elastic Mesos Cluster. http://github.com/indigo-dc/tosca-types/blob/master/examples/mesos_elastic_cluster.yaml (2017)
36. INDIGO-DataCloud: TOSCA template for Powerfit application. https://github.com/indigo-dc/tosca-types/blob/master/examples/powerfit.yaml (2017)
37. Kacsuk, P., Kecskemeti, G., Kertesz, A., Nemeth, Z., Kovács, J., Farkas, Z.: Infrastructure aware scientific workflows and infrastructure aware workflow managers in science gateways. J Grid Comput., 641–654. https://doi.org/10.1007/s10723-016-9380-0 (2016)
38. Korambath, P., Wang, J., Kumar, A., Hochstein, L., Schott, B., Graybill, R., Baldea, M., Davis, J.: Deploying kepler workflows as services on a cloud infrastructure for smart manufacturing. Procedia Comput. Sci. **29**, 2254–2259 (2014)
39. Koski, K., Hormia-Poutanen, K., Chatzopoulos, M., Legrė, Y., Day, B.: Position Paper: European Open Science Cloud for Research. Tech. Rep. october, EUDAT, LIBER, OpenAIRE, EGI, GĖANT Bari (2015)
40. Krieger, M.T., Torreno, O., Trelles, O., Kranzlmüller, D.: Building an open source cloud environment with autoscaling resources for executing bioinformatics and biomedical workflows. Futur. Gener. Comput. Syst. **67**, 329–340 (2017). https://doi.org/10.1016/j.future.2016.02.008
41. Kurkcuoglu Soner, Z., Bonvin, A.: Science in the clouds: virtualizing haddock powerfit and disvis using indigo-datacloud solutions (2016)
42. Lipton, P.C.T., Moser, S.I., Palma, D.V., Spatzier, T.I.: Topology and Orchestration Specification for Cloud Applications. Tech. rep., OASIS Standard (2013)
43. Liu, C., Mao, Y., Van der Merwe, J., Fernandez, M.: Cloud Resource Orchestration: a Data-Centric Approach. In: Proceedings of the Biennial Conference on Innovative Data Systems Research (CIDR), pp. 1–8. Citeseer (2011)
44. López García, Á., Fernández-del Castillo, E.: Analysis of scientific cloud computing requirements. In: Proceedings of the IBERGRID 2013 Conference, p. 147 158 (2013)

45. López García, Á., Fernández-del Castillo, E., Orviz Fernández, P.: Standards for enabling heterogeneous IaaS cloud federations. Comput. Standard Inter. **47**, 19–23 (2016). https://doi.org/10.1016/j.csi.2016.02.002
46. López García, Á., Zangrando, L., Sgaravatto, M., Llorens, V., Vallero, S., Zaccolo, V., Bagnasco, S., Taneja, S., Pra, S.D., Salomoni, D., Donvito G.: Improved cloud resource allocation: how INDIGO-datacloud is overcoming the current limitations in cloud schedulers. arXiv:1707.06403 (2017)
47. Lorido-Botran, T., Miguel-Alonso, J., Lozano, J.A.: A review of auto-scaling techniques for elastic applications in cloud environments. J Grid Comput. **12**(4), 559–592 (2014). https://doi.org/10.1007/s10723-014-9314-7
48. Marathon: Marathon. https://mesosphere.github.io/marathon/ (2017)
49. Metsch, T., Edmonds, A.: Open Cloud Computing Interface-Infrastructure. Tech. rep., Open Grid Forum (2010)
50. Metsch, T., Edmonds, A.: Open Cloud Computing Interface-RESTful HTTP Rendering. Tech. rep., Open Grid Forum (2011)
51. Microsoft Azure: Microsoft Azure. https://azure.microsoft.com/ (2017)
52. Moltó, G., Caballer, M., Pérez, A., Alfonso, D.C., Blanquer, I.: Coherent application delivery on hybrid distributed computing infrastructures of virtual machines and docker containers. In: 2017 25Th Euromicro International Conference on Parallel, Distributed and Network-Based Processing (PDP), pp. 486–490 (2017). https://doi.org/10.1109/PDP.2017.29
53. Monna, S., Marcucci, N.M., Marinaro, G., Fiore, S., D'Anca, A., Antonacci, M., Beranzoli, L., Favali, P.: An Emso data case study within the indigo-Dc project. In: EGU General Assembly Conference Abstracts, vol. 19, p. 12493 (2017)
54. Nyrén, R., Metsch, T., Edmonds, A., Papaspyrou, A.: Open Cloud Computing Interface–Core. Tech. rep., Open Grid Forum (2010)
55. OASIS: Organization for the Advancement of Structured Information Standards (OASIS). https://www.oasis-open.org (2015)
56. Open Telekom Cloud (OTC): Open Telekom Cloud (OTC). https://cloud.telekom.de/en/ (2017)
57. OpenNebula: OneFlow. http://docs.opennebula.org/5.2/advanced_components/application_flow_and_auto-scaling/index.html (2017)
58. OpenNebula Project: OpenNebula. https://www.opennebula.org (2017)
59. OpenStack Foundation: Heat Orchestration Template (HOT) Guide. https://docs.openstack.org/heat/latest/template_guide/hot_guide.html (2017)
60. OpenStack Foundation: OpenStack. https://www.openstack.org (2017)
61. OpenStack Foundation: Openstack Heat. http://wiki.openstack.org/wiki/Heat (2017)
62. OpenStack Foundation: OpenStack Heat Translator. https://github.com/openstack/heat-translator (2017)
63. OpenStack Foundation: OpenStack heat-translator project contribution statistics. http://stackalytics.com/?release=all&metric=commits&module=heat-translator (2017)
64. OpenStack Foundation: OpenStack Tacker. https://wiki.openstack.org/wiki/Tacker (2017)
65. OpenStack Foundation: OpenStack tosca-parser project contribution statistics. http://stackalytics.com/?release=all&metric=commits&module=tosca-parser (2017)
66. OpenStack Foundation: TOSCA Parser. https://github.com/openstack/tosca-parser (2017)
67. OpenTOSCA: OpenTOSCA. http://www.opentosca.org/ (2017)
68. Owsiak, M., Plociennik, M., Palak, B., Zok, T., Reux, C., Di Gallo, L., Kalupin, D., Johnson, T., Schneider, M.: Running simultaneous kepler sessions for the parallelization of parametric scans and optimization studies applied to complex workflows. J Comput. Sci. **20**, 103–111 (2017)
69. Palma, D., Rutkowski, M., Spatzier T.: TOSCA Simple Profile in YAML Version 1.1. Tech. rep., OASIS Standard. http://docs.oasis-open.org/tosca/TOSCA-Simple-Profile-YAML/v1.1/TOSCA-Simple-Profile-YAML-v1.1.html (2016)
70. Petcu, D.: Consuming resources and services from multiple clouds: from terminology to cloudware support. J Grid Comput. **12**(2), 321–345 (2014). https://doi.org/10.1007/s10723-013-9290-3
71. Plóciennik, M., Fiore, S., Donvito, G., Owsiak, M., Fargetta, M., Barbera, R., Bruno, R., Giorgio, E., Williams, D.N., Aloisio, G.: Two-level dynamic workflow orchestration in the INDIGO DataCloud for large-scale, climate change data analytics experiments. Procedia Comput. Sci. **80**, 722–733 (2016). https://doi.org/10.1016/j.procs.2016.05.359
72. Płóciennik, M., Fiore, S., Donvito, G., Owsiak, M., Fargetta, M., Barbera, R., Bruno, R., Giorgio, E., Williams, D.N., Aloisio, G.: Two-level dynamic workflow orchestration in the indigo datacloud for large-scale, climate change data analytics experiments. Procedia Comput. Sci. **80**, 722–733 (2016)
73. Python: Python Package Index (PyPI). https://pypi.python.org/pypi (2017)
74. Ramakrishnan, L., Jackson, K.R., Canon, S., Cholia, S., Shalf, J.: Defining future platform requirements for e-Science clouds. In: Proceedings of the 1st ACM Symposium on Cloud Computing - SoCC '10, p. 101 (2010). https://doi.org/10.1145/1807128.1807145
75. Ramakrishnan, L., Zbiegel, P.T.T.T.: Magellan: experiences from a science cloud. In: Proceedings of the 2Nd International Workshop on Scientific Cloud Computing, pp. 49–58 (2011). http://dl.acm.org/citation.cfm?id=1996119
76. Salomoni, D., Campos, I., Gaido, L., Donvito, G., Antonacci, M., Fuhrman, P., Marco, J., Lopez-Garcia, A., Orviz, P., Blanquer, I., et al.: Indigo-datacloud: foundations and architectural description of a platform as a service oriented to scientific computing. arXiv:1603.09536 (2016)
77. Sánchez-Expósito, S., Martín, P., Ruiz, J.E., Verdes-Montenegro, L., Garrido, J., Sirvent, R., Falcó, A.R., Badia, R.M., Lezzi, D.: Web services as building blocks for science gateways in astrophysics. J Grid Comput. **14**(4), 673–685 (2016). https://doi.org/10.1007/s10723-016-9382-y

78. SlipStream: SlipStream. http://sixsq.com/products/slipstream/ (2017)
79. Stockton, D.B., Santamaria, F.: Automating NEURON simulation deployment in cloud resources. Neuroinformatics **15**(1), 51–70 (2017). https://doi.org/10.1007/s12021-016-9315-8
80. Teckelmann, R., Reich, C., Sulistio, A.: Mapping of Cloud Standards to the Taxonomy of Interoperability in Iaas. In: 2011 IEEE Third International Conference on Cloud Computing Technology and Science (Cloudcom), pp. 522–526. IEEE (2011)
81. Toor, S., Osmani, L., Eerola, P., Kraemer, O., Lindén, T., Tarkoma, S., White, J.: A scalable infrastructure for CMS data analysis based on OpenStack Cloud and Gluster file system. J Phys.: Conf. Ser. **513**(6), 062,047 (2014). https://doi.org/10.1088/1742-6596/513/6/062047. http://stacks.iop.org/1742-6596/513/i=6/a=062047?key=crossref.84033a04265ce343371c7f38064e7143
82. UK Government Cabinet Office: Open Standards Principles. https://www.gov.uk/government/publications/open-standards-principles (2015)
83. Yangui, S., Marshall, I.J., Laisne, J.P., Tata, S.: Compatibleone: the open source cloud broker. J Grid Comput. **12**(1), 93–109 (2014)
84. Zhao, Y., Li, Y., Raicu, I., Lu, S., Tian, W., Liu, H.: Enabling scalable scientific workflow management in the cloud. Futur. Gener. Comput. Syst. **46**, 3–16 (2015). https://doi.org/10.1016/j.future.2014.10.023
85. van Zundert, G., Trellet, M., Schaarschmidt, J., Kurkcuoglu, Z., David, M., Verlato, M., Rosato, A., Bonvin, A.: The DisVis and PowerFit web servers: explorative and integrative modeling of biomolecular complexes. J. Mol. Biol. **429**(3), 399–407 (2013). http://www.sciencedirect.com/science/article/pii/S0022283616305277

5.1.1.19. Virtualized Computational Environments on the cloud to foster group skills through PBL: A case study in architecture

J. D. Segrelles, A. Martinez, N. Castilla, and G. Moltó, "Virtualized Computational Environments on the cloud to foster group skills through PBL: A case study in architecture," Comput. Educ., vol. 108, pp. 131–144, May 2017, doi: https://dx.doi.org/10.1016/j.compedu.2017.02.001

Base de datos de indexación	Web of Science (JCR)
Índice de impacto	3.819
Año	2016
Categoría	Computer Science, Interdisciplinary Applications
Posición de la revista en el área	11 de 105
Tercil	T1
Cuartil	Q1
Número de citas en JCR	5
Número de citas totales	12

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional (RETOS I+D) BigCLOE (TIN2016-79951-R), liderado por el candidato, donde se utiliza despliegue automatizado de infraestructura virtual para dar soporte a un caso de uso de educación en el ámbito de aprendizaje basado en problemas. Es también resultado del Proyecto de Innovación y Mejora Educativa (PIME) A04, aplicando esta tecnología en una asignatura del Grado en Arquitectura de la Universitat Politècnica de València. Se trata de un trabajo de investigación en educación, no de innovación educativa.

Computers & Education 108 (2017) 131–144

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Virtualized Computational Environments on the cloud to foster group skills through PBL: A case study in architecture

J. Damian Segrelles [a, *], Alicia Martinez [b], Nuria Castilla [b], Germán Moltó [a]

[a] Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC – Universitat Politècnica de València – CIEMAT, camino de Vera s/n, 46022 Valencia, Spain

[b] Departamento de Construcciones Arquitectónicas, Universitat Politècnica de València, camino de Vera s/n, 46022 Valencia, Spain

ARTICLE INFO

Article history:
Received 29 July 2016
Received in revised form 30 January 2017
Accepted 6 February 2017
Available online 8 February 2017

Keywords:
Cooperative work
PBLs
Cloud computing
Virtualization

ABSTRACT

The ODISEA platform provides Virtualized Computational Environments (VCEs) on cloud providers as the computational infrastructure to support educational activities. A VCE consists of a collection of one or more Virtual Machines (VMs) to which the students connect from their own computers. In this paper a case study is presented in the architecture domain where a PBL activity is carried out in working groups. The study involves 293 students organized in 28 pilot groups that use customized VCEs created and deployed through the ODISEA platform on a Cloud, and 30 traditional groups that use a LMS platform. The VCE provides the software, hardware and specific configuration to ease the interrelation and cooperative work between the working groups, enhancing the process tracking and feedback gathering as well as providing a better organization of the teaching material. The results demonstrate that the VCE allows to improve the cooperative work, improving the final marks in the PBL developed by the pilot working groups. Also, an economical study is presented, highlighting the economic benefits of the Cloud with respect to traditional physical laboratories of PCs.

1. Introduction and background

Nowadays, students and employers agree on the importance of developing and evaluating in classrooms the skills that allow the student to acquire the competences required in their future jobs. For this, in the European universities, the implementation of academic degrees fostered by the European Higher Education Area (EHEA)[1] are centred around competences. This has encouraged teachers to design new curricula that incorporate innovative active learning methodologies that lead students to more realistic scenarios and, therefore, improving the development of the skills in the classrooms. As a consequence, in the last years, the EHEA has invested great efforts to identify and standardise the skills and competences required in the business market through the European Skills, Competences, Qualifications and Occupation (ESCO) (European Skills Competences, 2016) classification.

* Corresponding author. Institute for Molecular Imaging Technologies (I3M), Universitat Politècnica de València (UPVLC), Camino de Vera s/n, 46022 Valencia, Spain.

E-mail address: dquilis@dsic.upv.es (J.D. Segrelles).

[1] The European Higher Education Area (EHEA). http://www.ehea.info.

http://dx.doi.org/10.1016/j.compedu.2017.02.001
0360-1315/

Table 6
Summary of the scenarios and involved cost to support the VCEs on AWS.

Scenario	Max. Simultaneous students	Instance type	Cost/hour/VCE ($)	Number of VCEs	Cost/day ($)
Single VCE for team	5	t2.medium	$0.056	28	37,6
Shared VCE for 3 teams	15	t2.large	$0.112	10	26,88

scenario 1 (approx. 15 simultaneous students). Remember that not all students may be connected at the same time to a single VCE since they are made available on a 24 × 7 basis and groups can decide their own schedule. Therefore, we are assuming worst-case scenarios. For this, Table 6 summarises the information and the cost of deploying the VCEs on the UE Ireland region on AWS.

Notice that these costs can be further reduced by removing the 24 × 7 access assumption and providing, for example, access only 12 h a day so that students plan their access from 08:00 to 20:00. This would automatically half the costs. The price of a high-end workstation with 16 GB of RAM is in the order of 1.100 $ (e.g. a Dell XPS 8900 workstation costs 999 € in dell.es as consulted on January 2017). Therefore, providing a physical laboratory for a large number of students represents a significant amount of money, unless a usual time-sharing method is applied. In particular, a physical laboratory to simultaneously support the 144 students would require at least 143.856 € for the investment in hardware, without considering the cost for the room, cabling, networking, IT staff, hardware maintenance, etc. In addition, the benefits of using the cloud is both the ability to scale beyond the limits of a physical laboratory by deploying and terminating VCEs as required. We truly believe that the benefits introduced by cloud computing techniques will reshape the way computational resources are currently employed in higher education, with the adoption of on-premises and public clouds to seamlessly support the disparate computational requirements coming from different the subjects in the myriad of degrees offered by educational institutions.

4. Conclusions

This paper has described the application of the ODISEA platform to deploy Virtualized Computing Environments on an on-premises cloud platform to support a PBL activity that it is performed by working groups through a subject (INEL) in the area of Architecture. The system provided students with the computational resources, software and educational material required to perform all staged defined at the PBL activity in a centralized manner and easily accessible anywhere and anytime.

The use of VCE customized to perform a PBL in working groups has produced a positive impact on the final marks, incrementing the average 1.4 points and accumulating the largest number of students in the range of (Bourne et al., 2005; Roche & Madrazo, 2016). Also, the number of voluntary deliverables has increased, indicating that the motivation has been increased in the pilot groups. In both cases, we can conclude that this positive difference is statistically significant. It is important to highlight the reuse of VCEs in different PBL activities of other subjects. Notice that we can reuse the part of the recipe that define the shared folders and include only the new software and hardware required.

The same VCE can be deployed in public or on-premises clouds depending on the amount of scalability required. Being able to use both on-premises and public clouds, ODISEA enables educational enters to introduce cost saving strategies by outsourcing computational resources on public cloud platforms.

The results of the experience indicate that students feel very positive and satisfied with the experience. In particular, the ability to access the required resources, specially licensed applications, off-campus enabled them to better manage their own schedules. Also, using shared folders between students and professors to track the progress of the projects has been an invaluable tool that has fostered interrelation and cooperative work.

Finally, the ODISEA platform can be an ideal complement for blended learning experiences and MOOCs that require remote labs to be easily accessible by students in order to dynamically deploy customized virtual infrastructures on Cloud platforms.

Acknowledgement

The authors wish to thank the financial support received from Vicerrectorado de Estudios, Calidad y Acreditación of the Universitat Politècnica de València (UPV) to develop the PIME project “Entornos Virtuales Computacionales para la Evaluación de Competencias Transversales en la Nube”, with reference A04 and to the Ministerio de Economía, Industria y Competitividad for the project BigCLOE (TIN2016-79951-R). GM would like to thank AWS for the AWS Educate program that provides the credits required to support the educational activities.

References

Bourne, J., Harris, D., & y Mayadas, F. (2005). Online engineering Education: Learning anywhere, anytime. *Journal of Engineering Education, 94*(1), 131–146.
Caminero, A. C., Ros, S., Hernández, R., Robles-Gómez, A., Tobarra, L., & Granjo, P. J. T. (2016). VirTUal remoTe labORatories managEment System (TUTORES): Using cloud computing to acquire university practical skills. *IEEE Transactions on Learning Technologies, 9*(2), 133–145.
Catteddu, D. (2010). Cloud computing: Benefits, risks and recommendations for information security (pp. 17–17). In *Web application security*. Berlin Heidelberg: Springer.
Daniel, W. W. (1990). *Kolmogorov–smirnov one-sample test". Applied nonparametric statistics* (2nd ed.). Boston: PWS-Kent. ISBN 0-534-91976-6.

Di Blas, N., & y Paolini, P. (2014). *Multi-User virtual environments fostering collaboration in formal education*. Educational Technology & Society.
Ertmer, P. A. (2015). *Essential readings in problem-based learning*. Purdue University Press.
European Skills Competences. Qualifications and occupations (ESCO). https://ec.europa.eu/esco/portal/home Accessed 25 February 2016.
González-Martínez, J., Bote-Lorenzo, M., Gómez-Sánchez, E., & Cano-Parra, R. (2015). Cloud computing and education: A state-of-the-art survey. *Computers & Education, 80*, 132–151.
IBM Corp Released. (2015). *IBM SPSS statistics for Windows, version 23.0*. Armonk, NY: IBM Corp.
Ivica, C., Riley, J. T., & Shubert, C. (2009). StarHPC e teaching parallel programming within elastic compute cloud. In Proceedings of the 2009 31st International Conference on Information Technology Interfaces (ITI '09) (pp. 353e356).
Johnson, D. W., Johnson, R. T., & y Smith, K. A. (1998). *Active Learning: Cooperation in the college classroom*. Edina, Minnesota: Interaction Book Company.
Maitland, B. (1997). Problem-based learning for architecture and construction management. *The challenge of problem-based learning*, 211–217.
McCarthy, J. (2010). Blended learning environments: Using social networking sites to enhance the first year experience. *Australasian Journal of Educational Technology, 26*(6), 729–740.
Mircea, M., & Andreescu, A. I. (2011). Using cloud computing in higher education: A strategy to improve agility in the current financial crisis. *Communications of the IBIMA, 2011*, 15. http://dx.doi.org/10.5171/2011.875547. Article ID 875547.
Pérez-García, A., Gómez-Martínez, F., Alonso, A., Hernández, V., Alonso, J. M., de la Fuente, P., et al. (2014). Architrave: Advanced analysis of building structures integrated in computer-aided design. In *Construction and building research* (pp. 123–130). Netherlands: Springer.
Piga B, Morello E, Signorelli V (2011). The experience of an academic simulation laboratory: the use of visual simulations for education and research. InRespecting Fragile Places: 29th Education and Research in Computer Aided Architectural Design in Europe (eCAADe) Conference Proceedings, 734–742.
Problem-Based Learning (PBL). (2014). *How to implement, strategize, and infuse PBL in an engineering program? Akili, Waddah*.
Roche, J., & Madrazo, L. (2016). *Enhancing a housing design studio with a collaborative on-line learning space*. vol: 2016(1) pp: 220–229.
Savery, J. R. (2015). *Overview of problem-based learning: Definitions and distinctions. Essential readings in problem-based learning: Exploring and extending the legacy of Howard S. Barrows*.
Segrelles D., Moltó G. (2016). Assessment of Cloud-based Computational Environments for Higher Education. 2016 Proceedings of the Frontiers in Education (FIE).
Segrelles D., Moltó G., Caballer M. (2015). Remote Computational Labs for Educational Activities via a Cloud Computing Platform. In 2015 Proceedings of the Information Systems Education Conference (ISECON), pp. 309–321, 2015.
Sultan, N. (2010). Cloud computing for education: A new dawn? *International Journal of Information Management, 30*(2), 109–116.
Sun, G., & Shen, J. (2014). Facilitating social collaboration in mobile cloud-based learning: A teamwork as a service (TaaS) approach. *IEEE Transactions on Learning Technologies, 7*(3), 207–220.
Symbaloo. http://www.symbaloo.com. Accessed 28 July 2016.
Vaquero, L. M. (2011). EduCloud: PaaS versus IaaS cloud usage for an advanced computer science course. *IEEE Transactions on Education, 54*(4), 590e598.
Xu, L., Huang, D., & Tsai, W. T. (2014). Cloud-based virtual laboratory for network security education. *IEEE Transactions on Education, 57*(3), 145–150.
Zhang, D. (2014). Research on the Project-Based Learning Used in the Teaching of Construction Management Specialty. In 2014 International Conference on Construction and Real Estate Management.

5.1.1.20. INDIGO-DataCloud: a Platform to Facilitate Seamless Access to E-Infrastructures

D. Salomoni et al., "INDIGO-DataCloud: a Platform to Facilitate Seamless Access to E-Infrastructures," J. Grid Comput., vol. 16, no. 3, pp. 381–408, Sep. 2018, doi: https://dx.doi.org/10.1007/s10723-018-9453-3

Base de datos de indexación	Web of Science (JCR)
Índice de impacto	3.288
Año	2018
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	19 de 105
Tercil	T1
Cuartil	Q1
Número de citas en JCR	18
Número de citas totales	32

Comentario. Esta contribución fue el principal resultado académico del proyecto Europeo INDIGO-DataCloud (RIA 653549, 26 socios, 11 M€ de presupuesto), en el que el candidato desempeñó el rol de Task Leader de la tarea encargada de diseñar una plataforma PaaS para el despliegue y orquestación de infraestructuras virtuales sobre plataformas distribuidas Cloud de los diferentes socios del proyecto. En este proyecto se adaptó el Infrastructure Manager para soportar la especificación TOSCA (Topology Orchestration Specification for Cloud Applications). IM es el componente que ofrece soporte multi-Cloud al INDIGO-DataCloud PaaS Orchestrator, ambos siendo usados dentro de la iniciativa European Open Science Cloud (EOSC), en el proyecto EOSC-Hub, donde el candidato co-lidera la tarea T6.3 de procesamiento y orquestación.

J Grid Computing (2018) 16:381–408
https://doi.org/10.1007/s10723-018-9453-3

INDIGO-DataCloud: a Platform to Facilitate Seamless Access to E-Infrastructures

D. Salomoni · I. Campos · L. Gaido · J. Marco de Lucas · P. Solagna · J. Gomes · L. Matyska · P. Fuhrman · M. Hardt · G. Donvito · L. Dutka · M. Plociennik · R. Barbera · I. Blanquer · A. Ceccanti · E. Cetinic · M. David · C. Duma · A. López-García · G. Moltó · P. Orviz · Z. Sustr · M. Viljoen · F. Aguilar · L. Alves · M. Antonacci · L. A. Antonelli · S. Bagnasco · A. M. J. J. Bonvin · R. Bruno · Y. Chen · A. Costa · D. Davidovic · B. Ertl · M. Fargetta · S. Fiore · S. Gallozzi · Z. Kurkcuoglu · L. Lloret · J. Martins · A. Nuzzo · P. Nassisi · C. Palazzo · J. Pina · E. Sciacca · D. Spiga · M. Tangaro · M. Urbaniak · S. Vallero · B. Wegh · V. Zaccolo · F. Zambelli · T. Zok

Received: 25 November 2017 / Accepted: 19 July 2018 / Published online: 7 August 2018

Abstract This paper describes the achievements of the H2020 project INDIGO-DataCloud. The project has provided e-infrastructures with tools, applications and cloud framework enhancements to manage the demanding requirements of scientific communities, either locally or through enhanced interfaces. The middleware developed allows to federate hybrid resources, to easily write, port and run scientific applications to the cloud. In particular, we have extended existing PaaS (Platform as a Service) solutions, allowing public and private e-infrastructures, including those provided by EGI, EUDAT, and Helix Nebula, to integrate their existing services and make them available through AAI services compliant with GEANT interfederation policies, thus guaranteeing transparency and trust in the provisioning of such services. Our middleware facilitates the execution of applications using containers on Cloud and Grid based infrastructures, as well as on HPC clusters. Our developments are freely downloadable as open source components, and are already being integrated into many scientific applications.

Keywords Cloud computing · Platform as a service · Containers · Software management · Advanced user interfaces · Authorization and authentication

D. Salomoni · A. Ceccanti · C. Duma
INFN - CNAF, Bologna, Italy

I. Campos (✉) · J. Marco de Lucas · A. López-García · P. Orviz · F. Aguilar · L. Lloret
IFCA, Consejo Superior de Investigaciones Cientificas-CSIC, Santander, Spain
e-mail: isabel.campos@csic.es

L. Gaido · S. Bagnasco · S. Vallero · V. Zaccolo
INFN - Torino, Torino, Italy

G. Donvito · M. Antonacci
INFN - Bari, Bari, Italy

P. Fuhrman
Deutsches Elektronen Synchrotron (DESY), Hamburg, Germany

I. Blanquer · G. Moltó
Institute of Instrumentation for Molecular Imaging - Universitat Politècnica de València, Valencia, Spain

M. Plociennik · M. Urbaniak · T. Zok
PSNC IBCh PAS, Poznań, Poland

M. Hardt · B. Ertl · B. Wegh
Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

1 Introduction

INDIGO-DataCloud was an European project starting in April 2015, with the purpose of developing a modular architecture and software components to improve how scientific work is supported at the edge of computing services development. Its main goal has been to deliver a Cloud platform addressing the specific needs of scientists in a wide spectrum of disciplines, engaging public institutions and private companies. It aimed at being as inclusive as possible, developing open source software exploiting existing solutions, adopting and enhancing state of the art technologies, connecting with other initiatives and with leading commercial providers.

J. Gomes · M. David · L. Alves · J. Martins · J. Pina
Laboratory of Instrumentation and Experimental Particle Physics (LIP), Lisbon, Portugal

S. Fiore · A. Nuzzo · P. Nassisi · C. Palazzo
Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici, Lecce, Italy

R. Barbera · R. Bruno · M. Fargetta
INFN - Catania, Catania, Italy

D. Spiga
INFN - Perugia, Perugia, Italy

L. Dutka
Cyfronet AGH, Krakow, Poland

P. Solagna · M. Viljoen · Y. Chen
EGI Foundation, Amsterdam, Netherlands

L. Matyska · Z. Sustr
CESNET, Prague, Czech Republic

A. M. J. J. Bonvin · Z. Kurkcuoglu
University of Utrecht, Utrecht, The Netherlands

L. A. Antonelli · A. Costa · S. Gallozzi · E. Sciacca
Istituto Nazionale di Astrofisica, Rome, Italy

E. Cetinic · D. Davidovic
Ruder Boskovic Institute, Zagreb, Croatia

M. Tangaro · F. Zambelli
Consiglio Nazionale delle Ricerche, Istituto di Biomembrane, Bioenergetica e Biotecnologie Molecolari, Bari, Italy

F. Zambelli
Department of Biosciences, University of Milano, Milan, Italy

R. Barbera
Department of Physics and Astronomy, University of Catania, Catania, Italy

Since its inception, the project roadmap has been user community driven. Its main focus was on closing the existing technology gaps that hindered an optimal exploitation of Cloud technologies by scientific users. In order to do so, user requirements from several multidisciplinary scientific communities were collected, and systematized into specific technical requirements. This process was carried out across the entire lifetime of the project, which allowed the update of existing requirements as well as the insertion of new ones, thus driving the project architecture definition and the technological developments.

The project also made focus on delivering production-quality software, thus it defined procedures and quality metrics, which were followed by, and automatically checked for, all the INDIGO components. A comprehensive process to package and issue the INDIGO software was also defined. As an outcome of this, INDIGO delivered two main software releases (the first in August 2016, the second in April 2017), each followed by several minor updates. The latest release consists of about 40 open modular components, 50 Docker containers, 170 software packages, all supporting up-to-date open operating systems. This result was accomplished reusing and extending open source software and —whenever applicable— contributing code to upstream projects.

The paper is structured as follows. Section 2 contains a description on how the user requirements were collected and consolidated. From there, the INDIGO architecture is further elaborated from the lower Infrastructure as a Service layer (Section 3) moving towards the Platform layer (Section 4) in order to arrive to the user interfaces (Section 5). The overall software development process is described in Section 6. Section 7 contains a summary of some usage patterns on how to leverage the INDIGO solutions to develop, deploy and support applications in a Cloud framework. The conclusions are laid out in Section 8. The list of upstream contributed software can be found in the Appendix.

1.1 Context and State of the Art

From the collection of user community requests, and its consolidation into technical requirements (see Section 2), we identified a number of technology gaps that today hinder an optimal scientific exploitation of heterogeneous e-infrastructures.

- Theoretical HEP physics: the MasterCode software, used in theoretical physics, adopts INDIGO tools to run applications on Grids, Clouds and on HPC systems with an efficient, simple-to-use, consistent interface.
- In DARIAH, a pan-european social and technical infrastructure for arts and humanities, the deployment of a self-managed, auto-scalable Zenodo-based repository in the cloud is automated.
- Climate change: distributed, parallel data analysis in the context of the Earth System Grid Federation (ESGF) infrastructure is performed through software deployed on HPC and cloud environments in Europe and in the US.
- Image analysis: in the context of EuroBioImaging, a distributed infrastructure for microscopy, molecular and medical imaging, INDIGO components are used to perform automatic and scalable analysis of bone density.
- Astronomical data archives: big data consisting of images collected by telescopes are automatically distributed and accessed via INDIGO tools.

The same solutions are also being explored by industry, to provide innovative services to EU companies: for example, modelling water reservoirs integrating satellite information, improving security in cyberspace, or assisting doctors in diagnostics through medical images. INDIGO solutions are also being intensively tested in other projects, such as HelixNebula ScienceCloud.

INDIGO services are fundamental for the implementation of the EOSC. In particular, many INDIGO components are included in the unified service catalogue provided by the project EOSC-hub [58], that will put in place the basic layout for the European Open Science Cloud. Two additional Horizon 2020 projects were also approved (`DEEP Hybrid DataCloud` and `eXtreme DataCloud`), that will continue to develop and enhance INDIGO components.

The outcomes of INDIGO-DataCloud will persist, and also be extended, after the end of the project in the framework of the *INDIGO Software Collaboration agreement*. This Collaboration shall be continued without financial support from the European Union. It is open to new initiatives and partners willing to contribute, extend or maintain the INDIGO-DataCloud software components.

Acknowledgments INDIGO-Datacloud has been funded by the European Commision H2020 research and innovation program under grant agreement RIA 653549.

Appendix A: Contribution to Open Source Software Projects

Here follows the list of software developed in the framework of INDIGO-Datacloud that has been contributed upstream to the Open Source community.

- OpenStack (https://www.openstack.org)
  - Changes/contribution done already merged upstream
    - Nova Docker
    - Heat Translator (INDIGO-Data Cloud is 3rd overall contributor and core developer)
    - TOSCA parser (INDIGO-Data Cloud is 2nd overall contributor and core developer)
    - OpenID Connect CLI support
    - OOI: OCCI implementation for OpenStack
  - Changes/contribution under discussion to be merged upstream OpenStack Preemptible Instances support (extensions)
- OpenNebula
  - Changes/contribution done already merged upstream
    - ONEDock
- Changes/contribution done already merged upstream for:
  - Infrastructure Manager (http://www.grycap.upv.es/im/index.php)
  - CLUES (http://www.grycap.upv.es/clues/eng/index.php)
  - Onedata (https://onedata.org)
  - Apache Libcloud (https://github.com/apache/libcloud)

- Kepler Workflow Manager (https://kepler-project.org/)
- TOSCA adaptor for JSAGA (http://software.in2p3.fr/jsaga/dev/)
- CDMI and QoS extensions for dCache (https://www.dcache.org)
- Workflow interface extensions for Ophidia (http://ophidia.cmcc.it)
- OpenID Connect Java implementation for dCache (https://www.dcache.org)
- MitreID (https://mitreid.org/) and OpenID Connect (http://openid.net/connect/) libraries
- FutureGateway (https://www.catania-science-gateways.it/)

Appendix B: Tools and Services Involved in the Software Lifecycle

Figure 14 showcases the tools and services used for the development and distribution of the INDIGO-DataCloud software:

- Project management service using **openproject.org**: It provides tools such as an issue tracker, wiki, a placeholder for documents and a project management timeline.
- Source code is publicly available, housed externally in GitHub repositories, increasing so the visibility and simplifying the path to exploitation beyond the project lifetime. The INDIGO-DataCloud software is released under the Apache 2.0 software license [59].
- Continuous Integration service using **Jenkins**: Service to automate the building, testing and packaging, where applicable. Testing includes the style compliance and estimation of the unit and functional test coverage of the software components.
- Artifact repositories for RedHat and Debian packages [60] and virtual – Docker – images [61].
- Code review service using GitHub: Source code review is one integral part of the SQA as it appears as the last step in the change verification process. This service facilitates the code review process, recording the comments and allowing the reviewer to verify the candidate change before being merged into the production version.
- Issue tracking using GitHub Issues: Service to track issues, new features and bugs of INDIGO-DataCloud software components.
- Release notes, installation and configuration guides, user and development manuals are made available on **GitBook** [62].
- Code metrics services using **Grimoire**: To collect and visualize several metrics about the software components.

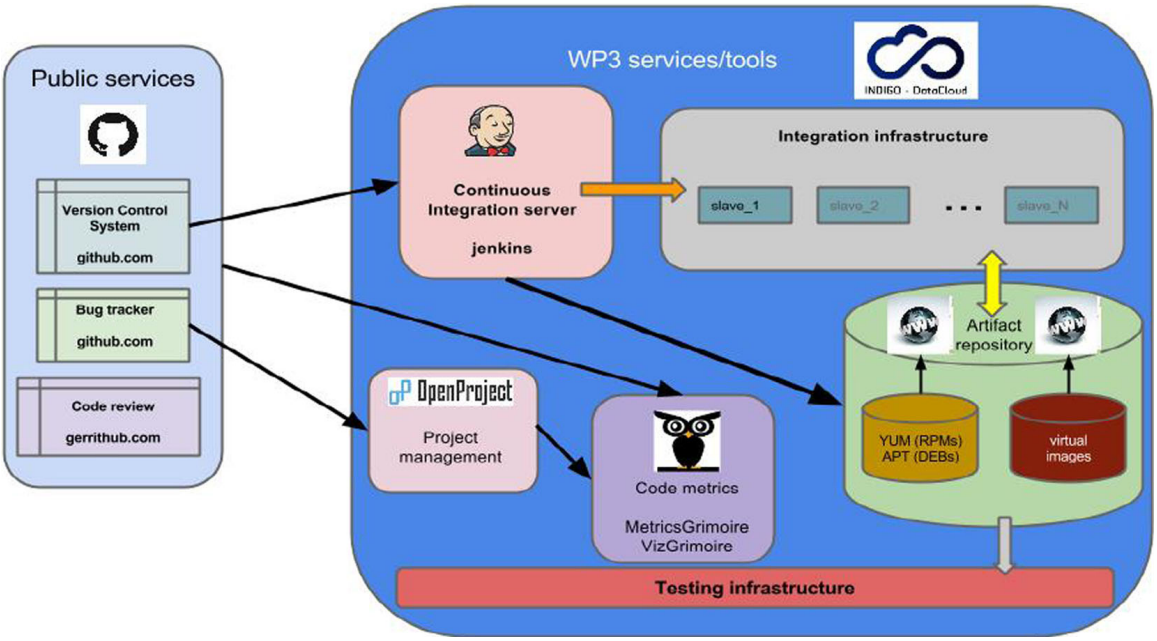


Fig. 14 Tools and services used to support the software lifecycle process

- Integration infrastructure: this infrastructure is composed of computing resources to support directly the CI service.
- Testing infrastructure: this infrastructure aims to provide a stable environment for users where they can preview the software and services developed by INDIGO-DataCloud, prior to its public release.
- Preview infrastructure: where the released artifacts are deployed and made available for testing and validation by the use-cases.

Appendix C: DevOps Adoption from User Communities

DisVis [63] and PowerFit [64] applications were integrated into a CI/CD pipeline described above. As it can be seen in the Fig. 15, with this pipeline in place the application developers were provided with both a means to validate the source code before merging and the creation of a new versioned Docker image, automatically available in the INDIGO-DataClouds catalogue for applications i.e. DockerHub???s `indigodatacloudapps` repository.

Once the application is deployed as a Docker container, and subsequently uploaded to `indigodatacloudapps` repository, it is instantiated in a new container to be validated. The application is then executed and the results compared with a set of reference outputs. Thus this pipeline implementation goes a step forward by testing the application execution for the last available Docker image in the catalogue.

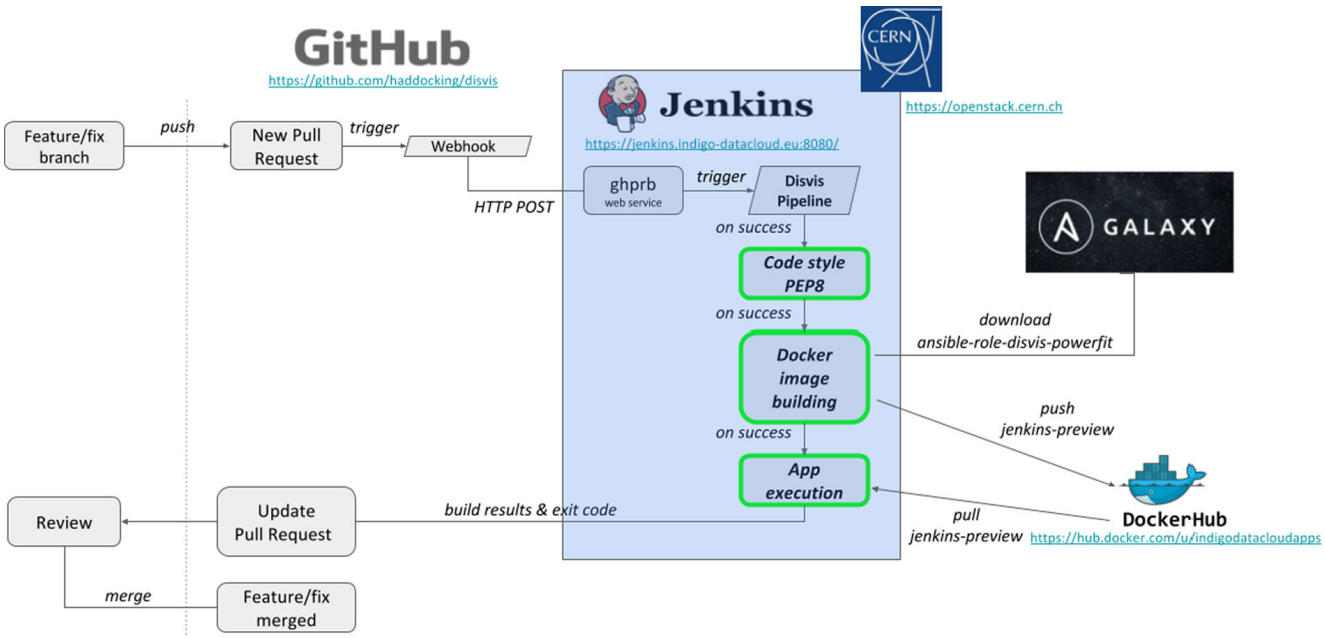


Fig. 15 DisVis development workflow using a CI/CD approach

References

1. García, A.L., Castillo, E.F.-d., Puel, M.: Identity federation with VOMS in cloud infrastructures. In: 2013 IEEE 5Th International Conference on Cloud Computing Technology and Science, pp 42–48 (2013)
2. Chadwick, D.W., Siu, K., Lee, C., Fouillat, Y., Germonville, D.: Adding federated identity management to OpenStack. Journal of Grid Computing **12**(1), 3–27 (2014)
3. Craig, A.L.: A design space review for general federation management using keystone. In: Proceedings of the 2014 IEEE/ACM 7th International Conference on Utility and Cloud Computing, pp 720–725. IEEE Computer Society (2014)
4. Pustchi, N., Krishnan, R., Sandhu, R.: Authorization federation in iaas multi cloud. In: Proceedings of the 3rd International Workshop on Security in Cloud Computing, pp 63–71. ACM (2015)
5. Lee, C.A., Desai, N., Brethorst, A.: A Keystone-Based Virtual Organization Management System. In: 2014 IEEE 6Th International Conference On Cloud Computing Technology and Science (Cloudcom), pp 727–730. IEEE (2014)
6. Castillo, E.F.-d., Scardaci, D., García, A.L.: The EGI Federated Cloud e-Infrastructure. Procedia Computer Science **68**, 196–205 (2015)
7. AARC project: AARC Blueprint Architecture, see https://aarc-project.eu/architecture. Technical report (2016)
8. Oesterle, F., Ostermann, S., Prodan, R., Mayr, G.J.: Experiences with distributed computing for meteorological applications: grid computing and cloud computing. Geosci. Model Dev. **8**(7), 2067–2078 (2015)
9. Plasencia, I.C., Castillo, E.F.-d., Heinemeyer, S., García, A.L., Pahlen, F., Borges, G.: Phenomenology tools on cloud infrastructures using OpenStack. The European Physical Journal C **73**(4), 2375 (2013)
10. Boettiger, C.: An introduction to docker for reproducible research. ACM SIGOPS Operating Systems Review **49**(1), 71–79 (2015)
11. Docker: http://www.docker.com (2013)
12. Gomes, J., Campos, I., Bagnaschi, E., David, M., Alves, L., Martins, J., Pina, J., Alvaro, L.-G., Orviz, P.: Enabling rootless linux containers in multi-user environments: the udocker tool. Computing Physics Communications. https://doi.org/10.1016/j.cpc.2018.05.021 (2018)
13. Zhang, Z., Chuan, W., Cheung, D.W.L.: A survey on cloud interoperability taxonomies, standards, and practice. SIGMETRICS perform. Eval. Rev. **40**(4), 13–22 (2013)
14. Lorido-Botran, T., Miguel-Alonso, J., Lozano, J.A.: A Review of Auto-scaling Techniques for Elastic Applications in Cloud Environments. Journal of Grid Computing **12**(4), 559–592 (2014)
15. Nyrén, R., Metsch, T., Edmonds, A., Papaspyrou, A.: Open Cloud Computing Interface–Core. Technical report, Open Grid Forum (2010)
16. Metsch, T., Edmonds, A.: Open Cloud Computing Interface-Infrastructure. Technical report, Open Grid Forum (2010)
17. Metsch, T., Edmonds, A.: Open Cloud Computing Interface-RESTful HTTP Rendering. Technical report, Open Grid Forum (2011)
18. (Ca Technologies) Lipton, P., (Ibm) Moser, S., (Vnomic) Palma, D., (Ibm) Spatzier, T.: Topology and Orchestration Specification for Cloud Applications. Technical report, OASIS Standard (2013)
19. Teckelmann, R., Reich, C., Sulistio, A.: Mapping of cloud standards to the taxonomy of interoperability in IaaS. In: Proceedings - 2011 3rd IEEE International Conference on Cloud Computing Technology and Science, CloudCom 2011, pp. 522–526 (2011)
20. García, A.L., Castillo, E.F.-d., Fernández, P.O.: Standards for enabling heterogeneous IaaS cloud federations. Computer Standards & Interfaces **47**, 19–23 (2016)
21. Caballer, M., Zala, S., García, A.L., Montó, G., Fernández, P.O., Velten, M.: Orchestrating complex application architectures in heterogeneous clouds. Journal of Grid Computing **16**(1), 3–18 (2018)
22. Hardt, M., Jejkal, T., Plasencia, I.C., Castillo, E.F.-d., Jackson, A., Weiland, M., Palak, B., Plociennik, M., Nielsson, D.: Transparent Access to Scientific and Commercial Clouds from the Kepler Workflow Engine. Computing and Informatics **31**(1), 119 (2012)
23. Fakhfakh, F., Kacem, H.H., Kacem, A.H.: Workflow Scheduling in Cloud Computing a Survey. In: IEEE 18Th International Enterprise Distributed Object Computing Conference Workshops and Demonstrations (EDOCW), 2014, Vol. 71, pp. 372–378. Springer, New York (2014)
24. Stockton, D.B., Santamaria, F.: Automating NEURON simulation deployment in cloud resources. Neuroinformatics **15**(1), 51–70 (2017)
25. Plóciennik, M., Fiore, S., Donvito, G., Owsiak, M., Fargetta, M., Barbera, R., Bruno, R., Giorgio, E., Williams, D.N., Aloisio, G.: Two-level Dynamic Workflow Orchestration in the INDIGO DataCloud for Large-scale, Climate Change Data Analytics Experiments. Procedia Computer Science **80**, 722–733 (2016)
26. Moreno-Vozmediano, R., Montero, R.S., Llorente, I.M.: Multicloud deployment of computing clusters for loosely coupled mtc applications. IEEE transactions on parallel and distributed systems **22**(6), 924–930 (2011)
27. Katsaros, G., Menzel, M., Lenk, A.: Cloud Service Orchestration with TOSCA, Chef and Openstack. In: Ic2e (2014)
28. Garcia, A.L., Zangrando, L., Sgaravatto, M., Llorens, V., Vallero, S., Zaccolo, V., Bagnasco, S., Taneja, S., Dal Pra, S., Salomoni, D., Donvito, G.: Improved Cloud resource allocation: how INDIGO-DataCloud is overcoming the current limitations in Cloud schedulers. J. Phys. Conf. Ser. **898**(9), 92010 (2017)
29. Singh, S., Chana, I.: A survey on resource scheduling in cloud computing issues and challenges. Journal of Grid Computing, pp. 1–48 (2016)
30. García, A.L., Castillo, E.F.-d., Fernández, P.O., Plasencia, I.C., de Lucas, J.M.: Resource provisioning in Science Clouds: Requirements and challenges. Software: Practice and Experience **48**(3), 486–498 (2018)

31. Chauhan, M.A., Babar, M.A., Benatallah, B.: Architecting cloud-enabled systems: a systematic survey of challenges and solutions. Software - Practice and Experience **47**(4), 599–644 (2017)
32. Somasundaram, T.S., Govindarajan, K.: CLOUDRB A Framework for scheduling and managing High-Performance Computing (HPC) applications in science cloud. Futur. Gener. Comput. Syst. **34**, 47–65 (2014)
33. Sotomayor, B., Keahey, K., Foster, I.: Overhead Matters: A Model for Virtual Resource Management. In: Proceedings of the 2nd International Workshop on Virtualization Technology in Distributed Computing SE - VTDC '06, p. 5. IEEE Computer Society, Washington (2006)
34. SS, S.S., Shyam, G.K., Shyam, G.K.: Resource management for Infrastructure as a Service (IaaS) in cloud computing SS Manvi A survey. J. Netw. Comput. Appl. **41**, 424–440 (2014)
35. INDIGO-DataCloud consortium: Initial requirements from research communities - d2.1, see https://www.indigo-datacloud.eu/documents/initial-requirements-research-communities-d21. Technical report (2015)
36. Europen open science cloud: https://ec.europa.eu/research/openscience (2015)
37. Proot: https://proot-me.github.io/ (2014)
38. Runc: https://github.com/opencontainers/runc (2016)
39. Fakechroot: https://github.com/dex4er/fakechroot (2015)
40. Pérez, A., Moltó, G., Caballer, M., Calatrava, A.: Serverless computing for container-based architectures Future Generation Computer Systems (2018)
41. de Vries, K.J.: Global fits of supersymmetric models after LHC run 1. Phd thesis Imperial College London (2015)
42. Openstack: https://www.openstack.org/ (2015)
43. See http://argus-documentation.readthedocs.io/en/stable/argus_introduction.html (2017)
44. See https://en.wikipedia.org/wiki/xacml (2013)
45. See http://www.simplecloud.info (2014)
46. Opennebula: http://opennebula.org/ (2018)
47. Redhat openshift: http://www.opencityplatform.eu (2011)
48. The cloud foundry foundation: https://www.cloudfoundry.org/ (2015)
49. Caballer, M., Blanquer, I., Moltó, G., de Alfonso, C.: Dynamic management of virtual infrastructures. Journal of Grid Computing **13**(1), 53–70 (2015)
50. See http://www.infoq.com/articles/scaling-docker-with-kubernetes (2014)
51. Prisma project: http://www.ponsmartcities-prisma.it/ (2010)
52. Opencitiy platform: http://www.opencityplatform.eu (2014)
53. Onedata: https://onedata.org/ (2018)
54. Dynafed: http://lcgdm.web.cern.ch/dynafed-dynamic-federation-project (2011)
55. Fts3: https://svnweb.cern.ch/trac/fts3 (2011)
56. Fernández, P.O., García, A.L., Duma, D.C., Donvito, G., David, M., Gomes, J.: A set of common software quality assurance baseline criteria for research projects, see http://hdl.handle.net/10261/160086. Technical report
57. Httermann, M.: Devops for developers Apress (2012)
58. EOSC-Hub: "Integrating and managing services for the European Open Science Cloud" Funded by H2020 research and innovation pr ogramme under grant agreement No. 777536. See http://eosc-hub.eu (2018)
59. Apache License: author = https://www.apache.org/licenses/LICENSE-2.0 (2004)
60. INDIGO Package Repo: http://repo.indigo-datacloud.eu/ (2017)
61. INDIGO DockerHub: https://hub.docker.com/u/indigodatacloud/ (2015)
62. Indigo gitbook: https://indigo-dc.gitbooks.io/indigo-datacloud-releases (2017)
63. Van Zundert, G.C., Bonvin, A.M.: Disvis: quantifying and visualizing the accessible interaction space of distance restrained biomolecular complexes. Bioinformatics **31**(19), 3222–3224 (2015)
64. Van Zundert, G.C., Bonvin, A.M.: Fast and sensitive rigid–body fitting into cryo–em density maps with powerfit. AIMS Biophys. **2**(0273), 73–87 (2015)

5.1.1.21. Multi-elastic Datacenters: Auto-scaled Virtual Clusters on Energy-Aware Physical Infrastructures

C. de Alfonso, M. Caballer, A. Calatrava, G. Moltó, and I. Blanquer, "Multi-elastic Datacenters: Auto-scaled Virtual Clusters on Energy-Aware Physical Infrastructures," J. Grid Comput., vol. 17, no. 1, pp. 191–204, Mar. 2019, doi: https://dx.doi.org/10.1007/s10723-018-9449-z

Base de datos de indexación	Web of Science (JCR)
Índice de impacto	2.095
Año	2019
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	37 de 108
Tercil	T2
Cuartil	Q1
Número de citas en JCR	3
Número de citas totales	5

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional (RETOS I+D) BigCLOE (TIN2016-79951-R), liderado por el candidato, donde se evoluciona el gestor de elasticidad CLUES para soportar elasticidad multi-nivel (despliegue de nodos de un cluster virtual y despliegue de nodos físicos en la infraestructura subyacente). CLUES se ofrece como herramienta de código abierto en GitHub y está disponible en http://www.grycap.upv.es/clues. Este software ha sido adoptado en diferentes proyectos Europeos entre los que destacamos INDIGO-DataCloud, DEEP Hybrid-DataCloud, EOSC-HUB y ATMOSPHERE, soportando la elasticidad en múltiples tipos de clusters virtuales (SLURM, Kubernetes, Mesos, etc.). Se utiliza en producción en la infraestructura Cloud federada por medio de EC3, la herramienta de despliegue de clusters virtuales elásticos. Se trata del principal resultado de la Tesis Doctoral de Carlos de Alfonso, titulada "Efficient and elastic management of computing infrastructures" que fue co-dirigida por el candidato y que ha sido consignada como mérito en 5.A.2 "Dirección de Tesis Doctorales".

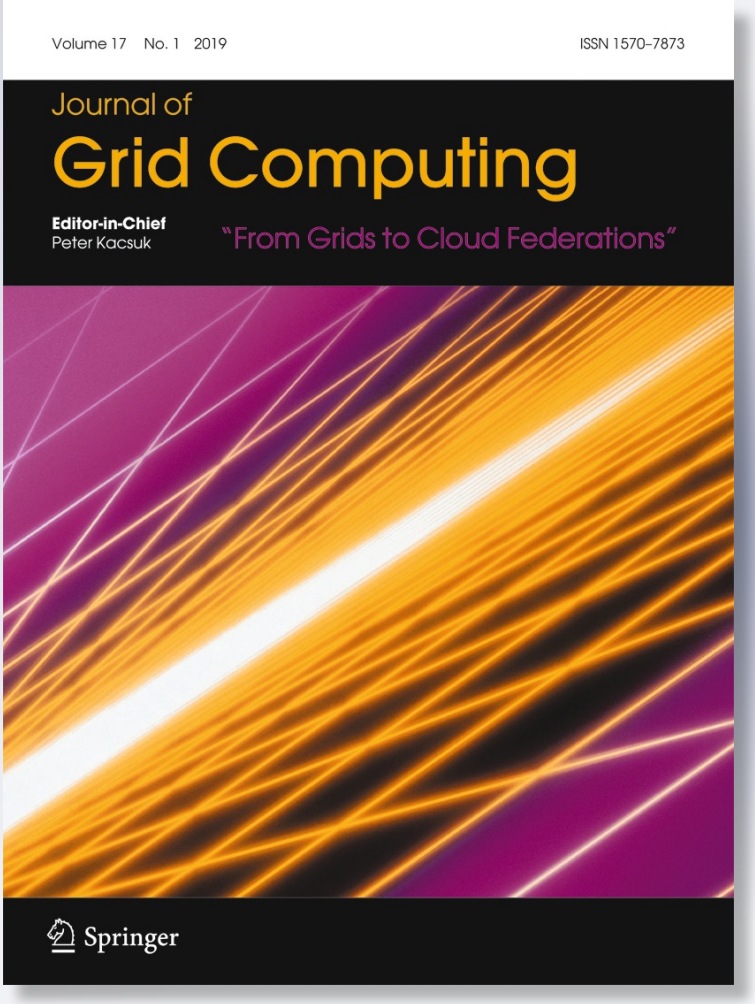
Multi-elastic Datacenters: Auto-scaled Virtual Clusters on Energy-Aware Physical Infrastructures

Carlos de Alfonso, Miguel Caballer, Amanda Calatrava, Germán Moltó & Ignacio Blanquer

Journal of Grid Computing
From Grids to Cloud Federations

ISSN 1570-7873
Volume 17
Number 1

J Grid Computing (2019) 17:191-204
DOI 10.1007/s10723-018-9449-z



J Grid Computing (2019) 17:191–204
https://doi.org/10.1007/s10723-018-9449-z

Multi-elastic Datacenters: Auto-scaled Virtual Clusters on Energy-Aware Physical Infrastructures

Carlos de Alfonso · Miguel Caballer · Amanda Calatrava · Germán Moltó · Ignacio Blanquer

Received: 21 June 2017 / Accepted: 16 July 2018 / Published online: 28 July 2018

Abstract Computer clusters are widely used platforms to execute different computational workloads. Indeed, the advent of virtualization and Cloud computing has paved the way to deploy virtual elastic clusters on top of Cloud infrastructures, which are typically backed by physical computing clusters. In turn, the advances in Green computing have fostered the ability to dynamically power on the nodes of physical clusters as required. Therefore, this paper introduces an open-source framework to deploy elastic virtual clusters running on elastic physical clusters where the computing capabilities of the virtual clusters are dynamically changed to satisfy both the user application's computing requirements and to minimise the amount of energy consumed by the underlying physical cluster that supports an on-premises Cloud. For that, we integrate: i) an elasticity manager both at the infrastructure level (power management) and at the virtual infrastructure level (horizontal elasticity); ii) an automatic Virtual Machine (VM) consolidation agent that reduces the amount of powered on physical nodes using live migration and iii) a vertical elasticity manager to dynamically and transparently change the memory allocated to VMs, thus fostering enhanced consolidation. A case study based on real datasets executed on a production infrastructure is used to validate the proposed solution. The results show that a multi-elastic virtualized datacenter provides users with the ability to deploy customized scalable computing clusters while reducing its energy footprint.

Keywords Cloud computing · Green computing · Elasticity · Virtualization · Infrastructure management

C. de Alfonso (✉) · M. Caballer · A. Calatrava · G. Moltó · I. Blanquer
Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC - Universitat Politècnica de València, Camino de Vera s/n, 46022, Valencia, Spain
e-mail: caralla@upv.es

M. Caballer
e-mail: micafer1@upv.es

A. Calatrava
e-mail: amcaar@upv.es

G. Moltó
e-mail: gmolto@dsic.upv.es

I. Blanquer
e-mail: iblanque@dsic.upv.es

1 Introduction

Computer clusters are a very common computing facility used both for scientific institutions and enterprises. A cluster consists of a set of computing nodes connected using at least one high-speed low-latency network and it is usually managed by a Local Resource Management System (LRMS) used to manage the whole lifecycle of the jobs [1]. These jobs typically represent different workloads such as High

area. Also, the components will be evolved to support Container Orchestration Platforms instead of Cloud Management Platforms, where challenges in the area of integrated vertical and horizontal elasticity require further research activity.

Funding Information The authors would like to thank the Spanish "Ministerio de Economía, Industria y Competitividad" for the project "BigCLOE" under grant reference TIN2016-79951-R.

The results of this work have been partially supported by ATMOSPHERE (Adaptive, Trustworthy, Manageable, Orchestrated, Secure, Privacy-assuring Hybrid, Ecosystem for Resilient Cloud Computing), funded by the European Commission under the Cooperation Programme, Horizon 2020 grant agreement No 777154.

References

1. Buyya, R.: High Performance Cluster Computing: Architectures and Systems. Prentice Hall PTR, Upper Saddle River (1999)
2. de Alfonso, C., Caballer, M., Alvarruiz, F., Moltó, G.: An economic and energy-aware analysis of the viability of outsourcing cluster computing to the cloud. Futur. Gener. Comput. Syst. (Int. J. Grid Comput eScience) **29**, 704–712 (2013). https://doi.org/10.1016/j.future.2012.08.014 http://www.sciencedirect.com/science/article/pii/S0167739X12001720?v=s5
3. Williams, D., Jamjoom, H., Liu, Y.H., Weatherspoon, H.: Overdriver: handling memory overload in an oversubscribed cloud. ACM SIGPLAN Not. **46**(7), 205 (2011). https://doi.org/10.1145/2007477.1952709. http://dl.acm.org/citation.cfm?id=2007477.1952709
4. Valentini, G., Lassonde, W., Khan, S., Min-Allah, N., Madani, S., Li, J., Zhang, L., Wang, L., Ghani, N., Kolodziej, J., Li, H., Zomaya, A., Xu, C.Z., Balaji, P., Vishnu, A., Pinel, F., Pecero, J., Kliazovich, D., Bouvry, P.: An overview of energy efficiency techniques in cluster computing systems. Clust. Comput. **16**(1), 3–15 (2013). https://doi.org/10.1007/s10586-011-0171-x
5. De Alfonso, C., Caballer, M., Hernández, V.: Efficient power management in high performance computer clusters. In: Proceedings of the 1st International Multi-conference on Innovative Developments in ICT, Proceedings of the International Conference on Green Computing 2010 (ICGreen 2010), 39–44 (2010)
6. OpenNebula: OpenNebula Cloud Software https://opennebula.org/. [Online; accessed 12-June-2017]
7. OpenStack: OpenStack Cloud Software. http://openstack.org. [Online; accessed 12 June 2017]
8. VMWare: VMWare vCenter Server. https://www.vmware.com/products/vcenter-server.html. [Online; accessed 12 June 2017]
9. De Alfonso, C., Blanquer, I.: Automatic consolidation of virtual machines in on-premises cloud platforms. In: IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing, pp. 1070–1079 (2017). https://doi.org/10.1109/CCGRID.2017.128
10. Chase, J.S., Irwin, D.E., Grit, L.E., Moore, J.D., Sprenkle, S.E.: Dynamic virtual clusters in a grid site manager. In: Proceedings of the 12th IEEE International Symposium on High Performance Distributed Computing, HPDC '03, p. 90. IEEE Computer Society, Washington, DC (2003). http://dl.acm.org/citation.cfm?id=822087.823392
11. Doelitzscher, F., Held, M., Reich, C., Sulistio, A.: Viteraas: Virtual cluster as a service. In: 2011 IEEE Third International Conference on Cloud Computing Technology and Science (CloudCom), pp. 652–657 (2011). https://doi.org/10.1109/CloudCom.2011.101
12. Wei, X., Wang, H., Li, H., Zou, L.: Dynamic deployment and management of elastic virtual clusters. In: 2011 Sixth Annual Chinagrid Conference (ChinaGrid), pp. 35–41 (2011). https://doi.org/10.1109/ChinaGrid.2011.31
13. de Assuncao, M.D., di Costanzo, A., Buyya, R.: Evaluating the cost-benefit of using cloud computing to extend the capacity of clusters. In: Proceedings of the 18th ACM International Symposium on High Performance Distributed Computing, HPDC '09, pp. 141–150. ACM, New York (2009). https://doi.org/10.1145/1551609.1551635. http://doi.acm.org/10.1145/1551609.1551635
14. Marshall, P., Keahey, K., Freeman, T.: Elastic site: Using clouds to elastically extend site resources. In: 2010 10th IEEE/ACM International Conference on Cluster, Cloud and Grid Computing (CCGrid), pp. 43–52 (2010). https://doi.org/10.1109/CCGRID.2010.80
15. Niu, S., Zhai, J., Ma, X., Tang, X., Chen, W.: Cost-effective cloud hpc resource provisioning by building semi-elastic virtual clusters. In: Proceedings of the International Conference on High Performance Computing, Networking, Storage and Analysis, SC '13, pp. 56:1–56:12. ACM, New York (2013). https://doi.org/10.1145/2503210.2503236. http://doi.acm.org/10.1145/2503210.2503236
16. Bialecki, A., Cafarella, M., Cutting, D., Omalley, O.: Hadoop: a framework for running applications on large clusters built of commodity hardware. Tech. rep. Apache Hadoop. http://hadoop.apache.org (2005)
17. MIT: StarCluster Elastic Load Balancer. http://web.mit.edu/stardev/cluster/docs/0.92rc2/manual/load_balancer.html
18. Appliance, C.C.S.: Creating elastic virtual clusters. http://cernvm.cern.ch/portal/elasticclusters (2015)
19. Research project, T.G.: The games research project. http://www.green-datacenters.eu (2013)
20. Cioara, T., Anghel, I., Salomie, I., Copil, G., Moldovan, D., Kipp, A.: Energy aware dynamic resource consolidation algorithm for virtualized service centers based on reinforcement learning. In: 2011 10th International Symposium on Parallel and Distributed Computing (ISPDC), pp. 163–169 (2011). https://doi.org/10.1109/ISPDC.2011.32
21. Farahnakian, F., Liljeberg, P., Plosila, J.: Energy-efficient virtual machines consolidation in cloud data centers using reinforcement learning. In: 2014 22nd Euromicro International Conference on Parallel, Distributed and Network-Based Processing (PDP), pp. 500–507 (2014). https://doi.org/10.1109/PDP.2014.109

22. Masoumzadeh, S., Hlavacs, H.: Integrating vm selection criteria in distributed dynamic vm consolidation using fuzzy q-learning. In: 2013 9th International Conference on Network and Service Management (CNSM), pp. 332–338 (2013). https://doi.org/10.1109/CNSM.2013.6727854
23. Feller, E., Rilling, L., Morin, C.: Energy-aware ant colony based workload placement in clouds. In: 2011 12th IEEE/ACM International Conference on Grid Computing (GRID), pp. 26–33 (2011). https://doi.org/10.1109/Grid.2011.13
24. Pop, C.B., Anghel, I., Cioara, T., Salomie, I., Vartic, I.: A swarm-inspired data center consolidation methodology. In: Proceedings of the 2nd International Conference on Web Intelligence, Mining and Semantics, WIMS '12, pp. 41:1–41:7. ACM, New York (2012). https://doi.org/10.1145/2254129.2254180
25. Marzolla, M., Babaoglu, O., Panzieri, F.: Server consolidation in clouds through gossiping. In: Proceedings of the 2011 IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks, WOWMOM '11, pp. 1–6. IEEE Computer Society, Washington, DC (2011). https://doi.org/10.1109/WoWMoM.2011.5986483
26. Ghafari, S., Fazeli, M., Patooghy, A., Rikhtechi, L.: Bee-mmt: A load balancing method for power consumption management in cloud computing. In: 2013 Sixth International Conference on Contemporary Computing (IC3), pp. 76–80 (2013). https://doi.org/10.1109/IC3.2013.6612165
27. Ajiro, Y., Tanaka, A.: Improving packing algorithms for server consolidation. In: International CMG Conference, pp. 399–406. Computer Measurement Group (2007)
28. Verma, A., Ahuja, P., Neogi, A.: pmapper: power and migration cost aware application placement in virtualized systems. In: Proceedings of the 9th ACM/IFIP/USENIX International Conference on Middleware, Middleware '08, pp. 243–264. Springer, New York (2008)
29. Beloglazov, A., Abawajy, J., Buyya, R.: Energy-aware resource allocation heuristics for efficient management of data centers for cloud computing. Future Gener. Comput. Syst. **28**(5), 755–768 (2012). https://doi.org/10.1016/j.future.2011.04.017
30. Guazzone, M., Anglano, C., Canonico, M.: Exploiting vm migration for the automated power and performance management of green cloud computing systems. In: Proceedings of the First International Conference on Energy Efficient Data Centers, E2DC'12, pp. 81–92. Springer, Berlin (2012). https://doi.org/10.1007/978-3-642-33645-4_8
31. Shi, L., Furlong, J., Wang, R.: Empirical evaluation of vector bin packing algorithms for energy efficient data centers. In: 2013 IEEE Symposium on Computers and Communications (ISCC), pp. 000,009–000,015 (2013). https://doi.org/10.1109/ISCC.2013.6754915
32. Tomás, L., Tordsson, J.: Improving cloud infrastructure utilization through overbooking. In: Proceedings of the 2013 ACM Cloud and Autonomic Computing Conference on - CAC '13, p. 1. ACM Press, New York (2013). https://doi.org/10.1145/2494621.2494627
33. Dawoud, W., Takouna, I., Meinel, C.: Elastic vm for cloud resources provisioning optimization. In: Abraham, A., Lloret Mauri, J., Buford, J., Suzuki, J., Thampi, S. (eds.) Advances in Computing and Communications, Communications in Computer and Information Science, vol. 190, pp. 431–445. Springer, Berlin (2011). https://doi.org/10.1007/978-3-642-22709-7_43
34. Tasoulas, E., Haugerund, H.R., Begnum, K.: Bayllocator: a proactive system to predict server utilization and dynamically allocate memory resources using Bayesian networks and ballooning. In: Proceedings of the 26th International Conference on Large Installation System Administration: Strategies, Tools, and Techniques, pp. 111–122. USENIX Association (2012)
35. Hines, M.R., Gordon, A., Silva, M., Da Silva, D., Ryu, K., Ben-Yehuda, M.: Applications know best: performance-driven memory overcommit with Ginkgo. In: 2011 IEEE Third International Conference on Cloud Computing Technology and Science, pp. 130–137. IEEE (2011). https://doi.org/10.1109/CloudCom.2011.27
36. Litke, A.: Manage resources on overcommitted KVM hosts. Tech. rep. IBM. http://www.ibm.com/developerworks/library/l-overcommit-kvm-resources/ (2011)
37. De Alfonso, C., Caballer, M., Alvarruiz, F., Hernández, V.: An energy management system for cluster infrastructures. Comput. Electr. Eng. **39**(8), 2579–2590 (2013). https://doi.org/10.1016/j.compeleceng.2013.05.004
38. Moltó, G., Caballer, M., de Alfonso, C.: Automatic memory-based vertical elasticity and oversubscription on cloud platforms. Futur. Gener. Comput. Syst. **56**, 1–10 (2016). https://doi.org/10.1016/j.future.2015.10.002
39. Calatrava, A., Romero, E., Moltó, G., Caballer, M., Alonso, J.M.: Self-managed cost-efficient virtual elastic clusters on hybrid Cloud infrastructures. Futur. Gener. Comput. Syst. **61**, 13–25 (2016). https://doi.org/10.1016/j.future.2016.01.018. http://authors.elsevier.com/sd/article/S0167739X16300024, http://linkinghub.elsevier.com/retrieve/pii/S0167739X16300024
40. Caballer, M., Chatziangelou, M., Calatrava, A., Moltó, G., Pérez, A.: IM integration in the EGI VMOps Dashboard. In: EGI Conference 2017 and INDIGO Summit 2017 (2017)
41. Calatrava, A., Caballer, M., Moltó, G., Pérez, A.: Virtual Elastic Clusters in the EGI LToS with EC3. In: EGI Conference 2017 and INDIGO Summit 2017 (2017)
42. Iosup, A., Li, H., Jan, M., Anoep, S., Dumitrescu, C., Wolters, L., Epema, D.H.: The grid workloads archive. Futur. Gener. Comput. Syst. **24**(7), 672–686 (2008). https://doi.org/10.1016/j.future.2008.02.003. http://www.sciencedirect.com/science/article/pii/S0167739X08000125
43. Nordugrid dataset, the grid workloads archive (Online; accessed 27-March-2017). http://gwa.ewi.tudelft.nl/datasets/gwa-t-3-nordugrid/report/
44. Caballer, M., Blanquer, I., Moltó, G., de Alfonso, C.: Dynamic Management of Virtual Infrastructures. J. Grid Comput. **13**, 53–70 (2015). https://doi.org/10.1007/s10723-014-9296-5. http://link.springer.com/article/10.1007/s10723-014-9296-5

5.1.1.22. Serverless computing for container-based architectures

A. Pérez, G. Moltó, M. Caballer, and A. Calatrava, "Serverless computing for container-based architectures," Futur. Gener. Comput. Syst., vol. 83, pp. 50–59, Jun. 2018, doi: https://dx.doi.org/10.1016/j.future.2018.01.022

Base de datos de indexación	Web of Science (JCR)
Índice de impacto	5.768
Año	2018
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	8 de 105
Tercil	T1
Cuartil	Q1
Número de citas en JCR	25
Número de citas totales	54

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional (RETOS I+D) BigCLOE (TIN2016-79951-R), liderado por el candidato, y el principal resultado de la Tesis Doctoral de Alfonso Pérez González, titulada "Advanced Elastic Platforms for High Throughput Computing on Container- based and Serverless Infrastructures " y dirigida por el candidato. La contribución resume el desarrollo de SCAR, una herramienta de código abierto disponible en GitHub - https://github.com/grycap/scar que permite la ejecución de contenedores a partir de imágenes Docker en AWS Lambda, el principal servicio FaaS (Functions as a Service) de Amazon Web Services. Esta herramienta permitió la ejecución de aplicaciones complejas (como las científicas) en esta plataforma por lo que fue adoptada por diferentes casos de uso (como la ejecución de modelos de Deep Learning). La herramienta consta de 550 estrellas en GitHub, fue usada en el proyecto Europeo DEEP Hybrid-DataCloud[3] y es la única herramienta española que aparece listada en el catálogo de productos serverless de la Cloud Native Computing Foundation (CNCF)[4]. Se ha registrado el software en la UPV con el título "Serverless Container-aware Architectures (SCAR)" disponible adicionalmente en Explora UPV[5].

[3] https://deep-hybrid-datacloud.eu/2020/03/25/event-driven-execution-of-deep-open-catalog-modules-for-prediction-on-amazon-web-services/
[4] https://landscape.cncf.io/format=serverless&selected=scar
[5] https://aplicat.upv.es/exploraupv/ficha-tecnologia/patente_software/24666

Future Generation Computer Systems 83 (2018) 50–59

Contents lists available at ScienceDirect

Future Generation Computer Systems

journal homepage: www.elsevier.com/locate/fgcs

Serverless computing for container-based architectures

Alfonso Pérez *, Germán Moltó, Miguel Caballer, Amanda Calatrava

Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC - Universitat Politècnica de València, Camino de Vera s/n, 46022, Valencia, Spain

HIGHLIGHTS

- A framework to run containerized applications in serverless computing is proposed.
- Containers out of Docker images can now be run on AWS Lambda.
- Highly-parallel event-driven file-processing serverless computing is introduced.
- An analysis of the Freeze/Thaw cycle of AWS Lambda and caching is assessed.
- Bursty workloads of short stateless jobs can benefit from serverless computing.

ARTICLE INFO

Article history:
Received 26 July 2017
Received in revised form 5 January 2018
Accepted 9 January 2018

Keywords:
Cloud computing
Serverless
Docker
Elasticity
AWS lambda

ABSTRACT

New architectural patterns (e.g. microservices), the massive adoption of Linux containers (e.g. Docker containers), and improvements in key features of Cloud computing such as auto-scaling, have helped developers to decouple complex and monolithic systems into smaller stateless services. In turn, Cloud providers have introduced *serverless* computing, where applications can be defined as a workflow of event-triggered functions. However, serverless services, such as AWS Lambda, impose serious restrictions for these applications (e.g. using a predefined set of programming languages or difficulting the installation and deployment of external libraries). This paper addresses such issues by introducing a framework and a methodology to create Serverless Container-aware ARchitectures (SCAR). The SCAR framework can be used to create highly-parallel event-driven serverless applications that run on customized runtime environments defined as Docker images on top of AWS Lambda. This paper describes the architecture of SCAR together with the cache-based optimizations applied to minimize cost, exemplified on a massive image processing use case. The results show that, by means of SCAR, AWS Lambda becomes a convenient platform for High Throughput Computing, specially for highly-parallel bursty workloads of short stateless jobs.

1. Introduction

Cloud computing introduced the ability to provision on-demand computational resources reducing the needs for on-premises resources. Indeed, Virtual Machines (VMs) have played a fundamental role to create customized and replicable execution environments for applications, in order to guarantee successful executions. Also, elasticity has been the cornerstone functionality of IaaS (*Infrastructure as a Service*) Cloud computing where new VMs can be provisioned in order to cope with increased workloads. Public Cloud providers such as Amazon Web Services (AWS) [1] have fostered the migration of complex application architectures to the Cloud in order to take advantage of the pay-per-use cost model.

In parallel, the mainstream adoption of Linux containers, propelled by the popularity of Docker [2], enabled users to maintain customized execution environments, in the shape of lightweight Docker images instead of bulky Virtual Machine Images. This paved the way for the microservices architectural pattern to rise, in order to decouple complex applications into several small, independently deployed services that interact via REST interfaces [3]. Creating distributed applications based on microservices required the ability to manage a fleet of Docker container at scale, thus fostering the appearance of Container Management Platforms (CMPs) such as Kubernetes, Apache Mesos or Docker Swarm. Public Cloud providers also provided their CMP offerings as a service, as is the case of Amazon ECS [4].

The ability to run containers at scale was adopted by public Cloud providers to create *serverless* computing [5] in which applications are defined as a set of event-triggered functions that execute without requiring the user to explicitly manage servers. As

* Corresponding author.
E-mail address: alpegon3@upv.es (A. Pérez).

https://doi.org/10.1016/j.future.2018.01.022
0167-739X/

Using the proposed approach, customized execution environments can now be employed instead of being locked-in to programming functions in the programming languages supported by the serverless platform (in our case AWS Lambda). This has easily introduced the ability to run generic applications on specific runtime environments defined by Docker Images stored in Docker Hub, a functionality that is actually missing from the current serverless computing platforms.

A High Throughput Computing programming model has been developed in order to create highly-parallel event-driven file-processing serverless applications that execute on customized runtime environments provided by Docker containers run on AWS Lambda. This has been exemplified by using a deep learning application to perform pattern recognition on an image dataset.

SCAR not only provides means to deploy containers in AWS Lambda, it also manages the Lambda functions' lifecycle and eases the execution of the serverless workflow by applying optimizations without the need of user intervention, such as caching the container's underlying file system to minimize the execution time.

However, the current limitations of AWS Lambda in terms of maximum execution time (5 min), maximum allocated memory (3008 MB) and, most important, ephemeral disk capacity (512 MB), impose serious restrictions for the applications that can benefit from SCAR. Bursty workloads of short stateless jobs are specially appropriate to benefit from the ultra-elastic capabilities of AWS Lambda, both in terms of the amount of concurrent Lambda function invocations (in the order of thousands) and the rapid elasticity (in the order of few seconds). Having said that, we expect these limits to be risen in future updates of the service, which will be greatly help expand the adoption of SCAR for applications that cannot be encapsulated in a Docker image fitting in such scarce amount of computing and storage resources.

Future work of SCAR includes adapting the development to other serverless providers. In particular, our dependence on udocker, begin developed in Python, suggests using a provider supporting that language, such as Microsoft Azure Functions (Google Cloud Functions currently only supports Node.JS). Notice that the programming model of SCAR is agnostic to the provider. In addition, SCAR users could benefit from a mechanism that maintains the deployed Lambda functions 'hot', based on the knowledge extracted from the freeze/thaw cycle study by means of periodic invocations of the Lambda functions. Finally, we are currently researching on mechanisms to checkpoint applications so that new Lambda functions are spawn recursively in order to bypass the maximum execution time for iterative scientific applications.

Acknowledgments

The authors would like to thank the Spanish "Ministerio de Economía, Industria y Competitividad" for the project "BigCLOE" under grant reference TIN2016-79951-R. The authors would also like to thank Jorge Gomes from LIP for the development of the *udocker* tool.

References

[1] Amazon, Amazon Web Services (AWS). https://aws.amazon.com. (Online; accessed 25 July 2017).
[2] Docker, Docker. https://www.docker.com. (Online; accessed 25 July 2017).
[3] Nicola Dragoni, Saverio Giallorenzo, Alberto Lluch-lafuente, Manuel Mazzara, Fabrizio Montesi, Ruslan Mustafin, Larisa Safina, Microservices: yesterday, today and tomorrow, CoRR (2016). abs/1606.04036.
[4] Amazon, Amazon EC2 Container Service. https://aws.amazon.com/ecs/. (Online; accessed 25 July 2017).
[5] Ioana Baldini, Paul Castro, Kerry Chang, Perry Cheng, Stephen Fink, Vatche Ishakian, Nick Mitchell, Vinod Muthusamy, Rodric Rabbah, Aleksander Slominski, Philippe Suter, Serverless computing: Current trends and open problems, Jun. 2017, pp. 1-20.
[6] Amazon, Amazon Lambda (AWS Lambda). https://aws.amazon.com/lambda/. (Online; accessed 25 July 2017).
[7] Google, Google Cloud Functions. https://cloud.google.com/functions/. (Online; accessed 25 July 2017).
[8] Microsoft. Microsoft Azure Functions. https://azure.microsoft.com/en-in/services/functions/. (Online; accessed 25 July 2017).
[9] The Apache Software Foundation. Apache Openwhisk. http://openwhisk.org/. (Online; accessed 25 July 2017).
[10] G. Mcgrath, J. Short, S. Ennis, B. Judson, P. Brenner, Cloud event programming paradigms: Applications and analysis, in: 2016 IEEE 9th International Conference on Cloud Computing, CLOUD, June 2016, pp. 400–406.
[11] Scott Hendrickson, Stephen Sturdevant, Tyler Harter, Venkateshwaran Venkataramani, Andrea C. Arpaci-Dusseau, Remzi H. Arpaci-Dusseau, Serverless computation with openlambda, in: 8th USENIX Workshop on Hot Topics in Cloud Computing, HotCloud 16, USENIX Association, Denver, CO, 2016.
[12] Amazon, AWS Elastic Beanstalk. https://aws.amazon.com/elasticbeanstalk. (Online; accessed 25 July 2017).
[13] Mario Villamizar, Oscar Garcés, Lina Ochoa, Harold. Castro, Lorena Salamanca, Mauricio Verano, Rubby Casallas, Santiago Gil, Carlos Valencia, Angee Zambrano, Mery Lang, Cost comparison of running web applications in the cloud using monolithic, microservice, and AWS lambda architectures, Serv. Oriented Comput. Appl. 11 (2) (2017) 233–247.
[14] Josef Spillner, Serhii Dorodko, Java code analysis and transformation into AWS lambda functions, CoRR (2017). abs/1702.05510.
[15] Josef Spillner, Snafu: Function-as-a-Service (FAAS) runtime design and implementation, CoRR (2017). abs/1703.07562.
[16] Eric Jonas, Shivaram Venkataraman, Ion Stoica, Benjamin Recht, Occupy the cloud: Distributed computing for the 99%, CoRR (2017). abs/1702.04024.
[17] Mengting Yan, Paul Castro, Perry Cheng, Vatche Ishakian, Building a chatbot with serverless computing, in: Proceedings of the 1st International Workshop on Mashups of Things and Apis, MOTA '16, ACM, New York, NY, USA, 2016, pp. 1–5.
[18] Alex Glikson, Stefan Nnastic, Schahram Dustdar, Deviceless edge computing: Extending serverless computing to the edge of the network, in: Proceedings of the 10th ACM International Systems and Storage Conference, SYSTOR '17, ACM, New York, NY, USA, 2017, p. 28:1.
[19] Node-RED, Node-RED. https://nodered.org/. (Online; accessed 25 July 2017).
[20] Alex Glikson, TRANSIT: Flexible pipeline for IoT data with Bluemix and Openwhisk. https://medium.com/openwhisk/transit-flexible-pipeline-for-iot-data-with-bluemix-and-openwhisk-4824cf20f1e0. (Online; accessed 25 July 2017).
[21] GRyCAP, SCAR Github repository. https://github.com/grycap/scar. (Online; accessed 25 July 2017).
[22] Theano, Theano. http://deeplearning.net/software/theano. (Online; accessed 25 July 2017).
[23] Joseph Redmon, Darknet. https://pjreddie.com/darknet/. (Online; accessed 25 July 2017).
[24] Erlang, Erlang. https://www.erlang.org/. (Online; accessed 25 July 2017).
[25] Jose Valim, Elixir. https://elixir-lang.org/. (Online; accessed 25 July 2017).
[26] ImageMagick Studio, Image Magick. https://www.imagemagick.org. (Online; accessed 25 July 2017).
[27] FFmpeg, FFmpeg. https://ffmpeg.org/. (Online; accessed 25 July 2017).
[28] Amazon, Amazon CloudWatch. https://aws.amazon.com/cloudwatch. (Online; accessed 25 July 2017).
[29] Virtuozzo, OpenVZ. https://openvz.org. (Online; accessed 25 July 2017).
[30] Canonical, LXC. https://linuxcontainers.org/. (Online; accessed 25 July 2017).
[31] Docker, Docker Hub. https://hub.docker.com/. (Online; accessed 25 July 2017).
[32] Jorge Gomes, udocker. https://github.com/indigo-dc/udocker. (Online; accessed 25 July 2017).
[33] Jorge Gomes, Isabel Campos, Emanuele Bagnaschi, Mario David, Luis Alves, Joao Martins, Joao Pina, Alvaro Lopez-Garcia, Pablo Orviz, Enabling rootless linux containers in multi-user environments: the udocker tool, 2017. arXiv preprint arXiv:1711.01758.
[34] D. Salomoni, I. Campos, L. Gaido, G. Donvito, P. Fuhrman, J. Marco, A. Lopez-Garcia, P. Orviz, I. Blanquer, G. Molto, M. Plociennik, M. Owsiak, M. Urbaniak, M. Hardt, A. Ceccanti, B. Wegh, J. Gomes, M. David, C. Aiftimiei, L. Dutka, S. Fiore, G. Aloisio, R. Barbera, R. Bruno, M. Fargetta, E. Giorgio, S. Reynaud, L. Schwarz, INDIGO-Datacloud: foundations and architectural description of a Platform as a Service oriented to scientific computing. Technical report, INDIGO-DataCloud, Mar 2016.
[35] Jorge Gomes, udocker documentation. https://github.com/indigo-dc/udocker/blob/udocker-fr/doc/user_manual.md. (Online; accessed 25 July 2017).
[36] JPiotr Roszatycki, Fakechroot. https://github.com/dex4er/fakechroot. (Online; accessed 25 July 2017).

[37] Amazon, Boto 3. http://boto3readthedocs.io. (Online; accessed 25 July 2017).
[38] GRyCAP, FFmpeg on AWS Lambda. https://github.com/grycap/scar/tree/master/examples/ffmpeg. (Online; accessed 25 July 2017).
[39] Amazon, AWS Lambda. How it works. http://docs.aws.amazon.com/es_es/lambda/latest/dg/lambda-introduction.html. (Online; accessed 25 July 2017).
[40] Amazon, Invoke. http://docs.aws.amazon.com/es_es/lambda/latest/dg/API_Invoke.html. (Online; accessed 25 July 2017).
[41] CentOS, Docker Hub: centos:7. https://hub.docker.com/_/centos/. (Online; accessed 25 July 2017).
[42] Bitnami, Docker Hub: bitnami/minideb. https://hub.docker.com/r/bitnami/minideb/. (Online; accessed 25 July 2017).
[43] GRyCAP, Docker Hub: grycap/jenkins:ubuntu14.04-python. https://hub.docker.com/r/grycap/jenkins. (Online; accessed 25 July 2017).
[44] Joseph Redmon, Darknet: Open source neural networks in C, 2013-2016. http://pjreddie.com/darknet/.
[45] Joseph Redmon, Ali Farhadi, Yolo9000: Better, faster, stronger, 2016. arXiv preprint arXiv:1612.08242.
[46] GRyCAP, Docker Hub: grycap/darknet. https://hub.docker.com/r/grycap/darknet/. (Online; accessed 25 July 2017).
[47] Amazon, Amazon Lambda pricing calculator. https://s3amazonaws.com/lambda-tools/pricing-calculator.html. (Online; accessed 25 July 2017).

Alfonso Pérez received B.Sc. + M.Sc. degrees in Computer Science and M.Sc. degree in Computer Engineering from the Universitat Politècnica de València (UPV), Spain, in 2011 and 2014, respectively. In 2011 he initiated his research career working in medical informatics projects related with clinical prediction models and computer interpretable guidelines. He has been member of the Grid and High Performance Computing research group (GRyCAP) at the Institute for Molecular Imaging (I3M) since 2015 where he began doing research work related with automatic cluster deployment and elasticity. In 2016 he started his Ph.D. in the field of Big Data and High Throughput Computing on Container-based and Serverless Infrastructures.

Germán Moltó received B.Sc. and Ph.D. degrees in Computer Science from the Universitat Politècnica de València (UPV), Spain, in 2002 and 2007, respectively. He has been a member of the Grid and High Performance Computing research group (GRyCAP) at the Institute for Molecular Imaging (I3M) since 2002. He is also an associate professor in the Department of Computer Systems and Computation (DSIC) at UPV. He has participated in several European projects and led national research projects in the area of cloud computing. His broad research interests are cloud computing and scientific computing.

Miguel Caballer obtained B.Sc., M.Sc., and Ph.D. degrees in Computer Science from the Universitat Politècnica de València (UPV), Spain, in 2000, 2012, and 2014, respectively. He has been a member of the Grid and High Performance Computing research group at the Institute for Molecular Imaging (I3M) since 2001. He has participated in several European and national research projects related to the application of parallel, grid, and cloud computing techniques to various areas of engineering. His other fields of interest include green computing.

Amanda Calatrava received the B.Sc., M.Sc. and Ph.D. degrees in computer science from the Universitat Politècnica de València (UPV) in 2010, 2012 and 2016, respectively. In 2011, she joined the Grid and High Performance Computing research group as a graduate under a collaboration fellowship while she worked on her Master's Thesis. She obtained her Master's Degree in February 2012, in which she specialized in grid and cloud computing. In November 2016, she obtained the Ph.D. degree whose work was focused in the field of virtual elastic clusters over hybrid cloud infrastructures. Currently, her research interests are focused in Virtualization, Cloud Computing and Scientific Computing.

5.1.1.23. A self-managed Mesos cluster for data analytics with QoS guarantees

S. López-Huguet et al., "A self-managed Mesos cluster for data analytics with QoS guarantees," Futur. Gener. Comput. Syst., vol. 96, no. 96, pp. 449–461, Jul. 2019, doi: https://dx.doi.org/10.1016/j.future.2019.02.047

Base de datos de indexación	Web of Science (JCR)
Índice de impacto	6.125
Año	2019
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	8 de 108
Tercil	T1
Cuartil	Q1
Número de citas en JCR	4
Número de citas totales	8

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional (RETOS I+D) BigCLOE (TIN2016-79951-R), liderado por el candidato, y utilizó la plataforma de computación intensiva basada en GPUs creada gracias al soporte económico recibido mediante la ayuda regional IDIFEDER/2018/032. Se trata de la contribución principal de Sergio López Huguet, cuyo Trabajo Final de Máster, titulado "Despliegue y Monitorización de un Cluster Mesos" fue co-dirigido por el candidato. Se usan métricas de calidad de servicio para determinar el escalado de un cluster con Apache Mesos para garantizar ejecución en tiempo.

Future Generation Computer Systems 96 (2019) 449–461

Contents lists available at ScienceDirect

Future Generation Computer Systems

journal homepage: www.elsevier.com/locate/fgcs

A self-managed Mesos cluster for data analytics with QoS guarantees

Sergio López-Huguet *, Alfonso Pérez, Amanda Calatrava, Carlos de Alfonso, Miguel Caballer, Germán Moltó, Ignacio Blanquer

Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC - Universitat Politècnica de València, Camino de Vera s/n, 46022, Valencia, Spain

HIGHLIGHTS

- QoS based vertical elasticity on Docker containers in Marathon Mesos framework.
- Automatic horizontal elasticity in a Mesos cluster.
- Software defined clusters deployed on the cloud.

ARTICLE INFO

Article history:
Received 9 May 2018
Received in revised form 29 October 2018
Accepted 22 February 2019
Available online 27 February 2019

Keywords:
Cloud orchestration
Elasticity
Quality of service
Data analytics
Hybrid clusters

ABSTRACT

This article describes the development of an automated configuration of a software platform for Data Analytics that supports horizontal and vertical elasticity to guarantee meeting a specific deadline. It specifies all the components, software dependencies and configurations required to build up the cluster, and analyses the deployment times of different instances, as well as the horizontal and vertical elasticity. The approach followed builds up self-managed hybrid clusters that can deal with different workloads and network requirements. The article describes the structure of the recipes, points out to public repositories where the code is available and discusses the limitations of the approach as well as the results of several experiments.

1. Introduction

The need for data analytics platforms has raised in the recent years, in parallel to the increase in the computing and data storage requirements, in order to tackle the challenges of data processing. Configuring and operating such platforms is not straightforward and requires non-trivial system administration skills. Data analytics platforms involve multiple components and resources, which must be appropriately linked and cross-configured. In addition, dealing with unpredictable workloads is an operationally complex task that requires dynamically readjusting the resources and reconfiguring them on the fly.

In this way, this article presents a set of tools and configuration recipes for deploying a virtual self-managed cluster of computing nodes. The cluster can scale horizontally (in and out), by adding and removing computing resources and reconfiguring them according to the workload, and vertically (up and down), by readjusting the assigned resources to individual jobs dynamically to satisfy a given Quality of Service (QoS).

This paper introduces the problem, the software architecture, the automatic deployment tools and recipes, the elasticity mechanism and the experiments, discussing the results obtained. The reminder of the paper is structured as follows. First, Section 2 examines the requirements of a data analytics platform and revises the state of the art related to the work presented in the paper. Then, Section 3 presents the proposed architecture of the platform used to perform data analytics and the mechanisms involved in the elasticity management. Also, a brief analysis of each component involved in the architecture is presented in this section. Section 4 describes the most relevant metrics obtained from the deployment of the self-managed virtual cluster and the execution of several test cases to validate the horizontal and vertical elasticity. Section 5 discusses the main developments and improvements presented in this work in comparison with the state of the art. Finally, Section 6 summarizes the main results, concludes the paper and points to future work.

2. Requirements & state of the art

This section presents the requirements and reviews the state of the art of the two main areas of research that constitute the

* Corresponding author.
E-mail addresses: serlohu@upv.es (S. López-Huguet), alpegon3@upv.es (A. Pérez), amcaar@i3m.upv.es (A. Calatrava), calfonso@upv.es (C. de Alfonso), micafer1@upv.es (M. Caballer), gmolto@dsic.upv.es (G. Moltó), iblanque@dsic.upv.es (I. Blanquer).

https://doi.org/10.1016/j.future.2019.02.047
0167-739X/

jobs is one of the basic functionalities offered by the standard cluster configuration. In all the test cases it is demonstrated how the cluster admits different types of jobs and executes them without issues.

For running periodic batch jobs, the cluster must be prepared to accept a set of jobs defined to be executed in an specific time. In Section 4.2 a batch of jobs are programmed to be launched and the cluster executes them by adjusting the resources available. This demonstrates that the defined architecture is not only able to process this kind of scheduled jobs, it is also able to self adapt horizontally depending on the workload. Moreover, the jobs presented in Section 4.2 are a set of Spark jobs that were executed in parallel thus complying with the last requirement presented which required to execute Spark jobs in parallel.

In addition, the QoS restrictions and the vertical elasticity were tested in Section 4.3. The execution of batch jobs with QoS restrictions by adjusting the share of CPU assigned is done thanks to a set of plugins developed and deployed automatically in combination with the frameworks available in the architecture presented.

Moreover, and as an extra step towards reusability and community usage, all the code developed for this project is publicly available and any user with access to one of the supported cloud providers (which include the most popular ones) can deploy an elastic cluster and tweak the configuration to fit the needs.

Future work includes testing the cluster with bigger setups, such as several hundred nodes and thousands of jobs during long periods of time but unfortunately and due to all the test being done in real infrastructures with shared resources and real users, the test cases have to be limited.

Acknowledgments

The work presented in this article has been partially funded by a research grant from the regional government of the Comunitat Valenciana (Spain), co-funded by the European Union ERDF funds (European Regional Development Fund) of the Comunitat Valenciana 2014-2020, with reference IDIFEDER/2018/032 (High-Performance Algorithms for the Modelling, Simulation and early Detection of diseases in Personalized Medicine). The authors would also like to thank the Spanish "Ministerio de Economía, Industria y Competitividad" for the project "BigCLOE" with reference number TIN2016-79951-R.

References

[1] EUBra-BIGSEA, Deliverable D7.1: End-user requirements elicitation, 2018, http://www.eubra-bigsea.eu/sites/default/files/D7_1_End-User_Requirements_Final.pdf, (Online; Accessed April 2018).
[2] OASIS Topology and orchestration specification for cloud applications (TOSCA), 2018, https://www.oasis-open.org/committees/tc_home.php?wg_abbrev=tosca, (Online; Accessed April 2018).
[3] OpenStack, Openstack heat, 2018, http://wiki.openstack.org/wiki/Heat, (Online; Accessed April 2018).
[4] OpenStack, Heat orchestration template (hot) guide, 2018, https://docs.openstack.org/heat/latest/template_guide/hot_guide.html, (Online; Accessed April 2018).
[5] OpenStack, Openstack, 2018, https://www.openstack.org/, (Online; Accessed April 2018).
[6] OpenNebula, Opennebula, 2018, https://opennebula.org/, (Online; Accessed April 2018).
[7] OpenNebula, OneFlow, 2018, http://docs.opennebula.org/5.2/advanced_components/application_flow_and_auto-scaling/index.html, (Online; Accessed April 2018).
[8] DXC Technology, Eucalyptus cloud platform, 2018, https://github.com/eucalyptus/eucalyptus, (Online; Accessed April 2018).
[9] Amazon, Cloudformation, 2018, https://aws.amazon.com/cloudformation/, (Online; Accessed April 2018).
[10] Cloudify, Cloudify, 2018, https://cloudify.co, (Online; Accessed April 2018).
[11] The Apache Software Foundation, Apache aria tosca orchestration engine, 2018, http://ariatosca.incubator.apache.org, (Online; Accessed April 2018).
[12] I. Giannakopoulos, N. Papailiou, C. Mantas, I. Konstantinou, D. Tsoumakos, N. Koziris, CELAR: Automated application elasticity platform, in: 2014 IEEE International Conference on Big Data (Big Data), 2014, pp. 23–25.
[13] SixSq, Slipstream, 2018, http://sixsq.com/products/slipstream/, (Online; Accessed April 2018).
[14] Sami Yangui, Iain James Marshall, Jean Pierre Laisne, Samir Tata, Compatibleone: The open source cloud broker, J. Grid Comput. 12 (1) (2014) 93–109.
[15] University of Stuttgart, Opentosca, 2018, http://www.opentosca.org, (Online; Accessed April 2018).
[16] Amazon, Amazon eC2, 2018, https://aws.amazon.com/ec2/, (Online; Accessed April 2018).
[17] Miguel Caballer, Ignacio Blanquer, Germán Moltó, Carlos de Alfonso, Dynamic management of virtual infrastructures, J. Grid Comput. 13 (1) (2015) 53–70.
[18] Chris Anderson, The end of theory: The data deluge makes the scientific method obsolete, 2018, http://www.wired.com/2008/06/pb-theory/, (Online; Accessed April 2018).
[19] J. Dean, S. Ghemawat, Simplified data processing on large clusters, Commun. ACM 51 (1) (2008) 107–113.
[20] The Apache Software Foundation, Apache hadoop, 2018, http://hadoop.apache.org, (Online; Accessed April 2018).
[21] The Apache Software Foundation, Apache hive, 2018, http://hive.apache.org, (Online; Accessed April 2018).
[22] The Apache Software Foundation, Apache pig, 2018, http://pig.apache.org, (Online; Accessed April 2018).
[23] The Apache Software Foundation, Apache spark, 2018, http://spark.apache.org, (Online; Accessed April 2018).
[24] Ltd. Canonical, Linux containers, 2018, https://linuxcontainers.org/, (Online; Accessed April 2018).
[25] Docker Inc., Docker, 2018, https://www.docker.com/, (Online; Accessed April 2018).
[26] Gregory M. Kurtzer, Vanessa Sochat, Michael W. Bauer, Singularity: Scientific containers for mobility of compute, PLoS One 12 (5) (2017) 1–20, https://doi.org/10.1371/journal.pone.0177459.
[27] Wes Felter, Alexandre Ferreira, Ram Rajamony, Juan Rubio, An updated performance comparison of virtual machines and Linux containers, in: ISPASS 2015 - IEEE International Symposium on Performance Analysis of Systems and Software, 2015, pp. 171–172.
[28] The Linux Foundation, Kubernetes, 2018, http://kubernetes.io/, (Online; Accessed April 2018).
[29] Deis, Deis, 2018, https://deis.com/, (Online; Accessed April 2018).
[30] The Apache Software Foundation, Apache mesos, 2018, http://mesos.apache.org/, (Online; Accessed April 2018).
[31] Inc. Mesosphere, Chronos, 2018, https://mesos.github.io/chronos/, (Online; Accessed April 2018).
[32] Inc. Mesosphere, Marathon, 2018, http://mesosphere.github.io/marathon/, (Online; Accessed April 2018).
[33] Amazon, AWS Auto scaling, 2018, https://aws.amazon.com/es/autoscaling/, (Online; Accessed March 2018].
[34] Paul Marshall, Kate Keahey, Tim Freeman, Elastic site: Using clouds to elastically extend site resources, in: CCGrid 2010 - 10th IEEE/ACM International Conference on Cluster, Cloud, and Grid Computing, 2010, pp. 43–52.
[35] Paul Marshall, Henry Tufo, Kate Keahey, David La Bissoniere, Matthew Woitaszek, Architecting a large-scale elastic environment: Recontextualization and adaptive cloud services for scientific computing, in: ICSOFT 2012 - Proceedings of the 7th International Conference on Software Paradigm Trends, 2012, pp. 409–418.
[36] Massachusetts Institute of Technology, Starcluster, 2018, http://web.mit.edu/stardev/cluster/, (Online; Accessed April 2018).
[37] Massachusetts Institute of Technology, Starcluster elastic load balancer, 2018, http://web.mit.edu/stardev/cluster/docs/0.92rc2/manual/load_balancer.html, (Online; Accessed April 2018).
[38] Nikolaos Chalvantzis, Ioannis Konstantinou, Nektarios Kozyris, BBQ: Elastic MapReduce over cloud platforms, in: Proceedings - 2017 17th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing, CCGRID 2017, 2017, pp. 766–771.
[39] Amanda Calatrava, Eloy Romero, Germán Moltó, Miguel Caballer, Jose Miguel Alonso, Self-managed cost-efficient virtual elastic clusters on hybrid cloud infrastructures, Future Gener. Comput. Syst. 61 (2016) 13–25.
[40] Carlos De Alfonso, Miguel Caballer, Fernando Alvarruiz, Vicente Hernández, An energy management system for cluster infrastructures, Comput. Electr. Eng. 39 (8) (2013) 2579–2590.
[41] Z. Shen, S. Subbiah, X. Gu, J. Wilkes, CloudScale: elastic resource scaling for multi-tenant cloud systems, in: Proceedings of the 2nd Symposium on Cloud Computing, 2011, pp. 5:1—-5:14.
[42] EUBra-BIGSEA, Deliverable D3.4: Qos infrastructure services intermediate version, 2018, https://www.eubra-bigsea.eu/sites/default/files/D3.4%20EUBra-BIGSEA%20QoS%20infrastructure%20services.pdf, (Online; Accessed April 2018).

[43] Germán Moltó, Miguel Caballer, Carlos De Alfonso, Automatic memory-based vertical elasticity and oversubscription on cloud platforms, Future Gener. Comput. Syst. 56 (2016) 1–10.
[44] Soodeh Farokhi, Pooyan Jamshidi, Ewnetu Bayuh Lakew, Ivona Brandic, Erik Elmroth, A hybrid cloud controller for vertical memory elasticity: A control-theoretic approach, Future Gener. Comput. Syst. 65 (2016) 57–72.
[45] Yahya Al-Dhuraibi, Fawaz Paraiso, Nabil Djarallah, Philippe Merle, Autonomic vertical elasticity of docker containers with ELASTICDOCKER, in: IEEE International Conference on Cloud Computing, CLOUD, 2017-June, 2017, pp. 472–479.
[46] Chao Zheng, Ben Tovar, Douglas Thain, Deploying high throughput scientific workflows on container schedulers with makeflow and mesos, in: Proceedings - 2017 17th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing, CCGRID 2017, 2017, pp. 130–139.
[47] DC/OS, Autoscaling with marathon, 2018, https://dcos.io/docs/1.7/usage/tutorials/autoscaling/, (Online; Accessed April 2018).
[48] Google, Google cloud, 2018, https://cloud.google.com/, (Online; Accessed April 2018).
[49] Microsoft, Azure, 2018, https://azure.microsoft.com, (Online; Accessed April 2018).
[50] Monasca, Monasca, 2018, http://monasca.io/, (Online; Accessed April 2018).
[51] Apache Software Foundation, Apache kafka, 2018, https://kafka.apache.org/, (Online; Accessed April 2018).
[52] Apache Software Foundation, Apache storm, 2018, http://storm.apache.org/, (Online; Accessed April 2018).
[53] Inc InfluxData, InfluxDB, 2018, https://www.influxdata.com/, (Online; Accessed April 2018).
[54] Grafana Labs, Grafana, 2018, https://grafana.com/, (Online; Accessed April 2018).
[55] OpenStack, Openstack keystone, 2018, https://wiki.openstack.org/wiki/Keystone, (Online; Accessed April 2018).
[56] Virtuozzo, CRIU, 2018, https://criu.org/Main_Page, (Online; Accessed April 2018).
[57] weaveworks, Weave, 2018, https://www.weave.works/, (Online; Accessed April 2018).

Sergio López-Huguet received his B.Sc. in Computational Mathematics from Universitat Jaume I (UJI) in 2011–2015 and his M.Sc. in Computer Engineering from Universitat Politècnica de València (UPV) in 2015–2017. In 2016, he joined the Grid and High Performance Computing Group (GRyCAP) in the Institute of Instrumentation for Molecular Imaging (I3M) at the UPV. Nowadays, he is Ph.D. student in the mentioned Research Group. Besides, he has participated in various international projects. Since 2016, he has been working in Cloud Computing, container management and service monitoring. His Ph.D. is focused on Cloud Computing, High Performance Computing and Medical Image processing.

Alfonso Pérez received B.Sc. + M.Sc. degrees in Computer Science and M.Sc. degree in Computer Engineering from the Universitat Politècnica de València (UPV), Spain, in 2011 and 2014, respectively. In 2011 he initiated his research career working in medical informatics projects related with clinical prediction models and computer interpretable guidelines. He has been member of the Grid and High Performance Computing research group (GRyCAP) at the Institute for Molecular Imaging (I3M) since 2015 where he began doing research work related with automatic cluster deployment and elasticity. In 2016 he started his Ph.D. in the field of Big Data and High Throughput Computing on Container-based and Serverless Infrastructures.

Amanda Calatrava received the B.Sc., M.Sc. and Ph.D. degrees in computer science from the Universitat Politècnica de València (UPV) in 2010, 2012 and 2016, respectively. In 2011, she joined the Grid and High Performance Computing research group as a graduate under a collaboration fellowship while she worked on her Master's Thesis. She obtained her Master's Degree in February 2012, in which she specialized in grid and cloud computing. In November 2016, she obtained the Ph.D. degree whose work was focused in the field of virtual elastic clusters over hybrid cloud infrastructures. Currently, her research interests are focused in Virtualization, Cloud Computing and Scientific Computing.

Carlos de Alfonso obtained the B.Sc., M.Sc. and Ph.D. degrees in Computer Science from the Universitat Politècnica de València (UPV), Spain, in 2000 and 2015. In 2000 he joined the Grid and High Performance Computing research group, at UPV. Since 2007 he is a Technician for the Support of Research at UPV, with a profile of Grid and Cloud computing. He has been part of several national, European and international projects and contracts in the fields of Grid. During the last years he has oriented his activity mainly to Cloud Computing, and Containerization of Workloads for HPC.

Miguel Caballer obtained B.Sc., M.Sc. and Ph.D. degrees in Computer Science from the Universitat Politècnica de València (UPV), Spain, in 2000, 2012, and 2014, respectively. He has been a member of the Grid and High Performance Computing research group at the Institute for Molecular Imaging (I3M) since 2001. He has participated in several European and national research projects related to the application of parallel, grid, and cloud computing techniques to various areas of engineering. His other fields of interest include green computing.

Germán Moltó received B.Sc. and Ph.D. degrees in Computer Science from the Universitat Politècnica de València (UPV), Spain, in 2002 and 2007, respectively. He has been a member of the Grid and High Performance Computing research group (GRyCAP) at the Institute for Molecular Imaging (I3M) since 2002. He is also an associate professor in the Department of Computer Systems and Computation (DSIC) at UPV. He has participated in several European projects and led national research projects in the area of cloud computing. His broad research interests are cloud computing and scientific computing.

Ignacio Blanquer, associate professor of the Computer System Department at UPV since 1999 (currently accredited to full professor), has been a member of GRyCAP since 1993, and he leads the group since 2016. He has been involved in Parallel Computation and Medical Image processing, participating in more than 55 national and European Research Projects, has authored and co-authored 40 articles in indexed journals and book chapters and in more than 90 papers in national and international journals and conference proceedings. He has served as coordinator of the application area in the Spanish Network for e-Science, including his role in the managerial board was Community Manager in VENUS-C, where he collected and evaluated user requirements and provided hands-on support for migration to the cloud of 27 applications. He has been the project coordinator of EUBrazilCloudConnect (FP7), EUBRazil-BIGSEA (H2020) and CLUVIEM (national research project), and currently is the project coordinator of ATMOSPHERE (H2020) and co-principal investigator in the BigCLOE national research project.

5.1.1.24. A framework and a performance assessment for serverless MapReduce on AWS Lambda

V. Giménez-Alventosa, G. Moltó, and M. Caballer, "A framework and a performance assessment for serverless MapReduce on AWS Lambda," Futur. Gener. Comput. Syst., vol. 97, pp. 259–274, Aug. 2019, doi: 10.1016/j.future.2019.02.057.

Base de datos de indexación	Web of Science (JCR)
Índice de impacto	6.125
Año	2019
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	08 de 108
Tercil	T1
Cuartil	Q1
Número de citas en JCR	4
Número de citas totales	13

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional (RETOS I+D) BigCLOE (TIN2016-79951-R), liderado por el candidato. Es uno de los resultados de la Tesis Doctoral de Vicent Giménez, co-dirigida por el candidato y con fecha prevista de defensa en 2022, en el ámbito del uso de computación serverless para el ámbito científico. Esta contribución dio lugar a MARLA, una herramienta de código abierto disponible en GitHub: https://github.com/grycap/marla para la ejecución de programas MapReduce sobre AWS Lambda, la plataforma serverless de AWS. Esta contribución permitió identificar prestaciones desbalanceadas para aplicaciones de cómputo distribuido en plataformas serverless e iniciar una línea de investigación en balanceo de carga serverless.

Future Generation Computer Systems 97 (2019) 259–274

Contents lists available at ScienceDirect

Future Generation Computer Systems

journal homepage: www.elsevier.com/locate/fgcs

A framework and a performance assessment for serverless MapReduce on AWS Lambda

V. Giménez-Alventosa *, Germán Moltó, Miguel Caballer

Instituto de Instrumentación para Imagen Molecular (I3M) Centro mixto CSIC - Universitat Politècnica de València, Camino de Vera s/n, 46022, Valencia, Spain

HIGHLIGHTS

- A Python-based framework to support serverless MapReduce on AWS Lambda is introduced.
- AWS Lambda provides a highly scalable platform for the execution of MapReduce jobs.
- A thorough assessment of AWS Lambda identified significant performance fluctuations.
- Coupled jobs, such as using MapReduce, may exhibit highly variable execution times when run on AWS Lambda.

ARTICLE INFO

Article history:
Received 17 October 2018
Received in revised form 14 January 2019
Accepted 22 February 2019
Available online 7 March 2019

Keywords:
MapReduce
Serverless
Cloud computing
Elasticity

ABSTRACT

MapReduce is one of the most widely used programming models for analysing large-scale datasets, i.e. Big Data. In recent years, serverless computing and, in particular, Functions as a Service (FaaS) has surged as an execution model in which no explicit management of servers (e.g. virtual machines) is performed by the user. Instead, the Cloud provider dynamically allocates resources to the function invocations and fine-grained billing is introduced depending on the execution time and allocated memory, as exemplified by AWS Lambda. In this article, a high-performant serverless architecture has been created to execute MapReduce jobs on AWS Lambda using Amazon S3 as the storage backend. In addition, a thorough assessment has been carried out to study the suitability of AWS Lambda as a platform for the execution of High Throughput Computing jobs. The results indicate that AWS Lambda provides a convenient computing platform for general-purpose applications that fit within the constraints of the service (15 min of maximum execution time, 3008 MB of RAM and 512 MB of disk space) but it exhibits an inhomogeneous performance behaviour that may jeopardise adoption for tightly coupled computing jobs.

1. Introduction

MapReduce [1] is one of the most used programming models for analysing large-scale datasets, i.e. Big Data. Apache Hadoop [2], an open-source platform for reliable, scalable and distributed computing provided the execution support to the MapReduce programming model. Indeed, the Hadoop ecosystem has flourished in the last years resulting in a myriad of tools and services for distributed programming, NoSQL databases, SQL-based databases and machine learning, among many other categories (see the Hadoop Ecosystem table [3] for further details). Apache Hadoop requires a distributed computing infrastructure to support the execution of MapReduce applications.

Infrastructure as a Service (IaaS) Clouds provide distributed computing infrastructures, offered by public Cloud providers such as Amazon Web Services (AWS) [4], Microsoft Azure [5] and Google Cloud Platform (GCP) [6]. Indeed, these providers include in their portfolios services to be able to automatically deploy Hadoop (and Spark) clusters on pay-as-you-go basis. This is the case of Amazon Elastic MapReduce (EMR) [7], for AWS, HDInsight [8] for Microsoft Azure, or Cloud Dataproc [9], for GCP. These services provide automatic deployment capabilities and, to some extent, the ability to scale the clusters in order to increase or decrease the number of worker nodes of the cluster. There are also software projects to dynamically deploy Hadoop (and Spark) clusters on on-premises Clouds. This is the case of Sahara [10], to provision data-intensive application clusters on top of the OpenStack [11] Cloud Management Platform (CMP).

In recent years serverless computing has surged as an execution model in which no explicit management of servers (e.g. virtual machines) is performed by the user. Instead, the Cloud provider dynamically allocates resources to the execution unit,

* Corresponding author.
E-mail address: vicent.gimenez@i3m.upv.es (V. Giménez-Alventosa).

https://doi.org/10.1016/j.future.2019.02.057
0167-739X/

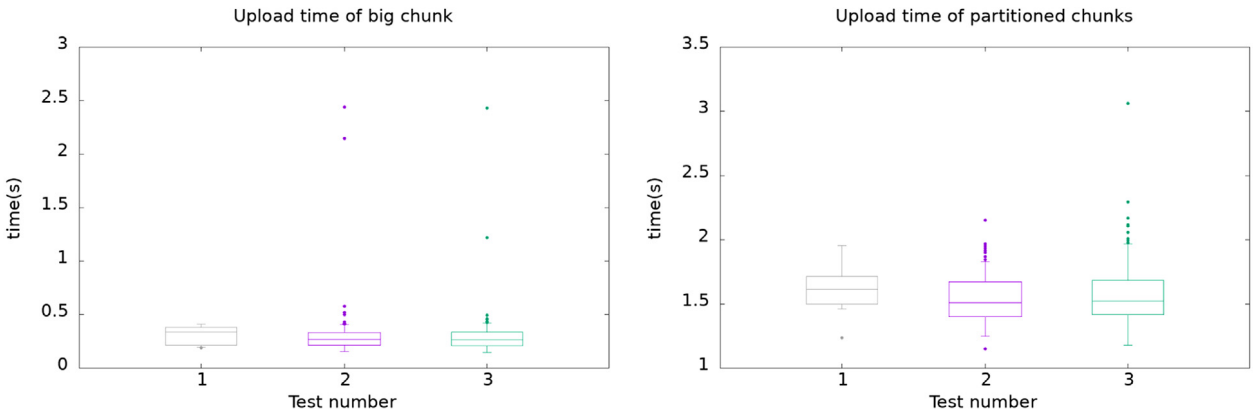


Fig. 17. Upload time distributions on network tests where only one invocation is executed at once. Each test uses 20 chunks and execute 10, 100 and 100 invocations respectively.

instance that actually executes the function (chosen by AWS), the function will exhibit execution times that can be up to 51% slower.

This poses a problem for coupled job executions, like MapReduce, in which a delay in just one the mappers affects the whole execution since the reduce phase cannot be started. This fluctuation in the execution can eventually cause timeouts in the Lambda functions and disrupt job executions if they have not been configured to accommodate this effect. This has also an economic impact since the pricing model of AWS Lambda depends on the amount of milliseconds executed, together with the RAM allocated to the Lambda function.

A similar effect was identified in the network performance. Multiple Lambda functions that put or get data in S3 buckets can produce, depending on the number of concurrent functions and size of data to store, a timeout on "slower" functions. However, with a good configuration of the application, the slow Lambda function will be re-invoked and, eventually, will finish its execution. Therefore, this effect can produce an increment in time and cost but the execution will be done eventually, as exemplified in our architecture.

Still, AWS Lambda provides an ideal computing platform in which automated scaling is handled by the Cloud provider and application developers can benefit from it for general purpose computing. Our presented architecture provides a general MapReduce platform completely executed in a serverless environment with a pay-per-use pricing model. This really stands out as a convenient approach to offer a MapReduce service that is pre-deployed as a set of Lambda functions at zero cost and the execution pipeline is triggered by uploading a file into a bucket, resulted in automated scaling to perform a MapReduce job tailored to the dataset to be processed in terms of the number of mappers.

Future works include extending the framework to support additional programming languages as well as other Cloud providers. In particular, we would like to study whether the fluctuations in AWS Lambda performance are present in the corresponding service offerings by other Cloud providers.

Acknowledgements

This study was supported by the program "Ayudas para la contratación de personal investigador en formación de carácter predoctoral, programa VALi+d" under grant number ACIF/2018/148 from the Conselleria d'Educació of the Generalitat Valenciana, Spain. The authors would also like to thank the Spanish "Ministerio de Economía, Industria y Competitividad" for the project "BigCLOE" with reference number TIN2016-79951-R.

References

[1] Jeffrey Dean, Sanjay Ghemawat, Mapreduce: simplified data processing on large clusters, Commun. ACM 51 (1) (2008) 107–113.
[2] ApacheHadoop, https://hadoop.apache.org/, Accessed: 2018-10-1.
[3] HadoopTable, https://hadoopecosystemtable.github.io/, Accessed: 2018-10-1.
[4] AWS, https://aws.amazon.com/, Accessed: 2018-10-1.
[5] Azure, https://azure.microsoft.com/, Accessed: 2018-10-1.
[6] GCP, https://cloud.google.com/, Accessed: 2018-10-1.
[7] EMR, https://aws.amazon.com/emr/, Accessed: 2018-10-1.
[8] HDInsight, https://azure.microsoft.com/en-us/services/hdinsight/, Accessed: 2018-10-1.
[9] Cloud Dataproc, https://cloud.google.com/dataproc/, Accessed: 2018-10-1.
[10] OpenStack Sahara, Accessed: 2018-10-8, https://docs.openstack.org/sahara/latest/, Accessed: 2018-10-1.
[11] OpenStack, https://www.openstack.org/, Accessed: 2018-10-1.
[12] Alex Glikson, Stefan Nastic, Schahram Dustdar, Deviceless edge computing: extending serverless computing to the edge of the network, in: Conference: the 10th ACM International Systems and Storage Conference, 2017.
[13] Eric Jonas, Qifan Pu, Shivaram Venkataraman, Ion Stoica, Benjamin Recht, Occupy the cloud: distributed computing for the 99%, in: Proceedings of the 2017 Symposium on Cloud Computing, 2017, pp. 445–451.
[14] Mengting Yan, Paul Castro, Perry Cheng, Vatche Ishakian, Building a chatbot with serverless computing, in: MOTA '16 Proceedings of the 1st International Workshop on Mashups of Things and APIs, 2016.
[15] AWS Lambda, https://aws.amazon.com/lambda/, Accessed: 2018-10-1.
[16] WoSC, https://www.serverlesscomputing.org/wosc17/, Accessed: 2018-10-1.
[17] Lambda MapReduce, https://aws.amazon.com/blogs/compute/ad-hoc-big-data-processing-made-simple-with-serverless-mapreduce/, Accessed: 2018-10-1.
[18] PyWren, https://github.com/pywren/pywren, Accessed: 2018-10-1.
[19] Ooso, https://github.com/d2si-oss/ooso, Accessed: 2018-10-1.
[20] Corral, https://github.com/bcongdon/corral, Accessed: 2018-10-8.
[21] Kamil Figiela, Adam Gajek, Adam Zima, Beata Obrok, Maciej Malawski, Performance evaluation of heterogeneous cloud functions, Concurrency Comput. (2018).
[22] Hyungro Lee, Kumar Satyam, Geoffrey Fox, Evaluation of production serverless computing environments, in: 2018 IEEE 11th International Conference on Cloud Computing (CLOUD), 2018.
[23] Wes Lloyd, Shruti Ramesh, Swetha Chinthalapati, Lan Ly, Shrideep Pallickara, Serverless computing: an investigation of factors influencing microservice performance, in: Cloud Engineering (IC2E), 2018 IEEE International Conference on, IEEE, 2018, pp. 159–169.
[24] S3 Scalability, https://aws.amazon.com/blogs/aws/amazon-s3-performance-tips-tricks-seattle-hiring-event/, Accessed: 2018-09-25.
[25] Amplab benchmark, https://amplab.cs.berkeley.edu/benchmark/, Accessed: 2018-10-1.
[26] Andrew Pavlo, Erik Paulson, Alexander Rasin, Daniel J. Abadi, David J. DeWitt, Samuel Madden, Michael Stonebraker, A comparison of approaches to large-scale data analysis, in: SIGMOD 2009, 2009.
[27] Simson L. Garfinkel, An evaluation of amazon's grid computing services: ec2, s3, and sqs, in: Harvard Computer Science Group Technical Report TR-08-07, 2007.

[28] Laing Wang, Mengyuan Li, Yinqian Zhang, Thomas Ristenpart, Michael Swift, Peeking behind the curtains of serverless platforms, in: Annual Technical Conference, 2018.
[29] Configuring Lambda functions, https://docs.aws.amazon.com/lambda/latest/dg/resource-model.html, Accessed: 2018-09-24.
[30] Amazon S3 request rate, https://docs.aws.amazon.com/AmazonS3/latest/dev/request-rate-perf-considerations.html, Accessed: 2018-12-19.
[31] S3 Multipart Upload, https://docs.aws.amazon.com/AmazonS3/latest/dev/qfacts.html, Accessed: 2018-09-25.

Vicent Giménez Alventosa received BSc + MSc. Degree in Physics, Master's Degree in Advanced Physics from the Universitat de València (UV), Spain, in 2014 and 2015, respectively. Master's Degree in Parallel and Distributed Computing from the Universitat Politécnica de Valéncia (UPV), Spain, in 2017. He has been a member of the Grid and High Performance Computing research group (GRyCAP) at the Institute for Molecular Imaging (I3M) since 2018 where he started his PhD.

Germán Moltó received BSc and PhD degrees in Computer Science from the Universitat Politécnica de Valéncia (UPV), Spain, in 2002 and 2007, respectively. He has been a member of the Grid and High Performance Computing research group (GRyCAP) at the Institute for Molecular Imaging (I3M) since 2002. He is also an associate professor in the Department of Computer Systems and Computation (DSIC) at UPV. He has participated in several European projects and led national research projects in the area of cloud computing. His broad research interests are cloud computing and scientific computing.

Miguel Caballer obtained BSc, MSc, and PhD degrees in Computer Science from the Universitat Politécnica de Valéncia (UPV), Spain, in 2000, 2012, and 2014, respectively. He has been a member of the Grid and High Performance Computing research group at the Institute for Molecular Imaging (I3M) since 2001. He has participated in several European and national research projects related to the application of parallel, grid, and cloud computing techniques to various areas of engineering. His other fields of interest include green computing.

5.1.1.25. Accelerated serverless computing based on GPU virtualization

D. M. Naranjo, S. Risco, C. de Alfonso, A. Pérez, I. Blanquer, and G. Moltó, "Accelerated serverless computing based on GPU virtualization," J. Parallel Distrib. Comput., vol. 139, pp. 32–42, May 2020, doi: https://dx.doi.org/10.1016/j.jpdc.2020.01.004

Base de datos de indexación	Web of Science / JCR
Índice de impacto	2.296
Año	2019
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	35 de 108
Tercil	T1
Cuartil	Q1
Número de citas en JCR	1
Número de citas totales	3

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional (RETOS I+D) BigCLOE (TIN2016-79951-R), liderado por el candidato, y utilizó la plataforma de computación intensiva basada en GPUs creada gracias al soporte económico recibido mediante la ayuda regional IDIFEDER/2018/032. Se trata de uno de los resultados de la Tesis Doctoral de Diana María Naranjo, titulada "Serverless Computing Strategies on Cloud Platforms", co-dirigida por el candidato, que integra el uso de computación basada en GPUs con serverless computing en nuestra herramienta de código abierto para soportar la ejecución de aplicaciones científicas bajo el modelo FaaS denominada OSCAR, disponible en GitHub en: https://github.com/grycap/oscar. El caso de uso de procesado de imágenes de ecografía transtorácica se obtuvo mediante la colaboración con la empresa QUIBIM

Journal of Parallel and Distributed Computing 139 (2020) 32–42

Contents lists available at ScienceDirect

J. Parallel Distrib. Comput.

journal homepage: www.elsevier.com/locate/jpdc

Accelerated serverless computing based on GPU virtualization

Diana M. Naranjo *, Sebastián Risco, Carlos de Alfonso, Alfonso Pérez, Ignacio Blanquer, Germán Moltó

Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC - Universitat Politècnica de València, Camino de Vera s/n, 46022, Valencia, Spain

ARTICLE INFO

Article history:
Received 3 May 2019
Received in revised form 15 January 2020
Accepted 16 January 2020
Available online 25 January 2020

Keywords:
Serverless computing
GPUs
GPU virtualization

ABSTRACT

This paper introduces a platform to support serverless computing for scalable event-driven data processing that features a multi-level elasticity approach combined with virtualization of GPUs. The platform supports the execution of applications based on Docker containers in response to file uploads to a data storage in order to perform the data processing in parallel. This is managed by an elastic Kubernetes cluster whose size automatically grows and shrinks depending on the number of files to be processed. To accelerate the processing time of each file, several approaches involving virtualized access to GPUs, either locally or remote, have been evaluated. A use case that involves the inference based on deep learning techniques on transthoracic echocardiography imaging has been carried out to assess the benefits and limitations of the platform. The results indicate that the combination of serverless computing and GPU virtualization introduce an efficient and cost-effective event-driven accelerated computing approach that can be applied for a wide variety of scientific applications.

1. Introduction

Serverless computing [25] stands out as a computing paradigm that has been widely adopted by the industry for ultra-scalable event-driven processing on abstracted computational Clouds. Major public Cloud providers such as Amazon Web Services [3] have included services such as AWS Lambda [5] to support the definition and managed execution of functions. Those functions, coded in the supported programming languages, can be executed in response to certain events such as an HTTP request to an API Gateway [45] or a file upload to an object storage service, such as Amazon S3 [4]. AWS Lambda provides a convenient platform for processing a large number of short stateless independent jobs. To be more precise, up to 3000 parallel invocations is currently supported for up to 15 min of execution time using ephemeral storage and without the ability to perform communications among the invocations since no incoming TCP connections are supported.

Indeed, serverless computing has been widely adopted to support multiple use cases such as creating scalable web sites, real-time file processing, real-time stream processing, and Extract, Transform and Load (ETL) processes, as indicated in the work by Lynn et al. [30].

However, the following limitations of current serverless platforms offered by major public Cloud providers impose a serious restriction for their adoption in the scientific computing domain: (i) limited maximum execution time, unfeasible for long-running scientific applications; (ii) limited resources, since resource-intensive scientific applications may require beyond 3008 MB of RAM (current maximum memory size of AWS Lambda); (iii) restricted execution environment, since scientific applications typically require a wide variety of libraries; (iv) limited ephemeral storage, since 512 MB of disk space is insufficient to host the execution of applications with large dependencies and (v) inability to access GPU resources within the function invocation for intensive workloads.

To this aim, a myriad of open-source serverless frameworks supporting the Functions as a Service (FaaS) [12] computing paradigm have surged in the last years, such as OpenFaaS [11] and Knative [16]. They execute functions, coded in certain programming languages, in response to HTTP events and other sources of events and typically rely on pre-provisioned computing platforms based on Container Orchestration Platforms (COP) such as Kubernetes [28] and Apache Mesos [7,20]. These platforms are typically oriented to the execution of bursts of short HTTP-based requests, since they intend to mimic the functionality offered by their public Cloud providers counterparts.

However, serverless computing for data-processing scientific applications typically exhibit the following unique requirements: (i) execution of long resource-intensive jobs; (ii) ability to profit from accelerated computing supported by GPUs; (iii) ability to

* Corresponding author.
E-mail addresses: dnaranjo@i3m.upv.es (D.M. Naranjo), serisgal@i3m.upv.es (S. Risco), caralla@upv.es (C. de Alfonso), alpegon3@upv.es (A. Pérez), iblanque@dsic.upv.es (I. Blanquer), gmolto@dsic.upv.es (G. Moltó).

https://doi.org/10.1016/j.jpdc.2020.01.004
0743-7315/

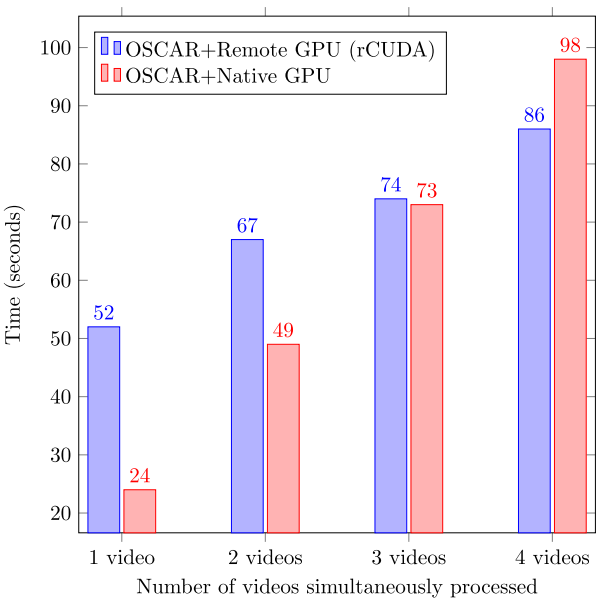


Fig. 9. Execution times for processing up to 4 videos (180 frames) in scenario 3 and 4.

platforms. The integration of rCUDA into the OSCAR architecture constitutes an important advance in serverless computing and in the shared access of a GPU by multiple applications in a Kubernetes cluster.

Future work involves the integration of a plugin of Kubernetes with the aim of eliminating the bottleneck introduced in the processing of several videos simultaneously and thus sharing a GPU among multiple pods. In addition, the integration of OSCAR with SCAR is intended to achieve hybrid workloads based in on-premises and public Clouds.

Declaration of competing interest

No author associated with this paper has disclosed any potential or pertinent conflicts which may be perceived to have impending conflict with this work. For full disclosure statements refer to https://doi.org/10.1016/j.jpdc.2020.01.004.

CRediT authorship contribution statement

Diana M. Naranjo: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Data curation, Writing - original draft, Writing - review & editing, Visualization, Project administration. **Sebastián Risco:** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Data curation, Writing - original draft, Writing - review & editing, Visualization. **Carlos de Alfonso:** Conceptualization, Methodology, Writing - original draft, Resources. **Alfonso Pérez:** Conceptualization, Methodology, Writing - original draft. **Ignacio Blanquer:** Conceptualization, Methodology, Validation, Writing - original draft, Writing - review & editing, Funding acquisition. **Germán Moltó:** Conceptualization, Methodology, Validation, Writing - original draft, Writing - review & editing, Visualization, Supervision, Funding acquisition.

Acknowledgments

The work presented in this article has been partially funded by a research grant from the regional government of the Comunitat Valenciana (Spain), co-funded by the European Union ERDF funds (European Regional Development Fund) of the Comunitat Valenciana 2014–2020, with reference IDIFEDER/2018/032 (High-Performance Algorithms for the Modeling, Simulation and early Detection of diseases in Personalized Medicine). The authors would also like to thank the Spanish "Ministerio de Economía, Industria y Competitividad" for the project "BigCLOE" with reference number TIN2016-79951-R and the project ATMOSPHERE, funded jointly by the European Commission under the Cooperation Programme, Horizon 2020 grant agreement No 777154 and the Brazilian Ministério de Ciência, Tecnologia e Inovação (MCTI), number 51119. D.M.N would like to thank the "Generalitat Valenciana, Spain" for the grant GrisolíaP/2017/071.

References

[1] C. de Alfonso, M. Caballer, F. Alvarruiz, V. Hernández, An energy management system for cluster infrastructures, Comput. Electr. Eng. 39 (8) (2013) 2579–2590, URL http://www.sciencedirect.com/science/article/pii/S0045790613001365.
[2] Alibaba, Alibaba Cloud Function Compute, URL https://www.alibabacloud.com/products/function-compute.
[3] Amazon, Amazon Web Services (AWS), URL http://aws.amazon.com.
[4] Amazon, Amazon Simple Storage Service (Amazon S3), URL http://aws.amazon.com/s3/.
[5] Amazon Web Services, AWS Lambda, URL https://aws.amazon.com/lambda.
[6] Apache, OpenWhisk, URL https://openwhisk.apache.org/.
[7] Apache Mesos, URL http://mesos.apache.org/.
[8] M. Caballer, I. Blanquer, G. Moltó, C. de Alfonso, Dynamic management of virtual infrastructures, J. Grid Comput. 13 (1) (2015) 53–70, http://dx.doi.org/10.1007/s10723-014-9296-5, URL http://link.springer.com/article/10.1007/s10723-014-9296-5.
[9] E. Camacho-Ramos, A. Jimenez-Pastor, I. Blanquer, F. García-Castro, A. Alberich-Bayarri, Computer Aided Diagnosis for Rheumatic Heart Disease by AI Applied to Features Extraction from Echocardiography.
[10] J. Duato, A.J. Pena, F. Silla, R. Mayo, E.S. Quintana-Orti, rCUDA: Reducing the number of GPU-based accelerators in high performance clusters, in: 2010 International Conference on High Performance Computing & Simulation, IEEE, 2010, pp. 224–231, http://dx.doi.org/10.1109/HPCS.2010.5547126, URL http://ieeexplore.ieee.org/document/5547126/.
[11] A. Ellis, OpenFaaS, URL https://www.openfaas.com/.
[12] E. van Eyk, A. Iosup, S. Seif, M. Thömmes, The SPEC cloud group's research vision on FaaS and serverless architectures, in: Proceedings of the 2nd International Workshop on Serverless Computing - WoSC '17, 2017, pp. 1–4, http://dx.doi.org/10.1145/3154847.3154848, URL http://dl.acm.org/citation.cfm?doid=3154847.3154848.
[13] Fission, URL https://fission.io/.
[14] V. Giménez-Alventosa, G. Moltó, M. Caballer, A framework and a performance assessment for serverless MapReduce on AWS Lambda, Future Gener. Comput. Syst. (2019) http://dx.doi.org/10.1016/j.future.2019.02.057, URL https://linkinghub.elsevier.com/retrieve/pii/S0167739X18325172.
[15] G. Giunta, R. Montella, G. Agrillo, G. Coviello, A GPGPU transparent virtualization component for high performance computing clouds, in: P. D'Ambra, M. Guarracino, D. Talia (Eds.), Euro-Par 2010 - Parallel Processing, Springer Berlin Heidelberg, Berlin, Heidelberg, 2010, pp. 379–391.
[16] Google, Knative, URL https://github.com/knative/.
[17] Google, Google Cloud Functions, URL https://cloud.google.com/functions/.
[18] Google, Tensorflow, URL https://www.tensorflow.org/.
[19] V. Gupta, A. Gavrilovska, K. Schwan, H. Kharche, N. Tolia, V. Talwar, P. Ranganathan, GViM: GPU-accelerated virtual machines, in: Proceedings of the 3rd ACM Workshop on System-Level Virtualization for High Performance Computing, HPCVirt '09, ACM, New York, NY, USA, 2009, pp. 17–24, http://dx.doi.org/10.1145/1519138.1519141, URL http://doi.acm.org/10.1145/1519138.1519141.
[20] B. Hindman, A. Konwinski, M. Zaharia, A. Ghodsi, A.D. Joseph, R. Katz, S. Shenker, I. Stoica, Mesos: A Platform for Fine-Grained Resource Sharing in the Data Center, USENIX Association, 2011, pp. 295–308, URL http://dl.acm.org/citation.cfm?id=1972457.1972488.
[21] IBM, IBM Cloud Functions, URL https://www.ibm.com/cloud/functions.
[22] V. Ishakian, V. Muthusamy, A. Slominski, Serving deep learning models in a serverless platform, in: 2018 IEEE International Conference on Cloud Engineering, IC2E, 2018, pp. 257–262, http://dx.doi.org/10.1109/IC2E.2018.00052.
[23] A. Jimenez-Pastor, A. Alberich-Bayarri, F. Garcia-Castro, L. Marti-Bonmati, Automatic visceral fat characterisation on CT scans through deep learning and CNN for the assessment of metabolic syndrome, in: ECR 2019: Book of Abstracts. Insights Into Imaging, Vol. 10 (S1), 2019.

[24] E. Jonas, Q. Pu, S. Venkataraman, I. Stoica, B. Recht, Occupy the cloud: distributed computing for the 99%, in: Proceedings of the 2017 Symposium on Cloud Computing - SoCC '17, ACM Press, New York, New York, USA, 2017, pp. 445–451, http://dx.doi.org/10.1145/3127479.3128601, arXiv:1702.04024, URL http://dl.acm.org/citation.cfm?doid=3127479.3128601.

[25] E. Jonas, J. Schleier-Smith, V. Sreekanti, C.-C. Tsai, A. Khandelwal, Q. Pu, V. Shankar, J.M. Carreira, K. Krauth, N. Yadwadkar, J. Gonzalez, R.A. Popa, D.A. Patterson, J. Carreira, J.E. Gonzalez, Cloud Programming Simplified: A Berkeley View on Serverless Computing, Tech. Rep., 2019, http://arxiv.org/abs/1902.03383, URL http://www2.eecs.berkeley.edu/Pubs/TechRpts/2019/EECS-2019-3.html.

[26] Keras, Keras, URL https://keras.io/.

[27] J. Kim, T.J. Jun, D. Kang, D. Kim, D. Kim, GPU enabled serverless computing framework, in: 2018 26th Euromicro International Conference on Parallel, Distributed and Network-Based Processing, PDP, 2018, pp. 533–540, http://dx.doi.org/10.1109/PDP2018.2018.00090.

[28] Kubernetes, Kubernetes, URL https://kubernetes.io/.

[29] U. Kurkure, Episode 3: Performance comparison of native GPU to virtualized GPU and scalability of virtualized GPUs for machine learning, 2017, URL https://blogs.vmware.com/performance/2017/10/episode-3-performance-comparison-native-gpu-virtualized-gpu-scalability-virtualized-gpus-machine-learning.html.

[30] T. Lynn, P. Rosati, A. Lejeune, V. Emeakaroha, A preliminary review of enterprise serverless cloud computing (function-as-a-service) platforms, in: Proceedings of the International Conference on Cloud Computing Technology and Science, CloudCom, Vol. 2017-Decem, IEEE, 2017, pp. 162–169, http://dx.doi.org/10.1109/CloudCom.2017.15, URL http://ieeexplore.ieee.org/document/8241104/.

[31] Microsoft, Microsoft Azure Functions, URL https://azure.microsoft.com/en-us/services/functions/.

[32] Microsoft, Microsoft Cognitive Toolkit, URL https://www.microsoft.com/en-us/cognitive-toolkit/.

[33] MinIO, URL https://min.io.

[34] B.R. Nascimento, A.Z. Beaton, M.C.P. Nunes, A.C. Diamantino, G.A. Carmo, K.K. Oliveira, C.M. Oliveira, Z.M.A. Meira, S.R.T. Castilho, E.L. Lopes, I.M. Castro, V.M. Rezende, G. Chequer, T. Landay, A. Tompsett, A.L.P. Ribeiro, C. Sable, Echocardiographic prevalence of rheumatic heart disease in Brazilian schoolchildren: Data from the PROVAR study, Int. J. Cardiol. 219 (2016) 439–445, http://dx.doi.org/10.1016/j.ijcard.2016.06.088, URL http://www.sciencedirect.com/science/article/pii/S0167527316310907.

[35] Nuclio, URL https://nuclio.io/.

[36] NVIDIA, What is a virtual GPU, 2018, URL https://blogs.nvidia.com/blog/2018/06/11/what-is-a-virtual-gpu/.

[37] Open Container Initiative, URL https://www.opencontainers.org/.

[38] Oracle, Fn Project, URL https://fnproject.io/.

[39] A. Pérez, G. Moltó, M. Caballer, A. Calatrava, Serverless computing for container-based architectures, Future Gener. Comput. Syst. 83 (2018) 50–59, http://dx.doi.org/10.1016/j.future.2018.01.022, URL http://linkinghub.elsevier.com/retrieve/pii/S0167739X17316485.

[40] F. Pérez, C. Reaño, F. Silla, Providing CUDA acceleration to KVM virtual machines in InfiniBand clusters with rCUDA, in: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol. 9687, 2016, pp. 82–95, http://dx.doi.org/10.1007/978-3-319-39577-7_7, URL https://link.springer.com/chapter/10.1007/978-3-319-39577-7{_7}.

[41] A. Pérez, S. Risco, D.M. Naranjo, M. Caballer, G. Moltó, Serverless computing for event-driven data processing applications, in: 2019 IEEE International Conference on Cloud Computing, CLOUD 2019, 2019.

[42] Pivotal, Project riff, URL https://projectriff.io/.

[43] C. Reano, F. Silla, A performance comparison of CUDA remote GPU virtualization frameworks, in: 2015 IEEE International Conference on Cluster Computing, IEEE, 2015, pp. 488–489, http://dx.doi.org/10.1109/CLUSTER.2015.76, URL http://ieeexplore.ieee.org/document/7307623/.

[44] C. Reaño, F. Silla, G. Shainer, S. Schultz, Local and remote GPUs perform similar with EDR 100G InfiniBand, in: Proceedings of the Industrial Track of the 16th International Middleware Conference on ZZZ - Middleware Industry '15, ACM Press, New York, New York, USA, 2015, pp. 1–7, http://dx.doi.org/10.1145/2830013.2830015, URL http://dl.acm.org/citation.cfm?doid=2830013.2830015.

[45] A.W. Services, API Gateway, URL https://aws.amazon.com/api-gateway.

[46] V. Shankar, K. Krauth, Q. Pu, E. Jonas, S. Venkataraman, I. Stoica, B. Recht, J. Ragan-Kelley, Numpywren: serverless linear algebra, 2018, URL https://arxiv.org/abs/1810.09679.

[47] L. Shi, H. Chen, J. Sun, K. Li, vCUDA: GPU-accelerated high-performance computing in virtual machines, IEEE Trans. Comput. 61 (6) (2012) 804–816, http://dx.doi.org/10.1109/TC.2011.112.

[48] J. Spillner, C. Mateos, D.A. Monge, Faaster, better, cheaper: the prospect of serverless scientific computing and HPC, in: Communications in Computer and Information Science, Vol. 796, Springer, Cham, 2018, pp. 154–168, http://dx.doi.org/10.1007/978-3-319-73353-1_11, URL http://link.springer.com/10.1007/978-3-319-73353-1{_11}.

[49] Y. Suzuki, S. Kato, H. Yamada, K. Kono, GPUvm: GPU virtualization at the hypervisor, IEEE Trans. Comput. 65 (9) (2016) 2752–2766, http://dx.doi.org/10.1109/TC.2015.2506582.

[50] H. Tan, Y. Tan, X. He, K. Li, K. Li, A virtual multi-channel GPU fair scheduling method for virtual machines, IEEE Trans. Parallel Distrib. Syst. 30 (2) (2019) 257–270, http://dx.doi.org/10.1109/TPDS.2018.2865341.

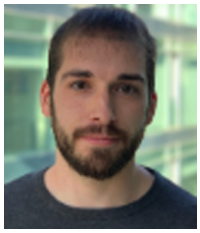
[51] M. Ujaldón, CUDA achievements and GPU challenges ahead, in: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol. 9756, 2016, pp. 207–217, http://dx.doi.org/10.1007/978-3-319-41778-3_20, URL https://link.springer.com/chapter/10.1007/978-3-319-41778-3{_20}.

[52] L. Vu, H. Sivaraman, R. Bidarkar, GPU virtualization for high performance general purpose computing on the ESX hypervisor, in: Simulation Series, vol. 46, 2014.

[53] J.P. Walters, A.J. Younge, D.I. Kang, K.T. Yao, M. Kang, S.P. Crago, G.C. Fox, GPU passthrough performance: A comparison of KVM, Xen, VMWare ESXi, and LXC for CUDA and OpenCL applications, in: 2014 IEEE 7th International Conference on Cloud Computing, 2014, pp. 636–643, http://dx.doi.org/10.1109/CLOUD.2014.90.

[54] H. Yu, C.J. Rossbach, Full Virtualization for GPUs Reconsidered, 2017.

Diana M. Naranjo, Degree in Telecommunications and Electronics from the University of Pinar del Río "Hermanos Saíz Montes de Oca", Cuba, from 2010 to 2015. She is a member of the Grid and High Performance Computing (GRyCAP) research group of the Institute of Molecular Imaging (I3M) since 2017, where she conducts her doctoral studies in research related to Big Data, high-performance computing in container-based and serverless infrastructures.



Sebastián Risco received BSc degree in Computer Engineering from the Universitat Politècnica de València (UPV), Spain, in 2017. In 2017 he started his MSc degree in Information Management. He joined the Grid and High Performance Computing research group (GRyCAP) in 2018, while he worked on his Master's Thesis. His research interests are focused in Serverless Computing, Cloud Computing and Container Orchestration Systems.

Carlos de Alfonso obtained the B.Sc., M.Sc. and Ph.D. degrees in Computer Science from the Universitat Politècnica de València (UPV), Spain, in 2000 and 2015. In 2000 he joined the Grid and High Performance Computing research group, at UPV. Since 2007 he is a Technician for the Support of Research at UPV, with a profile of Grid and Cloud computing. He has been part of several national, European and international projects and contracts in the fields of Grid. During the last years he has oriented his activity mainly to Cloud Computing, and Containerization of Workloads for HPC.

Alfonso Pérez received BSc + MSc. degrees in Computer Science and MSc. degree in Computer Engineering from the Universitat Politècnica de València (UPV), Spain, in 2011 and 2014, respectively. In 2011 he initiated his research career working in medical informatics projects related with clinical prediction models and computer interpretable guidelines. He has been member of the Grid and High Performance Computing research group (GRyCAP) at the Institute for Molecular Imaging (I3M) since 2015 where he began doing research work related with automatic cluster deployment and elasticity. In 2016 he started his PhD in the field of Big Data and High Throughput Computing on Container-based and Serverless Infrastructures.

Ignacio Blanquer, associate professor of the Computer System Department at UPV since 1999 (currently accredited to full professor), has been a member of GRyCAP since 1993, and he leads the group since 2016. He has been involved in Parallel Computation and Medical Image processing, participating in more than 55 national and European Research Projects, has authored and co-authored 40 articles in indexed journals and book chapters and in more than 90 papers in national and international journals and conference proceedings. He has served as coordinator of the application area in the Spanish Network for e-Science, including his role in the managerial board was Community Manager in VENUS-C, where he collected and evaluated user requirements and provided hands-on support for migration to the cloud of 27 applications. He has been the project coordinator of EUBrazilCloudConnect (FP7), EUBRazil-BIGSEA (H2020) and CLUVIEM (national research project), and currently is the project coordinator of ATMOSPHERE (H2020) and co-principal investigator in the BigCLOE national research project.

Germán Moltó received B.Sc. and Ph.D. degrees in Computer Science from the Universitat Politècnica de València (UPV), Spain, in 2002 and 2007, respectively. He has been a member of the Grid and High Performance Computing research group (GRyCAP) at the Institute for Molecular Imaging (I3M) since 2002. He is also an associate professor in the Department of Computer Systems and Computation (DSIC) at UPV. He has participated in several European projects and led national research projects in the area of cloud computing. His broad research interests are cloud computing and scientific computing.

5.1.1.26. A Cloud-Based Framework for Machine Learning Workloads and Applications

A. Lopez Garcia et al., "A Cloud-Based Framework for Machine Learning Workloads and Applications," IEEE Access, vol. 8, pp. 18681–18692, 2020, doi: https://dx.doi.org/10.1109/ACCESS.2020.2964386

Base de datos de indexación	Web of Science / JCR
Índice de impacto	3.745
Año	2019
Categoría	Computer Science, Information Systems
Posición de la revista en el área	35 de 156
Tercil	T1
Cuartil	Q1
Número de citas en JCR	1
Número de citas totales	9

Comentario. Este artículo representa el principal resultado académico del proyecto Europeo Horizon 2020 DEEP Hybrid-DataCloud (777435) que describe la creación de una plataforma para el entrenamiento y el ofrecimiento como servicio de modelos de inteligencia artificial (AI) y de aprendizaje profundo (Deep Learning). El candidato desempeñó el rol de Deputy Work Package leader del paquete de trabajo encargado de las interfaces de usuario. También participó en la tarea encargada del modelado gráfico de las arquitecturas de aplicaciones mediante la especificación TOSCA, usando una versión de Alien4Cloud modificada por nuestro equipo para alinearla con la versión 1.3 en YAML del estándar de TOSCA, además de la creación de un plugin para el Infrastructure Manager (IM). Dichas contribuciones al proyecto de código abierto están disponibles en: https://github.com/indigo-dc/alien4cloud-deep

IEEE Access
Multidisciplinary : Rapid Review : Open Access Journal

Received December 20, 2019, accepted December 31, 2019, date of publication January 6, 2020, date of current version January 30, 2020.

Digital Object Identifier 10.1109/ACCESS.2020.2964386

A Cloud-Based Framework for Machine Learning Workloads and Applications

ÁLVARO LÓPEZ GARCÍA[1], JESÚS MARCO DE LUCAS[1], MARICA ANTONACCI[3], WOLFGANG ZU CASTELL[9,10], MARIO DAVID[2], MARCUS HARDT[6], LARA LLORET IGLESIAS[1], GERMÁN MOLTÓ[7], MARCIN PLOCIENNIK[5], VIET TRAN[8], ANDY S. ALIC[7], MIGUEL CABALLER[7], ISABEL CAMPOS PLASENCIA[1], ALESSANDRO COSTANTINI[4], STEFAN DLUGOLINSKY[8], DOINA CRISTINA DUMA[4], GIACINTO DONVITO[3], JORGE GOMES[2], IGNACIO HEREDIA CACHA[1], KEIICHI ITO[9], VALENTIN Y. KOZLOV[6], GIANG NGUYEN[8], PABLO ORVIZ FERNÁNDEZ[1], ZDENĚK ŠUstr[11], AND PAWEL WOLNIEWICZ[5]

[1]IFCA (CSIC-UC), 39005 Santander, Spain
[2]Laboratory of Instrumentation and Experimental Particle Physics, 1600-078 Lisbon, Portugal
[3]INFN Bari, 70126 Bari, Italy
[4]INFN CNAF, 40127 Bologna, Italy
[5]Poznan Supercomputing and Networking Center, IBCh PAS, 61-704 Poznan, Poland
[6]Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany
[7]Instituto de Instrumentación para Imagen Molecular (I3M), CSIC, Universitat Politècnica de València, 46022 Valencia, Spain
[8]Institute of Informatics, Slovak Academy of Sciences (IISAS), 845 07 Bratislava, Slovakia
[9]Helmholtz Zentrum München, Deutsches Forschungszentrum für Gesundheit, 85764 Oberschleißheim, Germany
[10]Department of Mathematics, Technische Universität München, 85748 Munich, Germany
[11]CESNET, 160 00 Prague, Czech Republic

Corresponding author: Álvaro López García (aloga@ifca.unican.es)

This work was supported by the project DEEP-Hybrid-DataCloud "Designing and Enabling E-infrastructures for intensive Processing in a Hybrid DataCloud" that has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant 777435.

ABSTRACT In this paper we propose a distributed architecture to provide machine learning practitioners with a set of tools and cloud services that cover the whole machine learning development cycle: ranging from the models creation, training, validation and testing to the models serving as a service, sharing and publication. In such respect, the DEEP-Hybrid-DataCloud framework allows transparent access to existing e-Infrastructures, effectively exploiting distributed resources for the most compute-intensive tasks coming from the machine learning development cycle. Moreover, it provides scientists with a set of Cloud-oriented services to make their models publicly available, by adopting a serverless architecture and a DevOps approach, allowing an easy share, publish and deploy of the developed models.

INDEX TERMS Cloud computing, computers and information processing, deep learning, distributed computing, machine learning, serverless architectures.

I. INTRODUCTION

The impact of emerging computing techniques together with an increasing dimension of large datasets and the availability of more and more performing and accessible computing resources is transforming many research areas. This opens the door to new opportunities to tackle unprecedented research challenges. Over the last decade there has been a boost on the usage of machine learning techniques in most of the research areas, and recently it has even improved with the adoption of deep learning techniques, e.g. LeCun et al. [1]. Although the basic components of the techniques are well known, recent advances arouse the interest from the scientific community towards this area, and it has already become a state-of-the-art technology in many fields, from computer vision to speech recognition.

The performance increase in the existing computing technologies and the availability of specialized computing devices played an important role in the advent of deep learning. In particular, the availability of more efficient and

The associate editor coordinating the review of this manuscript and approving it for publication was Liangxiu Han.

[66] D. Sculley, G. Holt, D. Golovin, E. Davydov, T. Phillips, D. Ebner, V. Chaudhary, M. Young, J.-F. Crespo, and D. Dennison, "Hidden technical debt in machine learning systems," in *Proc. Adv. Neural Inf. Process. Syst.*, 2015, pp. 2503–2511.

[67] C. Castellani and M. Edwards, Eds., *Marine Plankton: A Practical Guide to Ecology, Methodology, and Taxonomy*, vol. 1. London, U.K.: Oxford Univ. Press, 2017.

[68] C. Sieracki, M. Sieracki, and C. Yentsch, "An imaging-in-flow system for automated analysis of marine microplankton," *Mar. Ecol. Prog. Ser.*, vol. 168, pp. 285–296, Jul. 1998.

[69] L. Lloret, I. Heredia, F. Aguilar, E. Debusschere, K. Deneudt, and F. Hernandez, "Convolutional neural networks for phytoplankton identification and classification," *Biodiversity Inf. Sci. Standards*, vol. 2, May 2018, Art. no. e25762.

[70] I. Heredia and L. L. Iglesias, "Image classification engine," Tech. Rep., 2019. [Online]. Available: http://hdl.handle.net/10261/194498, doi: 10.20350/digitalCSIC/9892.

[71] I. Heredia and L. L. Iglesias, "Plants classification engine," Tech. Rep., 2019. [Online]. Available: http://hdl.handle.net/10261/194545, doi: 10.20350/digitalCSIC/9895.

[72] K. Ueda, "Inaturalist research-grade observations," Inaturalist. org. Occurrence Dataset, Tech. Rep., 2017. [Online]. Available: https://www.gbif.org/dataset/50c9509d-22c7-4a22-a47d-8c48425ef4a7, doi: 10.15468/ab3s5x

[73] I. Heredia and L. L. Iglesias, "Seeds classification engine," Tech. Rep., 2018. [Online]. Available: http://hdl.handle.net/10261/194549, doi: 10.20350/digitalCSIC/9897.

[74] F. Pando, I. Heredia, and L. L. Iglesias, "Deep learning for weed identification based on seed images," *Biodiversity Inf. Sci. Standards*, vol. 2, May 2018, Art. no. e25749.

[75] I. Heredia and L. L. Iglesias, "Conus classification engine," Tech. Rep., 2019. [Online]. Available: http://hdl.handle.net/10261/194548, doi: 10.20350/digitalCSIC/9896.

5.1.1.27. A Visual Dashboard to Track Learning Analytics for Educational Cloud Computing

D. M. Naranjo, J. R. Prieto, G. Moltó, and A. Calatrava, "A Visual Dashboard to Track Learning Analytics for Educational Cloud Computing," Sensors, vol. 19, no. 13, p. 2952, Jul. 2019, doi: https://dx.doi.org/10.3390/s19132952

Base de datos de indexación	Web of Science / JCR
Índice de impacto	3.031
Año	2019
Categoría	Instruments & Instrumentation
Posición de la revista en el área	15 de 61
Tercil	T1
Cuartil	Q1
Número de citas en JCR	1
Número de citas totales	8

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional (RETOS I+D) BigCLOE (TIN2016-79951-R), liderado por el candidato, aplicado a un caso de uso educativo en el marco del proyecto PIME titulado "Comunidades de Aprendizaje como servicios en la nube para el desarrollo y evaluación automática de Competencias Transversales y Objetivos Formativos específicos". En él se desarrolla una plataforma serverless para obtener, procesar y visualizar métricas de progreso, junto con un panel a modo de dashboard accesible para profesores y alumnos, siendo utilizado para tareas de auto-regulación del aprendizaje. La contribución es uno de los resultados de la tesis de Diana María Naranjo, titulada "Serverless Computing Strategies on Cloud Platforms", co-dirigida por el candidato.Se trata de un artículo de investigación aplicado al ámbito de la educación. No es un trabajo de innovación educativa.

sensors

MDPI

Article

A Visual Dashboard to Track Learning Analytics for Educational Cloud Computing

Diana M. Naranjo *, José R. Prieto, Germán Moltó * and Amanda Calatrava *

Instituto de Instrumentación para Imagen Molecular (I3M), Centro Mixto CSIC—Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain

* Correspondence: dnaranjo@i3m.upv.es (D.M.N.); gmolto@dsic.upv.es (G.M.); amcaar@i3m.upv.es (A.C.)

Received: 10 April 2019; Accepted: 2 July 2019; Published: 4 July 2019

Abstract: Cloud providers such as Amazon Web Services (AWS) stand out as useful platforms to teach distributed computing concepts as well as the development of Cloud-native scalable application architectures on real-world infrastructures. Instructors can benefit from high-level tools to track the progress of students during their learning paths on the Cloud, and this information can be disclosed via educational dashboards for students to understand their progress through the practical activities. To this aim, this paper introduces CloudTrail-Tracker, an open-source platform to obtain enhanced usage analytics from a shared AWS account. The tool provides the instructor with a visual dashboard that depicts the aggregated usage of resources by all the students during a certain time frame and the specific use of AWS for a specific student. To facilitate self-regulation of students, the dashboard also depicts the percentage of progress for each lab session and the pending actions by the student. The dashboard has been integrated in four Cloud subjects that use different learning methodologies (from face-to-face to online learning) and the students positively highlight the usefulness of the tool for Cloud instruction in AWS. This automated procurement of evidences of student activity on the Cloud results in close to real-time learning analytics useful both for semi-automated assessment and student self-awareness of their own training progress.

Keywords: visual learning analytics; learning analytics; learning dashboards; cloud computing

1. Introduction

The last years have witnessed unprecedented advances in the education field with the rise of on-line education platforms and highly successful MOOCs (Massive Online Open Courses). These courses are powered by the technological advances in multimedia production and the widespread presence of high bandwidth communication networks across the globe. Indeed, there is a common trend in students wanting to learn anywhere and anytime without the inherent barriers of traditional face-to-face education [1]. This has paved the way for new educational approaches to surge such as blended learning [2], which combines online multimedia material with traditional face-to-face classroom, or flipped learning [3], a pedagogical approach in which instruction shifts away from the classroom into individual learning and the classroom is used as an interactive learning environment [4,5].

Computer Science and Computer Engineering degrees in higher education institutions have also embraced this change and are starting to adopt techniques to foster out-of-class activities. In the field of distributed computing there have been previous experiences by the authors adopting Cloud computing to support the management of online courses [6] and to deploy highly available massively scalable remote computational labs [7]. As described in the work by Gonzalez et al. [8], many higher education institutions are adopting Cloud computing to benefit from reduced maintenance costs, rationalization of resources and simplified operation. For this, public Cloud providers such as Amazon

students' activities when learning to interact with the different AWS services. Gathering these analytics and exposing them via easy-to-use web-based graphical dashboards allows students to discriminate between the activities carried out and those pending to be done. Finally, providing timely feedback to students with indications of the missing actions fosters self-regulation and the ability to achieve best practices for managing computational resources in AWS, such as terminating resources after finishing a lab session.

To the author's knowledge, there is no educational dashboard referenced in the literature that provides automated compilation of the student activity in AWS in a high-level educational dashboard. CloudTrail-Tracker has been released as an open-source development available in GitHub (CloudTrail-Tracker GitHub repository: https://github.com/grycap/cloudtrail-tracker) so that other teachers can adopt it and report feedback.

6. Conclusions

This paper has introduced CloudTrail-Tracker, a platform that provides usage insights of an AWS account, which has been used to provide automated gathering of evidences of the activities performed by students on a shared AWS account. This has been possible by processing the data gathered by the virtual sensors distributed across the supported AWS services that collect usage data of the platform and centralize it through the AWS CloudTrail service.

The system can run at barely zero cost on an AWS account and it includes both an event processing back-end and a web-based educational dashboard that provides teachers with further knowledge on the way students are using AWS to carry out the activities proposed. This educational dashboard has been customized to support several subjects across three Master's Degrees and an online course on AWS so that the teachers, and the students themselves, precisely know the degree of completion of each hands-on lab together with the actions missing with the aim of fostering student self-regulation. Also, the dashboard helps system administrators to detect irregularities in the usage of the resources.

The satisfaction results across a population of 64 students indicate that more than 90% of students are highly satisfied with the accessibility and the ease of use of CloudTrail-Tracker together with the facility to understand the information shown by the tool. They consider it an appropriate support tool for the education in AWS technologies, while there is room to improve the detail of information related to the progress of students for each lab activity.

Future work involves further customization of the information shown. For the teachers, we will include additional panels that show real-time monitoring across multiple services and regions in order to overcome the 15 min delay, to anticipate problems of excessive resource usage during a lab session. For the students, we plan to provide not only access to their history of events and degree of completion for each hands-on session, but also the average performance of their peers in the subject. For synchronous teaching activities we expect this to be a booster for students that tend to procrastinate. We also aim to provide additional detailed information concerning the missing actions for students to better understand what actions to be done next. Finally, we plan to introduce gamification techniques in the dashboard so that students can challenge themselves and other students to increase motivation when carrying out the activities.

Author Contributions: Conceptualization, G.M.; Methodology, G.M., D.M.N. and J.R.P.; Software, J.R.P. and D.M.N.; Investigation, G.M., D.M.N. and A.C.; Writing—Original Draft, G.M., D.M.N. and A.C.; Writing—Review & Editing, G.M. and D.M.N.; Supervision, G.M.; Funding Acquisition, G.M.

Funding: This research was funded by the Spanish Ministerio de Economía, Industria y Competitividad, grant number TIN2016-79951-R (BigCLOE) and by the Vicerrectorado de Estudios, Calidad y Acreditación of the Universitat Politècnica de València (UPV) to develop the PIME B29.

Acknowledgments: D.M.N. would like to thank the "Generalitat Valenciana" for the grant GrisolíaP/2017/071.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Gaebel, M.; Kupriyanova, V.; Morais, R.; Colucci, E. *E-Learning in European Higher Education Institutions: Results of a Mapping Survey Conducted in October–December 2013*; European University Association: Brussels, Belgium, 2014.
2. Porter, W.W.; Graham, C.R.; Spring, K.A.; Welch, K.R. Blended learning in higher education: Institutional adoption and implementation. *Comput. Educ.* **2014**, *75*, 185–195. [CrossRef]
3. Thai, N.T.T.; De Wever, B.; Valcke, M. The impact of a flipped classroom design on learning performance in higher education: Looking for the best "blend" of lectures and guiding questions with feedback. *Comput. Educ.* **2017**, *107*, 113–126. [CrossRef]
4. Chen, Y.; Wang, Y.; Kinshuk; Chen, N.S. Is FLIP enough? Or should we use the FLIPPED model instead? *Comput. Educ.* **2014**, *79*, 16–27. [CrossRef]
5. Baepler, P.; Walker, J.D.; Driessen, M. It's not about seat time: Blending, flipping, and efficiency in active learning classrooms. *Comput. Educ.* **2014**, *78*, 227–236. [CrossRef]
6. Moltó, G.; Caballer, M. On Using the Cloud to Support Online Courses. In Proceedings of the 2014 Frontiers in Education Conference (FIE), Madrid, Spain, 22–25 October 2014; pp. 330–338. [CrossRef]
7. Segrelles, J.D.; Moltó, G.; Caballer, M. Remote Computational Labs for Educational Activities via a Cloud Computing Platform. In Proceedings of the 2015 Information Systems Education Conference (ISECON), Orlando, FL, USA, 5–7 November 2015; pp. 309–321.
8. González-Martínez, J.A.; Bote-Lorenzo, M.L.; Gómez-Sánchez, E.; Cano-Parra, R. Cloud computing and education: A state-of-the-art survey. *Comput. Educ.* **2015**, *80*, 132–151. [CrossRef]
9. Amazon. AWS Cloudtrail. Available online: https://aws.amazon.com/cloudtrail/?nc1=h_ls (accessed on 12 July 2018).
10. Ferguson, R. Learning analytics: Drivers, developments and challenges. *Int. J. Technol. Enhanc. Learn.* **2012**, *4*, 304–317. [CrossRef]
11. Schwendimann, B.A.; Rodríguez-Triana, M.J.; Vozniuk, A.; Prieto, L.P.; Boroujeni, M.S.; Holzer, A.; Gillet, D.; Dillenbourg, P. Perceiving Learning at a Glance: A Systematic Literature Review of Learning Dashboard Research. *IEEE Trans. Learn. Technol.* **2017**, *10*, 30–41. [CrossRef]
12. Sedrakyan, G.; Malmberg, J.; Verbert, K.; Järvelä, S.; Kirschner, P.A. Linking learning behavior analytics and learning science concepts: Designing a learning analytics dashboard for feedback to support learning regulation. *Comput. Hum. Behav.* **2018**. [CrossRef]
13. Tabaa, Y.; Medouri, A. LASyM: A learning analytics system for MOOCs. *Int. J. Adv. Comput. Sci. Appl. (IJACSA)* **2013**, *4*, 5. [CrossRef]
14. Patwa, N.; Seetharaman, A.; Sreekumar, K.; Srinivas, P. Learning Analytics: Enhancing the Quality of Higher Education. *Res. J. Econ.* **2018**, *2*, 1–7.
15. Verbert, K.; Govaerts, S.; Duval, E.; Santos, J.L.; Van Assche, F.; Parra, G.; Klerkx, J. Learning dashboards: An overview and future research opportunities. *Pers. Ubiq. Comput.* **2014**, *18*, 1499–1514. [CrossRef]
16. Arnold, K.E.; Pistilli, M.D. Course Signals at Purdue: Using Learning Analytics to Increase Student Success. In Proceedings of the 2nd International Conference on Learning Analytics and Knowledge, Vancouver, BC, Canada, 29 April–2 May 2012; ACM: New York, NY, USA, 2012; pp. 267–270. [CrossRef]
17. Govaerts, S.; Verbert, K.; Duval, E.; Pardo, A. The Student Activity Meter for Awareness and Self-reflection. In *CHI '12 Extended Abstracts on Human Factors in Computing Systems*; CHI EA '12; ACM: New York, NY, USA, 2012; pp. 869–884.
18. Lin, C.H.; Hu, S.S.; Lai, H.Y.; Chiang, C.F.; Tseng, H.C.; Cheng, Y.C. VisCa: A Dashboard System to Visualize Learning Activities from E-learning Platforms. In *Emerging Technologies for Education*; Wu, T.T., Gennari, R., Huang, Y.M., Xie, H., Cao, Y., Eds.; Springer International Publishing: Cham, Switzerland, 2017; pp. 422–427.
19. Ali, L.; Hatala, M.; Gašević, D.; Jovanović, J. A Qualitative Evaluation of Evolution of a Learning Analytics Tool. *Comput. Educ.* **2012**, *58*, 470–489. [CrossRef]
20. Leony, D.; Pardo, A.; de la Fuente Valentín, L.; de Castro, D.S.; Kloos, C.D. GLASS: A Learning Analytics Visualization Tool. In Proceedings of the 2nd International Conference on Learning Analytics and Knowledge, Vancouver, BC, Canada, 29 April–2 May 2012; ACM: New York, NY, USA, 2012; pp. 162–163. [CrossRef]

21. Santos, J.L.; Verbert, K.; Duval, E. Empowering students to reflect on their activity with StepUp !: Two case studies with engineering students. In Proceedings of the EFEPLE11 2nd Workshop on Awareness and Reflection in Technology-Enhanced Learning, CEUR WS, Saarbrücken, Germany, 18 September 2012.
22. Vieira, C.; Parsons, P.; Byrd, V. Visual learning analytics of educational data: A systematic literature review and research agenda. *Comput. Educ.* **2018**, *122*, 119–135. [CrossRef]
23. Jivet, I.; Scheffel, M.; Specht, M.; Drachsler, H. License to Evaluate: Preparing Learning Analytics Dashboards for Educational Practice. In Proceedings of the 8th International Conference on Learning Analytics and Knowledge, Sydney, Australia, 7–9 March 2018; ACM: New York, NY, USA, 2018; pp. 31–40. [CrossRef]
24. Amazon. Amazon CloudWatch. Available online: https://aws.amazon.com/cloudwatch/?nc1=h_ls (accessed on 12 July 2018).
25. Spectrum. Available online: https://spectrumapp.io/ (accessed on 12 July 2018).
26. Opsview. Opsview Monitor. Available online: https://www.opsview.com/ (accessed on 12 July 2018).
27. SignalFx. Available online: https://signalfx.com/ (accessed on 12 July 2018).
28. SolarWinds. AWS Cloud Monitoring. Available online: https://www.solarwinds.com/topics/aws-monitoring (accessed on 12 July 2018).
29. Lonn, S.; Aguilar, S.J.; Teasley, S.D. Investigating student motivation in the context of a learning analytics intervention during a summer bridge program. *Comput. Hum. Behav.* **2015**, *47*, 90–97. [CrossRef]
30. Irons, A. *Enhancing Learning through Formative Assessment and Feedback*; Routledge: Abingdon, UK, 2007.
31. Molenaar, I.; Knoop-van Campen, C. Teacher dashboards in practice: Usage and impact. In *European Conference on Technology Enhanced Learning*; Springer: Cham, Switzerland, 2017; pp. 125–138.
32. Charleer, S.; Klerkx, J.; Santos, J.L.; Duval, E. Improving awareness and reflection through collaborative, interactive visualizations of badges. *ARTEL@ EC-TEL* **2013**, *1103*, 69–81.
33. Janes, A.; Sillitti, A.; Succi, G. Effective dashboard design. *Cut. IT J.* **2013**, *26*, 17–24.
34. Muldner, K.; Wixon, M.; Rai, D.; Burleson, W.; Woolf, B.; Arroyo, I. Exploring the impact of a learning dashboard on student affect. In *International Conference on Artificial Intelligence in Education*; Springer: Cham, Switzerland, 2015; pp. 307–317.
35. Pintrich, P.R. A Conceptual Framework for Assessing Motivation and Self-Regulated Learning in College Students. *Educ. Psychol. Rev.* **2004**, *16*, 385–407. [CrossRef]
36. Corrin, L.; de Barba, P. *Exploring Students Interpretation of Feedback Delivered through Learning Analytics Dashboards*; Critical Perspectives on Educational Technology: Dunedin, New Zealand, 2014; pp. 629–663.
37. Butler, D.L.; Winne, P.H. Feedback and self-regulated learning: A theoretical synthesis. *Rev. Educ. Res.* **1995**, *65*, 245–281. [CrossRef]
38. De Freitas, S.; Gibson, D.; Alvarez, V.; Irving, L.; Star, K.; Charleer, S.; Verbert, K. How to use gamified dashboards and learning analytics for providing immediate student feedback and performance tracking in higher education. In Proceedings of the 26th International Conference on World Wide Web Companion. International World Wide Web Conferences Steering Committee, Perth, Australia, 3–7 April 2017; pp. 429–434.
39. Knight, S.; Buckingham Shum, S.; Littleton, K. Epistemology, Assessment, Pedagogy: Where Learning Meets Analytics in the Middle Space. *J. Learn. Anal.* **2016**, *1*, 23–47. [CrossRef]
40. Jivet, I.; Scheffel, M.; Drachsler, H.; Specht, M. Awareness is not enough: Pitfalls of learning analytics dashboards in the educational practice. In *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*; Springer, Cham, Switzerland, 2017; Volume 10474 LNCS, pp. 82–96. [CrossRef]
41. Arnold, K.E.; Karcher, B.; Wright, C.V.; McKay, J. Student empowerment, awareness, and self-regulation through a quantified-self student tool. In Proceedings of the Seventh International Learning Analytics & Knowledge Conference, Vancouver, BC, Canada, 13–17 March 2017; ACM: New York, NY, USA, 2017; pp. 526–527.

5.1.1.28. Toward Bio-Inspired Auto-Scaling Algorithms: An Elasticity Approach for Container Orchestration Platforms

J. Herrera and G. Moltó, "Toward Bio-Inspired Auto-Scaling Algorithms: An Elasticity Approach for Container Orchestration Platforms," IEEE Access, vol. 8, no. 1, pp. 52139–52150, 2020, doi: https://dx.doi.org/10.1109/ACCESS.2020.2980852

Base de datos de indexación	Web of Science / JCR
Índice de impacto	3.745
Año	2019
Categoría	Computer Science, Information Systems
Posición de la revista en el área	35 de 156
Tercil	T1
Cuartil	Q1
Número de citas en JCR	1
Número de citas totales	1

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional (RETOS I+D) BigCLOE (TIN2016-79951-R), liderado por el candidato, y supone la principal contribución de la tesis de José Herrera Hernández, titulada "Optimización de arquitecturas distribuidas para el procesado de datos" y dirigida por el candidato, donde se describe la similitud entre sistemas de auto-escalado descentralizado y los sistemas bio-inspirados, proponiendo algoritmos que implementen la toma de decisiones de forma distribuida. Se implementó un simulador de código abierto disponible en GitHub - https://github.com/grycap/cobeats para facilitar la reproducibilidad de los experimentos.

IEEE Access
Multidisciplinary : Rapid Review : Open Access Journal

Received January 12, 2020, accepted February 21, 2020, date of publication March 16, 2020, date of current version March 25, 2020.

Digital Object Identifier 10.1109/ACCESS.2020.2980852

Toward Bio-Inspired Auto-Scaling Algorithms: An Elasticity Approach for Container Orchestration Platforms

JOSÉ HERRERA AND GERMÁN MOLTÓ
Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC-Universitat Politècnica de València (UPV), 46022 Valencia, Spain
Corresponding author: José Herrera (jherrera@upv.es)

This work was supported by the Ministerio de Economía, Industria y Competitividad, Spanish Government, for the Project BigCLOE under Grant TIN2016-79951-R.

ABSTRACT The wide adoption of microservices architectures has introduced an unprecedented granularisation of computing that requires the coordinated execution of multiple containers with diverse lifetimes and with potentially different auto-scaling requirements. These applications are managed by means of container orchestration platforms and existing centralised approaches for auto-scaling face challenges when used for the timely adaptation of the elasticity required for the different application components. This paper studies the impact of integrating bio-inspired approaches for dynamic distributed auto-scaling on container orchestration platforms. With a focus on running self-managed containers, we compare alternative configuration options for the container life cycle. The performance of the proposed models is validated through simulations subjected to both synthetic and real-world workloads. Also, multiple scaling options are assessed with the purpose of identifying exceptional cases and improvement areas. Furthermore, a nontraditional metric for scaling measurement is introduced to substitute classic analytical approaches. We found out connections for two related worlds (biological systems and software container elasticity procedures) and we open a new research area in software containers that features potential self-guided container elasticity activities.

INDEX TERMS Auto-scaling, bio-inspired, sofware containers.

I. INTRODUCTION

The widespread adoption of Linux containers, and in particular Docker [1], as a mechanism for convenient application delivery has paved the way in the last years for the surge of the microservices architectural pattern [2] in which monolithic applications coded in a single programming language can be broken down into multiple polyglot services exposing interfaces. These are typically delivered and executed as containers managed by a Container Orchestration Platform (COP) such as Kubernetes [3] or Apache Mesos [4]. A COP acts as a scheduler for the execution of container-based workloads and provides secure access management to the pool of shared computing resources which are typically delivered in the shape of a cluster of computing nodes.

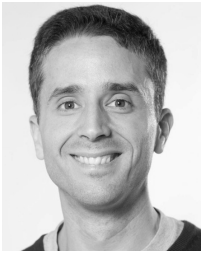
Previous literature agrees on the performance advantages of applications running on containers when compared to other virtualization technologies (see for example Felter *et al.* [5]). Indeed, an application running in a container can deliver a similar performance to when executed directly on bare metal. In addition, server density can be higher because no extra Operating System services are executed and, therefore, more containers can be executed per machine. However, microservices applications lead to faster creation, operation and removal of computing entities (containers) when compared to using Virtual Machines. This imposes a serious challenge for auto-scaling where more adaptable, precise and capable systems are required to manage the elasticity of large-scale fleets of containers belonging to multiple application architectures with dynamic elasticity requirements.

Adapting computational systems to the dynamic workload has been widely studied in previous works based on virtual machines and containers (Qu *et al.* [6], Hoenisch *et al.* [7]). Indeed, auto-scaling systems are already available for certain platforms, but the requirements of emerging application architectures requires a review of the methods used to perform auto-scaling in heterogeneous platforms of containers. In particular, it is important to understand the implications of

The associate editor coordinating the review of this manuscript and approving it for publication was Songwen Pei.

[23] T. C. Chieu and H. Chan, "Dynamic resource allocation via distributed decisions in cloud environment," in *Proc. IEEE 8th Int. Conf. e-Bus. Eng.*, Oct. 2011, pp. 125–130.
[24] S. Son and K. Mong Sim, "A price- and-time-slot-negotiation mechanism for cloud service reservations," *IEEE Trans. Syst., Man, Cybern. B, Cybern.*, vol. 42, no. 3, pp. 713–728, Jun. 2012.
[25] Y. Al-Dhuraibi, F. Paraiso, N. Djarallah, and P. Merle, "Autonomic vertical elasticity of docker containers with ELASTICDOCKER," in *Proc. IEEE 10th Int. Conf. Cloud Comput. (CLOUD)*, Jun. 2017, pp. 472–479.
[26] P. D. Kaur and I. Chana, "A resource elasticity framework for QoS-aware execution of cloud applications," *Future Gener. Comput. Syst.*, vol. 37, pp. 14–25, Jul. 2014.
[27] D. Jiang, G. Pierre, and C.-H. Chi, "Autonomous resource provisioning for multi-service Web applications," in *Proc. 19th Int. Conf. World Wide Web (WWW)*, 2010, pp. 471–480.
[28] L. R. Moore, K. Bean, and T. Ellahi, "Transforming reactive auto-scaling into proactive auto-scaling," in *Proc. 3rd Int. Workshop Cloud Data Platforms (CloudDP)*, 2013, pp. 7–12.
[29] V. R. Messias, J. C. Estrella, R. Ehlers, M. J. Santana, R. C. Santana, and S. Reiff-Marganiec, "Combining time series prediction models using genetic algorithm to autoscaling Web applications hosted in the cloud infrastructure," *Neural Comput. Appl.*, vol. 27, no. 8, pp. 2383–2406, Nov. 2016.
[30] A. Hussain. (2014). *Performance of Docker vs VMs*. Accessed: Jan. 11, 2020. [Online]. Available: https://es.slideshare.net/Flux7Labs/performance-of-docker-vs-vms
[31] V. Gupta, K. Kaur, and S. Kaur, "Performance comparison between light weight virtualization using docker and heavy weight virtualization," *Int. J. Adv. Technol. Eng. Sci.*, vol. 1, no. 5, pp. 509–514, 2017.
[32] B. B. Rad, H. J. Bhatti, and M. Ahmadi, "An introduction to docker and analysis of its performance," *Int. J. Comput. Sci. Netw. Secur.*, vol. 17, no. 3, p. 228, 2017.
[33] J. Von Neumann and A. W. Burks, *Theory Self-Reproducing Automata*. Urbana, IL, USA: Univ. of Illinois Press, 1996.
[34] J. Byl, "Self-reproduction in small cellular automata," *Phys. D, Nonlinear Phenomena*, vol. 34, nos. 1–2, pp. 295–299, Jan. 1989.
[35] M. Gardner, "Mathematical games: The fantastic combinations of John Conway's new solitaire game 'life,'" *Sci. Amer.*, vol. 223, no. 4, pp. 120–123, 1970.
[36] A. Deshpande and M. Kumar, *Artificial Intelligence for Big Data: Complete Guide to Automating Big Data Solutions Using Artificial Intelligence Techniques*. Birmingham, U.K.: Packt, 2018.
[37] A. E. Eiben and J. E. Smith, *Introduction to Evolutionary Computing*, vol. 53. Berlin, Germany: Springer, 2003.
[38] S. Salzberg, D. Searls, and S. Kasif, "Computational methods in molecular biology," in *New Comprehensive Biochemistry*. Amsterdam, The Netherlands: Elsevier, 1999.
[39] R. Khurana, *Software Engineering (WBUT)*, 4th ed. Vikas Publishing House, 2016, ch. 8.
[40] J. Herrera. (2018). *Cobeats—Container Bio-Inspired Enhanced Autoscaling System*. [Online]. Available: https://github.com/grycap/cobeats
[41] W. Ai, K. Li, S. Lan, F. Zhang, J. Mei, K. Li, and R. Buyya, "On elasticity measurement in cloud computing," *Sci. Program.*, vol. 2016, 2016, Art. no. 7519507, doi: 10.1155/2016/7519507.
[42] A. Kochut and K. Beaty, "On strategies for dynamic resource management in virtualized server environments," in *Proc. 15th Int. Symp. Modeling, Anal., Simulation Comput. Telecommun. Syst.*, Oct. 2007, pp. 193–200.
[43] H. Sakoe and S. Chiba, "Dynamic programming algorithm optimization for spoken word recognition," *IEEE Trans. Acoust., Speech, Signal Process.*, vol. ASSP-26, no. 1, pp. 43–49, Feb. 1978.
[44] Amazon. (2018). *Amazon Step Scaling*. Accessed: Jan. 11, 2020. [Online]. Available: https://docs.aws.amazon.com/autoscaling/ec2/userguide/as-scaling-simple-step.html
[45] M. McNaughton, "Predictive pod auto-scaling in the kubernetes container cluster manager," M.S. thesis, Williams College, Williamstown, MA, USA, 2016, p. 49. [Online]. Available: https://github.com/rootsongjc/cloud-native-slides-share/blob/master/kubernetes/Predictive-Pod-Auto-scaling-in-the-Kubernetes-Container-Cluster-Manager-by-Matt-McNaughton.pdf
[46] P. Gill, M. Arlitt, Z. Li, and A. Mahanti, "Youtube traffic characterization: A view from the edge," in *Proc. 7th ACM SIGCOMM Conf. Internet Meas. (IMC)*, 2007, pp. 15–28.
[47] (1995). *NASA*. Accessed: Jan. 11, 2020. [Online]. Available: ftp://ita.ee.lbl.gov/html/contrib/NASA-HTTP.html
[48] (1998). *World Cup Web Site Access Logs*. Accessed: Jan. 11, 2020. [Online]. Available: ftp://ita.ee.lbl.gov/html/contrib/WorldCup.html
[49] C. Henderson, *Building Scalable Web Sites*. Newton, MA, USA: O'Reilly Media, 2006.
[50] OpenShift. 2013. *Best Practices for Horizontal Application Scaling*. Accessed: Jan. 11, 2020. [Online]. Available: https://blog.openshift.com/best-practices-for-horizontal-application-scaling/
[51] Nomad. (2019). *The Million Container Challenge*. Accessed: Jan. 11, 2020. [Online]. Available: https://www.hashicorp.com/c1m
[52] D. Blog. (2015). *Scale Testing Docker Swarm to 30,000 Containers*. Accessed: Oct. 1, 2020. [Online]. Available: https://blog.docker.com/2015/11/scale-testing-docker-swarm-30000-containers/
[53] O. Docker. (2016). *Evaluating Container Platforms at Scale*. Accessed: Jan. 11, 2020. [Online]. Available: https://medium.com/on-docker/evaluating-container-platforms-at-scale-5e7b44d93f2c
[54] Kubernetes. (2015). *Kubernetes Performance Measurements and Roadmap*. Accessed: Jan. 11, 2020. [Online]. Available: https://kubernetes.io/blog/2015/09/kubernetes-performance-measurements-and

JOSÉ HERRERA received the master's degree in parallel and distributed computing from the Universitat Politècnica de València (UPV). He is currently pursuing the Ph.D. degree with the Grid and High Performance Computing Research Group (GRyCAP). He worked as a Predoctoral Researcher with the National Institute of Informatics (Tokyo), in 2016. He is also a Software Engineer with the Business Intelligence Team, Regional Government of Valencia (DGTIC-GVA), Spain. His research interests include big data infrastructures, scalability, business intelligence, and cloud computing.



GERMÁN MOLTÓ received the B.Sc. and Ph.D. degrees in computer science from the Universitat Politècnica de València (UPV), Spain, in 2002 and 2007, respectively. He has been a member of the Grid and High Performance Computing Research Group (GRyCAP), Institute for Molecular Imaging (I3M), since 2002. He is also an Associate Professor with the Department of Computer Systems and Computation (DSIC), UPV. He has participated in several H2020 European projects related to cloud computing (INDIGO-DataCloud, EOSC-HUB, DEEP Hybrid-DataCloud, and EOSC-SYNERGY) and led national research projects in the area of cloud computing. His broad research interests include cloud computing and scientific computing.

5.1.1.29. EMAP: A Cloud-Edge Hybrid Framework for EEG Monitoring and Cross-Correlation Based Real-time Anomaly Prediction

B. S. Prabakaran, A. Garcia Jimenez, G. Moltó Martinez, and M. Shafique, "EMAP: A Cloud-Edge Hybrid Framework for EEG Monitoring and Cross-Correlation Based Real-time Anomaly Prediction," in 2020 57th ACM/IEEE Design Automation Conference (DAC), 2020, no. July, pp. 1–6, doi: https://dx.doi.org/10.1109/DAC18072.2020.9218713

Base de datos de indexación	GII-GRIN-SCIE
Año	2020
Categoría	GGS Class 1 / GGS Rating A+
Número de citas totales	5

Comentario. Se trata de una colaboración realizada en el ámbito del Trabajo Final de Máster de Alberto García relativa al uso de tecnologías Cloud para la monitorización de anomalías en registros de actividad de salud.

EMAP: A Cloud-Edge Hybrid Framework for EEG Monitoring and Cross-Correlation Based Real-time Anomaly Prediction

Publisher: IEEE

Bharath Srinivas Prabakaran; Alberto García Jiménez; Germán Moltó Martínez; Muhammad Shafique **All Authors**

Abstract: State-of-the-art techniques for detecting, or predicting, neurological disorders (1) focus on predicting each disorder individually, and are (2) computationally expensive...**View more**

Metadata

Abstract:
State-of-the-art techniques for detecting, or predicting, neurological disorders (1) focus on predicting each disorder individually, and are (2) computationally expensive, leading to a delay that can potentially render the prediction useless, especially in critical events. Towards this, we present a real-time two-tiered framework called EMAP, which cross-correlates the input with all the EEG signals in our mega-database (a combination of multiple EEG datasets) at the cloud, while tracking the signal in real-time at the edge, to predict the occurrence of a neurological anomaly. Using the proposed framework, we have demonstrated a prediction accuracy of up to 94% for the three different anomalies that we have tested.

Published in: 2020 57th ACM/IEEE Design Automation Conference (DAC)

Date of Conference: 20-24 July 2020

Date Added to IEEE *Xplore*: 09 October 2020

ISBN Information:

Print on Demand(PoD) ISSN: 0738-100X

INSPEC Accession Number: 20035805

DOI: 10.1109/DAC18072.2020.9218713

Publisher: IEEE

Conference Location: San Francisco, CA, USA, USA

EMAP: A Cloud-Edge Hybrid Framework for EEG Monitoring and Cross-Correlation Based Real-time Anomaly Prediction

Bharath Srinivas Prabakaran*,‡, Alberto García Jiménez*,†,‡, Germán Moltó Martínez†, Muhammad Shafique*
*Institute of Computer Engineering, Technische Universität Wien (TU Wien), Austria
{bharath.prabakaran, muhammad.shafique}@tuwien.ac.at
†Sistemas Informáticos y computación, Universitat Politécnica de Valéncia, Spain
{algarji1@etsid.upv.es, gmolto@dsic.upv.es}

***Abstract*—State-of-the-art techniques for detecting, or predicting, neurological disorders (1) focus on predicting each disorder individually, and are (2) computationally expensive, leading to a delay that can potentially render the prediction useless, especially in critical events. Towards this, we present a real-time two-tiered framework called EMAP, which cross-correlates the input with all the EEG signals in our mega-database (a combination of multiple EEG datasets) at the cloud, while tracking the signal in real-time at the edge, to predict the occurrence of a neurological anomaly. Using the proposed framework, we have demonstrated a prediction accuracy of up to 94% for the three different anomalies that we have tested.**

***Index Terms*—Edge, Cloud, Wearable, IoT, EEG, Electroencephalogram, Brain, Anomaly, Prediction, Framework, Seizure, Encephalopathy, Stroke.**

I. Introduction

The human brain is responsible for performing a wide range of autonomous, semi-autonomous, and manual functions, such as generating thoughts, motor control, storing memories, regulating hormones, etc. [1]. It is susceptible to more than 600 diseases like tumors, epilepsy, Alzheimer's, and strokes [2]. These diseases can be diagnosed using medical imaging techniques, such as (functional) Magnetic Resonance Imaging (fMRI/MRI) and Computed Tomography (CT Scan), and Electroencephalography (EEG) [3]. These techniques are typically used to study the brain *ex-post-facto*, i.e., after the event has occurred, to evaluate the amount of damage that has been caused by the event [4]. Patients prone to such neurological orders could be in potentially fatal situations, where they could place themselves and other people in harm, for example, the occurrence of seizures or strokes in drivers and heavy equipment users.

State-of-the-art techniques, typically, analyze the EEG signals using compute-intensive algorithms and statistical methods, including machine learning/deep neural networks, to accurately detect/predict each neurological disorder *individually* [5]–[13]. This requires the edge device (typically a wearable or a sensor-head) to continuously transmit the EEG data to the cloud for further processing and feature extraction. Besides the communication time overheads, these fully cloud-based techniques pose serious privacy and security concerns for the users who might not wish to continuously transmit all of their bio-signal data over an insecure/untrustworthy network, or to store it on the third-party cloud platforms [14]. However, it may still be feasible to transmit certain parts of the data to the cloud, if extensive processing is required to recover from life-threatening situations, considering the fact that the third party cannot retrieve the complete signal information with incomplete data. Such a situation is more realistic and can be considered as a trade-off between privacy, security, and urgency-of-extensive-analysis.

Enabling such an efficient EEG processing system requires addressing the following ***research challenges***, as addressed in this work:

(1) How can the continuous monitoring of EEG signals at the edge device be used to predict multiple different neurological anomalies?
(2) How to enable real-time anomaly prediction with the help of a cloud-edge hybrid framework, while trying to minimize the amount of data transmitted to the cloud?

Novel Contributions: To address the above challenges, we propose the novel EMAP framework for predicting anomalies in real-time that employs the following key components:

- An efficient edge sensor node to continuously monitor the brain signals by collecting, pre-processing, and transmitting only one second of the EEG signal data to the cloud every few seconds;
- A Mega-database (MDB) of EEG signals, on the cloud, that was constructed by combining various state-of-the-art EEG databases containing normal and anomalous EEG signals, such as seizures, epilepsy, etc.;
- A novel signal cross-correlation search algorithm, which efficiently compares the patient's one-second EEG signal with all the signals of the MDB in the cloud, to quickly identify the top-100 analogous signals, which are transmitted to the edge;
- A novel real-time signal tracking algorithm at the edge to estimate the similarity of the top-100 analogous signals with the input in real-time, to eliminate dissimilar signals, estimate the probability of an anomaly, and predict its occurrence based on the inputs obtained from the subsequent time-steps.

Furthermore, to enable an efficient design of the EMAP framework, we perform a motivational analysis that studies the benefits of continuous monitoring and signal cross-correlation to estimate the probability of anomalies. The prediction accuracy of EMAP is evaluated for three different neurological disorders, namely, seizures, strokes, and encephalopathy, using 100 different input signals for each disorder.

Evaluation & Open-Sourcing: We have successfully obtained a prediction accuracy of 94%, 73%, and 79%, on average, for the three different anomalies that we have tested. To enable easy reproduction and adaption of the proposed EMAP framework, we will open-source the complete tool-flow at https://emap.sourceforge.io. Fig. 1 illustrates an overview of the contributions (in dark highlighted blocks) that have been proposed in the cloud-edge hybrid framework.

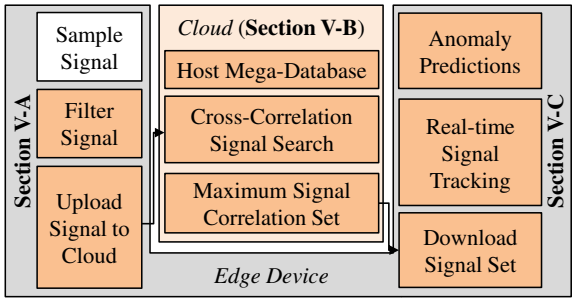


Fig. 1: Overview of the proposed contributions (dark highlighted boxes) in the cloud-edge hybrid framework.

II. Related Work

Electroencephalography (EEG) is a technique that is typically used to study the brain *ex-post-facto*, by medical experts, to ascertain the amount of damage caused due to a specific event. This typically requires high-quality EEG electrodes that are not portable or easy to use and can be highly expensive. For the purpose of continuous monitoring, 10-20 electrodes (considered to be an EEG placement standard), which cover the surface area of the head, can be placed on a cap (electrode-caps) to measure the EEG signal samples [15]. These devices can be

‡These two authors have contributed to this work equally.

978-1-7281-1085-1/20/$31.00 ©2020 IEEE

TABLE I: Average prediction accuracy of EMAP for three different neurological disorders, compared with he state-of-the-art prediction and detection techniques. *N.A. → technique not applicable for the given scenario.

	EMAP					SoA - *Prediction*		SoA - *Detection*		
	B1	**B2**	**B3**	**B4**	**B5**	[11]	[13]	[7]	[8]	[18]
Seizure	0.95	0.94	0.95	0.97	0.94	0.94	0.93	0.86	0.93	0.99
Encephalopathy	0.67	0.76	0.74	0.76	0.72	N.A.	N.A.	N.A.	N.A.	N.A.
Stroke	0.74	0.85	0.80	0.78	0.77	N.A.	N.A.	N.A.	N.A.	N.A.

Next, we evaluate the proposed EMAP framework for other anomalies, such as *encephalopathy* (Anomaly 2) and *stroke* (Anomaly 3), the results of which are presented in Table I. Due to the unavailability of similar highly annotated datasets for these two anomalies, i.e., the preset and onset of anomaly progression, for the following two cases, we have annotated the complete signal as an anomaly. We have achieved an average prediction accuracy of 73% and 79%, respectively for encephalopathy and strokes. This reduction in prediction accuracy is attributed to the unavailability of a substantially-labeled dataset such as the ones available for the seizure. Furthermore, since the proposed algorithm focuses on maximizing the sensitivity to anomalies and classifies near-threshold anomaly probability increases as anomalous, the classification accuracy of the normal signal is reduced, i.e., the average percentage of false-positives is ~15%, which is a limitation of the EMAP framework.

Finally, we evaluate the loss in accuracy of deploying the proposed signal cross-correlation search (Algorithm 1) in the cloud instead of the time-consuming exhaustive cross-signal. We evaluate the average signal cross-correlation of the top-100 signals with respect to the input for 100 different normal and anomalous input signals. The results of these experiments are illustrated in Fig. 11. As can be observed, *the average cross-correlation of the proposed approach is very close to the average cross-correlation of the signals obtained using the exhaustive cross-correlation technique*. Therefore, the loss in accuracy is almost non-existent and indistinguishable due to the substantially large and highly redundant data-set that we use. However, due to the sliding window technique deployed in the proposed approach, the top-100 signals selected are very diverse, i.e., typically, the top-100 signals exhibit high cross-correlation to the input, but can also exhibit very low cross-correlation in certain scenarios, as illustrated in the figure.

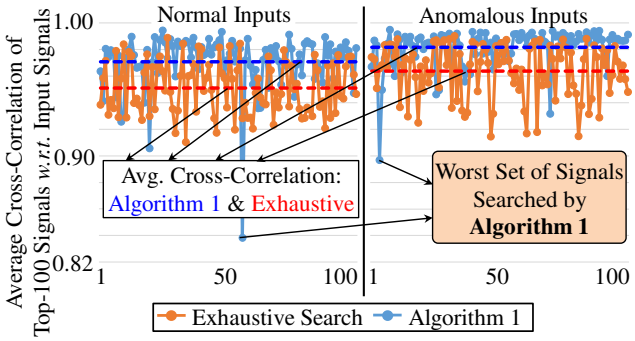


Fig. 11: Accuracy Evaluation of the Proposed Algorithm 1 Compared to the Exhaustive Cross-Correlation Search.

VII. Conclusion

In this work, we presented EMAP, a cloud-edge hybrid framework that is beneficial for continuously monitoring EEG signals and to estimate the probability of occurrence of an anomaly in real-time. The framework is composed of three key stages, namely, (i) *Signal Acquisition*, which is responsible for collecting, filtering, and transmitting the EEG data to the cloud; (ii) *Cloud Search*, where the input signal is cross-correlated with all the signals in the MDB, which is a construction of multiple openly accessible EEG dataset, to determine the top-100 signals with maximum similarity to the input signal; and (iii) *Edge Tracking*, where the subsequent EEG signal samples are used to eliminate the dissimilar signals and predict the occurrence of an anomaly. Using the proposed, we have achieved a prediction accuracy of 94%, 73%, and 79% for three different anomalies, namely, seizures, encephalopathy, and strokes, respectively. The EMAP framework has been made open-source at https://emap.sourceforge.io, to ensure ease of adoption and reproducibility.

Acknowledgement

This work was partially supported by Doctoral College Resilient Embedded Systems which is run jointly by TU Wien's Faculty of Informatics and FH-Technikum Wien.

References

[1] S. Herculano-Houzel, "The human brain in numbers: a linearly scaled-up primate brain," *Frontiers in human neuroscience*, vol. 3, p. 31, 2009.
[2] "Neurological disorders: Public health challenges," 2006. [Online]. Available: https://www.who.int/mental_health/neurology/neurological_disorders_report_web.pdf
[3] "Neurological diagnostic tests." [Online]. Available: https://www.aans.org/en/Patients/Neurosurgical-Conditions-and-Treatments/Neurological-Diagnostic-Tests
[4] "Neurological diagnostic tests and procedures fact sheet," Apr 2019. [Online]. Available: https://www.ninds.nih.gov/Disorders/Patient-Caregiver-Education/Fact-Sheets/Neurological-Diagnostic-Tests-and-Procedures-Fact
[5] A. O. Akmandor *et al.*, "Keep the stress away with soda: Stress detection and alleviation system," ***TMSCS***, 2017.
[6] Z. Mardi *et al.*, "Eeg-based drowsiness detection for safe driving using chaotic features and statistical tests," ***JMSS***, 2011.
[7] A. Burrello *et al.*, "Laelaps: An energy-efficient seizure detection algorithm from long-term human ieeg recordings without false alarms," in ***DATE***. IEEE, 2019.
[8] D. Pascual *et al.*, "A self-learning methodology for epileptic seizure detection with minimally-supervised edge labeling," in ***DATE***. IEEE, 2019.
[9] R. Hussein *et al.*, "Epileptic seizure detection: A deep learning approach," *arXiv preprint arXiv:1803.09848*, 2018.
[10] Y. Zhang *et al.*, "Integration of 24 feature types to accurately detect and predict seizures using scalp eeg signals," ***Sensors***, 2018.
[11] M.-P. Hosseini *et al.*, "Cloud-based deep learning of big eeg data for epileptic seizure prediction," in ***GlobalSIP***. IEEE, 2016.
[12] S. Kim *et al.*, "Wave2vec: Vectorizing electroencephalography bio-signal for prediction of brain disease," ***IJERPH***, 2018.
[13] F. Samie *et al.*, "Highly efficient and accurate seizure prediction on constrained iot devices," in ***DATE***. IEEE, 2018.
[14] S. N. Shirazi *et al.*, "The extended cloud: Review and analysis of mobile edge computing and fog from a security and resilience perspective," *IEEE Journal on Selected Areas in Communications*, 2017.
[15] OpenBCI. [Online]. Available: https://openbci.com
[16] M. Zhou *et al.*, "Epileptic seizure detection based on eeg signals and cnn," *Frontiers in neuroinformatics*, vol. 12, p. 95, 2018.
[17] S. F. Timashev *et al.*, "Analysis of cross-correlations in electroencephalogram signals as an approach to proactive diagnosis of schizophrenia," *Physica A: Statistical Mechanics and its Applications*, 2012.
[18] Z. Zhang *et al.*, "Seizure prediction using cross-correlation and classification," in ***ACSSC***. IEEE, 2015.
[19] M. Steer, "Beyond 3g," *IEEE microwave Magazine*, 2007.
[20] S. Parkvall *et al.*, "Lte-advanced-evolving lte towards imt-advanced," in ***VTC***. IEEE, 2008.
[21] A. L. Goldberger *et al.*, "PhysioBank, PhysioToolkit, and PhysioNet: Components of a new research resource for complex physiologic signals," *Circulation*, vol. 101, no. 23, pp. e215–e220, 2000 (June 13).
[22] A. Harati *et al.*, "The tuh eeg corpus: A big data resource for automated eeg interpretation," in ***SPMB***. IEEE, 2014.
[23] D. Dua *et al.*, "Uci machine learning repository," 2017. [Online]. Available: http://archive.ics.uci.edu/ml
[24] C. Brunner *et al.*, "Bnci horizon 2020–towards a roadmap for brain/neural computer interaction," in ***UAHCI***. Springer, 2014.
[25] P. Zwoliński *et al.*, "Open database of epileptic eeg with mri and post-operational assessment of focia real world verification for the eeg inverse solutions," *Neuroinformatics*, 2010.

The GII-GRIN-SCIE Conference Rating

Explore the GII-GRIN-SCIE (GGS) Conference Rating

Menu

Mirror@www.consorzio-cini.it - Mirror@valutazione.unibas.it - Mirror@gii-grin-scie-rating.scie.es

Search Details Previous Versions

Download **The GGS Conference Rating 2018** (Excel .xlsx file) - last updated: May, 30th 2018

This initiative is sponsored by GII (Group of Italian Professors of Computer Engineering), GRIN (Group of Italian Professors of Computer Science), and SCIE (Spanish Computer-Science Society). For details about the rating algorithm and the process, see the Conference Rating description page.

Search Conferences

Name		Search	Sample: *int*conf*data*
Acronym	DAC	Search	Sample: vldb or *ubi*
Class		Search	Sample: 1 or 2 or 3
Rating		Search	Sample: A++ or A+ or A or A- or B or B-
Collected Ratings		Search	Sample: A++, A++, A++ or A+, A, A

Legenda

Class	Ratings	Size	Description
Class 1	A++, A+	32 + 50 = **82 conferences**	excellent, top notch conferenc
Class 2	A, A-	82 + 93 = **175 conferences**	very good events
Class 3	B, B-	205 + 161 = **366 conferences**	events of good quality
-	Work in Progress	2172 conferences	work in progress

Your search returned 1 results.

Title	Acronym	GGS Class	GGS Rating	Qualified Classes	Collected Classes
DESIGN AUTOMATION CONFERENCE	DAC	1	A+	CORE:A, LiveSHINE:A++, MA:A++	A++, A++, A

Detailed Ratings (click to expand)

CORE:

Acronym	Title	Class
DAC	Design Automation Conf	A

LiveSHINE:

Acronym	Conference	Class	H-Index	RankH-Index	ClassH-Index	AvgCitations	RankAvgCitations	ClassAvgCitations	Publications	Citations
DAC	Design Automation Conference	A++	95	38	A++	24,87	132	A+	2165	53834

Microsoft Academic:

Acronym	Conference	Class	FieldRating	RankFieldRating	ClassFieldRating	AvgCitations	RankAvgCitations	ClassAvgCitations	Publications	Citations
DAC	Design Automation Conference	A++	205	32	A++	35,96	183	A++	7504	269823

5.1.1.30. Insights from Learning Analytics for Hands-On Cloud Computing Labs in AWS

G. Moltó, D. M. Naranjo, and J. D. Segrelles, "Insights from Learning Analytics for Hands-On Cloud Computing Labs in AWS," Appl. Sci., vol. 10, no. 24, p. 9148, Dec. 2020, doi: https://dx.doi.org/10.3390/app10249148

Base de datos de indexación	Web of Science / JCR
Índice de impacto	2.474
Año	2020
Categoría	Engineering, Multidisciplinary
Posición de la revista en el área	XX de XX
Tercil	T2
Cuartil	Q2
Número de citas en JCR	0
Número de citas totales	0

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional (RETOS I+D) BigCLOE (TIN2016-79951-R), liderado por el candidato, donde se diseñaron técnicas de procesado de datos mediante infraestructuras de tipo serverless. Estas técnicas se aplicaron para procesar los datos históricos generados por los alumnos del Curso Online de Cloud Computing con Amazon Web Services, impartido por el candidato, en el marco del proyecto "PIME/19-20/166", liderado por el candidato. Se trata de un artículo de investigación en el ámbito de la educación en sistemas de tipo Cloud Computing, no una publicación de innovación docente.

applied sciences

MDPI

Article

Insights from Learning Analytics for Hands-On Cloud Computing Labs in AWS

Germán Moltó *, Diana M. Naranjo * and J. Damian Segrelles *

Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC—Universitat Politècnica de València, 46022 Camino de Vera s/n, Spain

* Correspondence: gmolto@dsic.upv.es (G.M.); dnaranjo@i3m.upv.es (D.M.N.); dquilis@dsic.upv.es (J.D.S.)

Received: 10 November 2020; Accepted: 16 December 2020; Published: 21 December 2020

Abstract: Cloud computing instruction requires hands-on experience with a myriad of distributed computing services from a public cloud provider. Tracking the progress of the students, especially for online courses, requires one to automatically gather evidence and produce learning analytics in order to further determine the behavior and performance of students. With this aim, this paper describes the experience from an online course in cloud computing with Amazon Web Services on the creation of an open-source data processing tool to systematically obtain learning analytics related to the hands-on activities carried out throughout the course. These data, combined with the data obtained from the learning management system, have allowed the better characterization of the behavior of students in the course. Insights from a population of more than 420 online students through three academic years have been assessed, the dataset has been released for increased reproducibility. The results corroborate that course length has an impact on online students dropout. In addition, a gender analysis pointed out that there are no statistically significant differences in the final marks between genders, but women show an increased degree of commitment with the activities planned in the course.

Keywords: learning analytics; cloud computing

1. Introduction

The beginning of the digital era has exponentially increased the amount of data generated. The new data analytic techniques have received special attention in the research from the industrial and academic sectors [1]. The data sources that have emerged in the past years have allowed better characterization of student behavior.

The use of learning management systems (LMSs) has increased in recent years, especially in universities that offer online courses where students can immerse themselves in an individual and collaborative learning experience. In higher education, the use of analytics is an active area of research. Indeed, there are many different concepts when it comes to analytics, and finding a definition that fits all profiles can be complicated [2]. In the work by Barneveld et al. [3], several definitions are collected according to different terms, and they proposed the following: "an overarching concept described as data-driven decision making".

The growing interest in improving the students' learning methods has led to the creation of different institutions specialized in exploring the role and impact of analytics in teaching and learning in the education sector. In 2011, the Society for Learning Analytics Research (SoLAR: http://www.solaresearch.org) was founded as a non-profit interdisciplinary network of international researchers to explore the impact of big data and learning analytics in the education sector. Learning analytics in academia focuses on gathering the data generated by students during courses to manage student success, including early warning processes where the need for intervention by a teacher can be justified.

active involvement by the students, who are passively monitored; therefore, they do not need to spend additional time producing an activity report to justify that they carried out the lab activities.

Future work includes further evolving the CloudTrail-Tracker with predictive modules in order to anticipate the dropping out of students and to alert professors to introduce corrective countermeasures, such as extending the allocated timeframe for accessing the course or unblocking additional material in order to minimize the knowledge gap required to undertake the latest course modules.

Author Contributions: Conceptualization, G.M.; methodology, G.M. and D.M.N.; software, D.M.N.; investigation, G.M., D.M.N., and J.D.S.; resources, G.M.; data curation, D.M.N. and J.D.S.; writing—original draft preparation, G.M.; writing—review and editing, G.M., D.M.N., and J.D.S.; visualization, G.M., D.M.N., and J.D.S.; funding acquisition, G.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Spanish "Ministerio de Economía, Industria y Competitividad through grant number TIN2016-79951-R (BigCLOE)", the "Vicerrectorado de Estudios, Calidad y Acreditación" of the Universitat Politècnica de València (UPV) to develop the PIME B29 and PIME/19-20/166, and by the Conselleria d'Innovació, Universitat, Ciència i Societat Digital for the project "CloudSTEM" with reference number AICO/2019/313.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Motiwalla, L.; Deokar, A.V.; Sarnikar, S.; Dimoka, A. Leveraging Data Analytics for Behavioral Research. *Inf. Syst. Front.* **2019**, *21*, 735–742. [CrossRef]
2. Cooper, A. What is Analytics? Definition and Essential Characteristics. *CETIS Anal. Ser.* **2012**, *1*, 1–10.
3. Van Barneveld, A.; Arnold, K.; Campbell, J. Analytics in Higher Education: Establishing a Common Language. *Educ. Learn. Initiat.* **2012**, *1*, I–II.
4. Siemens, G.; Baker, R.S. Learning analytics and educational data mining: Towards communication and collaboration. In *Proceedings of the ACM International Conference Proceeding Series*; Association for Computing Machinery: New York, NY, USA, 2012; pp. 252–254. [CrossRef]
5. Siemens, G.; Dawson, S.; Lynch, G. *Improving the Quality and Productivity of the Higher Education Sector Policy and Strategy for Systems-Level Deployment of Learning Analytics Society for Learning Analytics Research*; Technical Report; Society for Learning Analytics Research for the Australian Office for Learning and Teaching: Canberra, Australia, 2013.
6. Blikstein, P. Multimodal learning analytics. In Proceedings of the Third International Conference on Learning Analytics and Knowledge, Leuven, Belgium, 8–12 April 2013. [CrossRef]
7. Worsley, M. Multimodal learning analytics' past, present, and, potential futures. In Proceedings of the 8th International Conference on Learning Analytics & Knowledge, Sydney, Australia, 6 March 2018; Volume 2163.
8. Hewson, E.R. Students' emotional engagement, motivation and behaviour over the life of an online course: Reflections on two market research case studies. *J. Interact. Media Educ.* **2018**. [CrossRef]
9. Kahan, T.; Soffer, T.; Nachmias, R. Types of participant behavior in a massive open online course. *Int. Rev. Res. Open Distance Learn.* **2017**, *18*, 1–18. [CrossRef]
10. Cross, S.; Whitelock, D. Similarity and difference in fee-paying and no-fee learner expectations, interaction and reaction to learning in a massive open online course. *Interact. Learn. Environ.* **2017**, *25*, 439–451. [CrossRef]
11. Koller, D.; Ng, A.; Do, C.; Chen, Z. Retention and Intention in Massive Open Online Courses: In Depth. *Educ. Rev.* **2013**, *48*, 62–63.
12. Phil Long, B.; Siemens, G. Penetrating the Fog: Analytics in Learning and Education. *Ital. J. Educ. Technol.* **2014**, *22*, 132–137.
13. Charleer, S.; Klerkx, J.; Duval, E. Learning dashboards. *J. Learn. Anal.* **2014**, *1*, 199–202. [CrossRef]
14. Worsley, M. Multimodal learning analytics—Enabling the future of learning through multimodal data analysis and interfaces. In Proceedings of the ICMI'12—ACM International Conference on Multimodal Interaction, Santa Monica, CA, USA, 22–26 October 2012; pp. 353–356. [CrossRef]

15. Spikol, D.; Prieto, L.; Rodríguez-Triana, M.; Worsley, M.; Ochoa, X.; Cukurova, M. Current and future multimodal learning analytics data challenges. In Proceedings of the Seventh International Learning Analytics & Knowledge Conference, Vancouver, BC, Canada, 13–17 March 2017; pp. 518–519. [CrossRef]
16. Ochoa, X.; Worsley, M.; Weibel, N.; Oviatt, S. Multimodal learning analytics data challenges. In Proceedings of the Sixth International Conference on Learning Analytics & Knowledge, Edinburgh, UK, 25–29 April 2016; pp. 498–499. [CrossRef]
17. Aguilar, J.; Sánchez, M.; Cordero, J.; Valdiviezo-Díaz, P.; Barba-Guamán, L.; Chamba-Eras, L. Learning analytics tasks as services in smart classrooms. *Univers. Access Inf. Soc.* **2018**, *17*, 693–709. [CrossRef]
18. Lu, O.H.; Huang, J.C.; Huang, A.Y.; Yang, S.J. Applying learning analytics for improving students engagement and learning outcomes in an MOOCs enabled collaborative programming course. *Interact. Learn. Environ.* **2017**, *25*, 220–234. [CrossRef]
19. Drachsler, H.; Kalz, M. The MOOC and learning analytics innovation cycle (MOLAC): A reflective summary of ongoing research and its challenges. *J. Comput. Assist. Learn.* **2016**, *32*, 281–290. [CrossRef]
20. Ruiperez-Valiente, J.A.; Munoz-Merino, P.J.; Gascon-Pinedo, J.A.; Kloos, C.D. Scaling to Massiveness with ANALYSE: A Learning Analytics Tool for Open edX. *IEEE Trans. Hum.-Mach. Syst.* **2017**, *47*, 909–914. [CrossRef]
21. Er, E.; Gómez-Sánchez, E.; Dimitriadis, Y.; Bote-Lorenzo, M.L.; Asensio-Pérez, J.I.; Álvarez-Álvarez, S. Aligning learning design and learning analytics through instructor involvement: A MOOC case study. *Interact. Learn. Environ.* **2019**, *27*, 685–698. [CrossRef]
22. Tabaa, Y.; Medouri, A. LASyM: A Learning Analytics System for MOOCs. *Int. J. Adv. Comput. Sci. Appl.* **2013**, *4*. [CrossRef]
23. Shorfuzzaman, M.; Hossain, M.S.; Nazir, A.; Muhammad, G.; Alamri, A. Harnessing the power of big data analytics in the cloud to support learning analytics in mobile learning environment. *Comput. Hum. Behav.* **2019**, *92*, 578–588. [CrossRef]
24. Klašnja-Milićević, A.; Ivanović, M.; Budimac, Z. Data science in education: Big data and learning analytics. *Comput. Appl. Eng. Educ.* **2017**, *25*, 1066–1078. [CrossRef]
25. SolarWinds. Loggly. Available online: https://www.loggly.com/ (accessed 19 December 2020).
26. Moltó, G.; Caballer, M. On Using the Cloud to Support Online Courses. In Proceedings of the 2014 Frontiers in Education Conference (FIE), Madrid, Spain, 22–25 October 2014; pp. 330–338. [CrossRef]
27. Caballer, M.; Blanquer, I.; Moltó, G.; de Alfonso, C. Dynamic Management of Virtual Infrastructures. *J. Grid Comput.* **2015**, *13*, 53–70. [CrossRef]
28. Segrelles, J.D.; Moltó, G.; Caballer, M. Remote Computational Labs for Educational Activities via a Cloud Computing Platform. In Proceedings of the Information Systems Education Conference (ISECON), Orlando, FL, USA, 5–7 November 2015; pp. 309–321.
29. AWS. AWS CloudTrail. Available online: https://aws.amazon.com/cloudtrail/ (accessed 19 December 2020).
30. Amazon. Amazon Simple Storage Service (Amazon S3). Available online: http://aws.amazon.com/s3/ (accessed 19 December 2020).
31. Naranjo, D.M.; Prieto, J.R.; Moltó, G.; Calatrava, A. A Visual Dashboard to Track Learning Analytics for Educational Cloud Computing. *Sensors* **2019**, *19*, 2952. [CrossRef]
32. Baldini, I.; Castro, P.; Chang, K.; Cheng, P.; Fink, S.; Ishakian, V.; Mitchell, N.; Muthusamy, V.; Rabbah, R.; Slominski, A.; et al. Serverless computing: Current trends and open problems. In *Research Advances in Cloud Computing*; Springer: Singapore, 2017; pp. 1–20. [CrossRef]
33. Diaz, D.; Cartnal, R. Term Length as an Indicator of Attrition in Online Learning. *Innov. J. Online Educ.* **2006**, *2*.
34. Chavatzia, T. *Cracking the Code: Girls' and Women's Education in Science, Technology, Engineering and Mathematics (STEM)*; UNESCO: Paris, France, 2017.
35. Barbera, E.; Candela, C.; Ramos, A. Career selection, professional development and gender stereotypes. *Rev. Psicol. Soc.* **2008**, *23*, 275–285.
36. Daniel, W.W. Kolmogorov–Smirnov one-sample test. *Appl. Nonparametric Stat.* **1990**, *2*.
37. Zimmerman, D.W. Comparative power of Student t test and Mann-Whitney U test for unequal sample sizes and variances. *J. Exp. Educ.* **1987**, *55*, 171–174. [CrossRef]
38. Kruskal, W.H.; Wallis, W.A. Use of ranks in one-criterion variance analysis. *J. Am. Stat. Assoc.* **1952**, *47*, 583–621. [CrossRef]

39. Field, A. *Discovering Statistics Using IBM SPSS Statistics*; SAGE, London, UK, 2013.
40. Voyer, D.; Voyer Susan D., D. Gender differences in scholastic achievement: A meta-analysis. *Psychol. Bull.* **2014**, *140*, 1174–1204. [CrossRef]
41. Ellemers, N.; Van Den Heuvel, H.; De Gilder, D.; Maass, A.; Bonvini, A. The underrepresentation of women in science: Differential commitment or the queen bee syndrome? *Br. J. Soc. Psychol.* **2004**, *43*, 315–338. [CrossRef] [PubMed]
42. Sheard, M. Hardiness commitment, gender, and age differentiate university academic performance. *Br. J. Educ. Psychol.* **2009**, *79*, 189–204. [CrossRef] [PubMed]

5.1.1.31. Deployment of Elastic Virtual Hybrid Clusters Across Cloud Sites

M. Caballer, M. Antonacci, Z. Šustr, M. Perniola, and G. Moltó, "Deployment of Elastic Virtual Hybrid Clusters Across Cloud Sites," J. Grid Comput., vol. 19, no. 1, p. 4, Mar. 2021, doi: https://dx.doi.org/10.1007/s10723-021-09543-5

Base de datos de indexación	Web of Science / JCR
Índice de impacto	3,986
Año	2020
Categoría	Comp. Science, Theory & Methods
Posición de la revista en el área	16 de 110
Tercil	T1
Cuartil	Q1
Número de citas en JCR	2
Número de citas totales	4

Comentario. Esta contribución es uno de los resultados del proyecto DEEP Hybrid DataCloud (777435) en los que el candidato actuó como deputy WP leader. Se trata además de una publicación relevante en colaboración internacional compuesta por miembros del INFN (Istituto Nazionale di Fisica Nucleare) y CESNET (entidad operadora de la infraestructura electrónica nacional para ciencia, investigación, desarrollo y educación en la República Checa). En la publicación se describe la adaptación de la herramienta Infrastructure Manager (IM) para el despliegue de clusters híbridos entre infraestructuras Cloud de múltiples centros de investigación utilizando técnicas avanzadas de red.

Journal of Grid Computing (2021) 19: 4
https://doi.org/10.1007/s10723-021-09543-5

Deployment of Elastic Virtual Hybrid Clusters Across Cloud Sites

Miguel Caballer · Marica Antonacci · Zdeněk Šustr · Michele Perniola · Germán Moltó

Received: 25 May 2020 / Accepted: 23 November 2020 / Published online: 15 February 2021

Abstract Virtual clusters are widely used computing platforms than can be deployed in multiple cloud platforms. The ability to dynamically grow and shrink the number of nodes has paved the way for customised elastic computing both for High Performance Computing and High Throughput Computing workloads. However, elasticity is typically restricted to a single cloud site, thus hindering the ability to provision computational resources from multiple geographically distributed cloud sites. To this aim, this paper introduces an architecture of open-source components that coherently deploy a virtual elastic cluster across multiple cloud sites to perform large-scale computing. These hybrid virtual elastic clusters are automatically deployed and configured using an Infrastructure as Code (IaC) approach on a distributed hybrid testbed that spans different organizations, including on-premises and public clouds, supporting automated tunneling of communications across the cluster nodes with advanced VPN topologies. The results indicate that cluster-based computing of embarrassingly parallel jobs can benefit from hybrid virtual clusters that aggregate computing resources from multiple cloud back-ends and bring them together into a dedicated, albeit virtual network.

Keywords Cloud Computing · Network virtualization · Cluster computing

M. Caballer · G. Moltó (✉)
Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC - Universitat Politècnica de València, Camino de Vera s/n, 46022, Valencia, Spain
e-mail: gmolto@dsic.upv.es

M. Caballer
e-mail: micafer1@upv.es

M. Antonacci · M. Perniola
Bari INFN, Via E. Orabona 4 70125 Bari, Italy
e-mail: marica.antonacci@ba.infn.it

Z. Šustr
CESNET, Zikova 4, 160 00 Praha 6, Czechia
e-mail: sustr4@cesnet.cz

1 Introduction

Scientific computing typically requires execution of resource-intensive applications that require collaborative usage of multiple computing and storage resources in order to satisfy the demands of the applications. This is why Distributed Computing Infrastructures (DCIs), such as the European Grid Infrastructure (EGI) [1] or the Open Science Grid (OSG) [2], emerged in the last decades to encompass the rise of eScience. Indeed, as described in [3], "eScience studies, enacts, and improves the ongoing process of innovation in computationally-intensive or data-intensive research methods; typically this is carried out collaboratively, often using distributed infrastructures".

The advent of cloud computing [4], exemplified by public cloud providers such as Amazon Web Services, Microsoft Azure or Google Cloud Platform, together

deploy additional working nodes and terminate them when no longer needed.

A real-world workload based on an existing dataset to be inferenced with available Deep Learning models from an open catalog has been adopted as use case to demonstrate the effectiveness of the designed platform. The integration of resources both from an on-premises cloud and from a public cloud provider has proved its benefits for cloud bursting within a single computing entity, which is the virtual cluster. This allows users to be completely abstracted from deciding which cloud sites the resources are actually being provisioned in.

The integration of the virtual router has provided seamless connectivity among the virtual nodes of the cluster, including automated encryption of communications, all dynamically deployed as part of the virtual infrastructure provision.

Future work includes performing large-scale tests involving a wide number of cloud sites in order to determine the bottlenecks of the developed approach. Also, the integration of both CPU and GPU based resources within the same virtual cluster entity pooled from multiple cloud sites and made available to users via different batch queues. Furthermore, optimising the ability to perform parallel provisioning of nodes in the PaaS Orchestrator will reduce the deployment time.

Another set of future work objectives relates to dynamic balancing of inter-cloud virtual network connections. The private virtual overlay networks based on the INDIGO Virtual Router, as explained in Section 3.5, already have the advantage of resembling actual physical "metropolitan area" networks (MAN) in their topology. They consist of multiple local networks (analogical to LANs) with routers directing traffic to and from distant networks – other LANs within the deployment. This is perceived as a benefit since it makes it easy for platform users to understand the topology of their deployment without learning new networking concepts. What is currently missing from the design, though, is the dynamic identification of the best path for each data frame, which has become the hallmark of IP-based traffic on the Internet. While the vRouter can be configured to recognize and maintain connections to multiple routing counterpoints within the virtual infrastructure, only one such connection is used as a primary route and the others would only serve as "hot backup", ready to take over in case the primary connection (or vRouter central point) fails.

Extending the overall configuration of the overlay deployment so that it mimics actual physical networks even in that trait of automatic optimum (shortest) path lookup would be a logical and potentially quite worthwhile step forward.

Acknowledgements The work presented in this article has been partially funded by project DEEP Hybrid-DataCloud (grant agreement No 777435). GM and MC would also like to thank the Spanish "Ministerio de Economía, Industria y Competitividad" for the project "BigCLOE" with reference number TIN2016-79951-R. Computational resources at CESNET, used in the real-world use case, were supplied by the project "e-Infrastruktura CZ" (e-INFRA LM2018140) provided within the program Projects of Large Research, Development and Innovations Infrastructures.

References

1. Kranzlmüller, D., de Lucas, J.M., Öster, P.: The European Grid Initiative (EGI). In: Remote Instrumentation and Virtual Laboratories, pp. 61–66. Springer, US (2010). https://doi.org/10.1007/978-1-4419-5597-5_6
2. Altunay, M., Avery, P., Blackburn, K., Bockelman, B., Ernst, M., Fraser, D., Quick, R., Gardner, R., Goasguen, S., Levshina, T., Livny, M., McGee, J., Olson, D., Pordes, R., Potekhin, M., Rana, A., Roy, A., Sehgal, C., Sfiligoi, I., Wuerthwein, F.: A science driven production cyberinfrastructure-the open science grid. J Grid Comput. **9**(2), 201–218 (2011). https://doi.org/10.1007/s10723-010-9176-6
3. Medeiros, C.B., Katz, D.S.: EScience today and tomorrow. https://doi.org/10.1016/j.future.2015.10.016 (2016)
4. Mell, P., Grance, T.: The NIST definition of cloud computing. NIST special publication 800-145 (Final), Tech. rep. http://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf (2011)
5. Slurm workload manager. https://slurm.schedmd.com/
6. Thain, D., Tannenbaum, T., Livny, M.: Distributed computing in practice: The Condor experience. https://doi.org/10.1002/cpe.938 (2005)
7. Fajardo, E.M., Dost, J.M., Holzman, B., Tannenbaum, T., Letts, J., Tiradani, A., Bockelman, B., Frey, J., Mason, D.: How much higher can HTCondor fly? In: Journal of Physics: Conference Series, vol 664, Institute of Physics Publishing (2015). https://doi.org/10.1088/1742-6596/664/6/062014
8. De Alfonso, C., Caballer, M., Alvarruiz, F., Moltó, G.: An economic and energy-aware analysis of the viability of outsourcing cluster computing to a cloud. Futur. Gener. Comput. Syst. **29**(3), 704–712 (2013). 10.1016/j.future.2012.08.014
9. INFN, INDIGO PaaS orchestrator. https://www.indigo-datacloud.eu/paas-orchestrator

10. CESNET, I.NDIGO.v.irtual.r.outer. https://github.com/indigo-dc/ansible-role-indigovr
11. U. of Zurich, ElastiCluster. https://github.com/elasticluster/elasticluster
12. MIT, StarCluster. http://web.mit.edu/stardev/cluster/
13. Coulter, J.E., Abeysinghe, E., Pamidighantam, S., Pierce, M.: Virtual clusters in the jetstream cloud: A story of elasticized hpc. In: Proceedings of the Humans in the Loop: Enabling and Facilitating Research on Cloud Computing, HARC '19, pp. 8:1–8:6. ACM, New York (2019). https://doi.org/10.1145/3355738.3355752
14. Yu, L., Cai, Z.: Dynamic scaling of virtual clusters with bandwidth guarantee in cloud datacenters. In: IEEE INFOCOM 2016 - The 35th Annual IEEE International Conference on Computer Communications, pp 1–9 (2016). https://doi.org/10.1109/INFOCOM.2016.7524355
15. Yu, L., Shen, H., Cai, Z., Liu, L., Pu, C.: Towards bandwidth guarantee for virtual clusters under demand uncertainty in multi-tenant clouds. IEEE Trans. Parallel Distrib. Syst **29**(2), 450–465 (2018). https://doi.org/10.1109/TPDS.2017.2754366
16. Caballer, M., De Alfonso, C., Alvarruiz, F., Moltó, G.: EC3: Elastic cloud computing cluster. J. Comput. Syst. Sci. **79**(8), 1341–1351 (2013). https://doi.org/10.1016/j.jcss.2013.06.005
17. Sipos, G., La Rocca, G., Scardaci, D., Solagna, P.: The EGI applications on demand service. Futur. Gener. Comput. Syst. **98**, 171–179 (2019). https://doi.org/10.1016/j.future.2019.03.009
18. Calatrava, A., Romero, E., Moltó, G., Caballer, M., Alonso, J.M.: Self-managed cost-efficient virtual elastic clusters on hybrid Cloud infrastructures. Futur. Gener. Comput. Syst. **61**, 3–25 (2016). https://doi.org/10.1016/j.future.2016.01.018
19. Azure, Azure cyclecloud. https://azure.microsoft.com/en-us/features/azure-cyclecloud/
20. AWS, AWS parallel cluster. https://aws.amazon.com/es/blogs/opensource/aws-parallelcluster/
21. AWS Batch. https://aws.amazon.com/batch/
22. ALCES flight. https://alces-flight.com/
23. Istio. Connect, secure, control, and observe services. https://istio.io/
24. Submariner k8s project documentation website. https://submariner.io/
25. Open netorking environment. https://networkencyclopedia.com/open-network-environment/
26. Open vSwitch. https://www.openvswitch.org/
27. Cloudify. https://cloudify.co/
28. Caballer, M., Zala, S., García, Á.L., Moltó, G., Fernández, P.O., Velten, M.: Orchestrating complex application architectures in heterogeneous clouds. J.Grid Comput. **16**(1), 3–18 (2018). https://doi.org/10.1007/s10723-017-9418-y arXiv:1711.03334
29. Caballer, M., Donvito, G., Moltó, G., Rocha, R., Velten, M.: TOSCA-based orchestration of complex clusters at the IaaS level. J Phys. Conf. Ser. **898**, 082036 (2017). https://doi.org/10.1088/1742-6596/898/8/082036 http://stacks.iop.org/1742-6596/898/i=8/a=082036?key=crossref.af71f04f17660fdd1e050f7c1e00b643
30. Barisits, M., Beermann, T., Berghaus, F., Bockelman, B., Bogado, J., Cameron, D., Christidis, D., Ciangottini, D., Dimitrov, G., Elsing, M., Garonne, V., di Girolamo, A., Goossens, L., Guan, W., Guenther, J., Javurek, T., Kuhn, D., Lassnig, M., Lopez, F., Magini, N., Molfetas, A., Nairz, A., Ould-Saada, F., Prenner, S., Serfon, C., Stewart, G., Vaandering, E., Vasileva, P., Vigne, R., Wegner, T.: Rucio: Scientific data management. Comput. Softw. Big Sci. **3**(1), 11 (2019). https://doi.org/10.1007/s41781-019-0026-3
31. Caballer, M., Blanquer, I., Moltó, G., de Alfonso, C.: Dynamic management of virtual infrastructures. J. Grid Comput. **13**(1), 53–70 (2015). https://doi.org/10.1007/s10723-014-9296-5
32. Palma, D., Rutkowski, M., Spatzier, T.: Simple-Profile-YAML-v1.1.html TOSCA Simple Profile in YAML Version 1.1, Tech. rep. http://docs.oasis-open.org/tosca/TOSCA-Simple-Profile-YAML/v1.1/TOSCA-Simple-Profile-YAML-v1.1.html (2016)
33. de Alfonso, C., Caballer, M., Alvarruiz, F., Hernández, V.: An energy management system for cluster infrastructures. Comput. Electr. Eng. **39**(8), 2579–2590 (2013). http://www.sciencedirect.com/science/article/pii/S0045790613001365
34. de Alfonso, C., Caballer, M., Calatrava, A., Moltó, G., Blanquer, I.: Multi-elastic Datacenters: Auto-scaled Virtual Clusters on Energy-Aware Physical Infrastructures. J. Grid Comput. **17**(1), 191–204 (2019). https://doi.org/10.1007/s10723-018-9449-z
35. Google, G.gleI.Pv6. https://www.google.com/intl/en/ipv6/statistics.html
36. Addepalli, S.R.: OVN4NFVK8s Plugin. https://github.com/opnfv/ovn4nfv-k8s-plugin (Sood, R.)
37. Audio model. https://marketplace.deep-hybrid-datacloud.eu/modules/deep-oc-audio-classification-tf.html
38. DEEP open catalog. https://marketplace.deep-hybrid-datacloud.eu
39. AudioSet: A large-scale dataset of manually annotated audio events. https://research.google.com/audioset/
40. Gomes, J., Bagnaschi, E., Campos, I., David, M., Alves, L., Martins, J., Pina, J., López-García, A., Orviz, P.: Enabling rootless linux containers in multi-user environments: The udocker tool. Comput. Phys. Commun. **232**, 84–97 (2018). https://doi.org/10.1016/j.cpc.2018.05.021 arXiv:1711.01758
41. Salamon, J., Jacoby, C., Bello, J.P.: A dataset and taxonomy for urban sound research. In: MM 2014 - Proceedings of the 2014 ACM Conference on Multimedia, Association for Computing Machinery, Inc, pp 1041–1044 (2014). https://doi.org/10.1145/2647868.2655045

5.1.1.32. Serverless Workflows for Containerised Applications in the Cloud Continuum

S. Risco, G. Moltó, D. M. Naranjo, and I. Blanquer, "Serverless Workflows for Containerised Applications in the Cloud Continuum," J. Grid Comput., vol. 19, no. 3, p. 30, Sep. 2021, doi: https://dx.doi.org/10.1007/s10723-021-09570-2

Base de datos de indexación	Web of Science / JCR
Índice de impacto	3.986
Año	2020
Categoría	Comp. Science, Theory & Methods
Posición de la revista en el área	16 de 110
Tercil	T1
Cuartil	Q1
Número de citas en JCR	2
Número de citas totales	5

Comentario. Esta es una de las contribuciones del proyecto H2020 AI-SPRINT (101016577) "Artificial Intelligence in Secure PRIvacy-preserving computing coNTinuum" en las que el candidato lidera el paquete de trabajo 3 (*Runtime environment*). En ella se demuestra la integración entre el software OSCAR (https://oscar.grycap.net) y SCAR (https://github.com/grycap/) para la creación de workflows de procesamiento de datos a lo largo del continuo computacional, empleando un caso de uso de detección de uso de mascarillas utilizando técnicas de AI/ML.

Journal of Grid Computing (2021) 19: 30
https://doi.org/10.1007/s10723-021-09570-2

Serverless Workflows for Containerised Applications in the Cloud Continuum

Sebastián Risco · Germán Moltó · Diana M. Naranjo · Ignacio Blanquer

Received: 29 October 2020 / Accepted: 21 June 2021/Published online: 13 July 2021

Abstract This paper introduces an open-source platform to support serverless computing for scientific data-processing workflow-based applications across the Cloud continuum (i.e. simultaneously involving both on-premises and public Cloud platforms to process data captured at the edge). This is achieved via dynamic resource provisioning for FaaS platforms compatible with scale-to-zero approaches that minimise resource usage and cost for dynamic workloads with different elasticity requirements. The platform combines the usage of dynamically deployed auto-scaled Kubernetes clusters on on-premises Clouds and automated Cloud bursting into AWS Lambda to achieve higher levels of elasticity. A use case in public health for smart cities is used to assess the platform, in charge of detecting people not wearing face masks from captured videos. Faces are blurred for enhanced anonymity in the on-premises Cloud and detection via Deep Learning models is performed in AWS Lambda for this data-driven containerised workflow. The results indicate that hybrid workflows across the Cloud continuum can efficiently perform local data processing for enhanced regulations compliance and perform Cloud bursting for increased levels of elasticity.

Keywords Cloud computing · Serverless computing · Workflow · Containers

S. Risco (✉) · G. Moltó · D. M. Naranjo · I. Blanquer
Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC - Universitat Politècnica de València, Camino de Vera s/n, 46022, Valencia, España
e-mail: serisgal@i3m.upv.es

G. Moltó
e-mail: gmolto@dsic.upv.es

D. M. Naranjo
e-mail: dnaranjo@i3m.upv.es

I. Blanquer
e-mail: iblanque@dsic.upv.es

1 Introduction

Cloud computing has become in the last decade the premier option for virtualised computing. It has increased hardware resource utilization and provided the ability to execute disparate computing workloads with complex requirements on shared computing infrastructures. Initial service delivery models, such as Infrastructure as a Service (IaaS), were exemplified by public Cloud services such as Amazon EC2 [4] and on-premises Cloud Management Platforms (CMPs) such as OpenStack [48]. These were later extended to accommodate additional models such as Platform as a Service (PaaS) and, more recently, Functions as a Service (FaaS). FaaS aims to rise the level of abstraction for application developers at the expense of relying on the infrastructure provider for automated elasticity, efficient virtual infrastructure provisioning and improved resource allocation.

Initial FaaS services, exemplified by public Cloud services such as AWS Lambda [6] and Azure Functions

It is important to point out that the gap between the two lines in Fig. 9 can be closed by increasing the number of parallel execution slots and reducing the time until they are initially available for execution. The former is bounded by the underlying physical hardware available, which is fixed, and the allocation of resources to the deployed Virtual Machines, i.e., the instance types, which can be configured at deployment time. The latter depends on the elasticity rules employed in the cluster. In our case, the CLUES elasticity manager governing the rules to scale out (add additional nodes) and scale in (terminate the free nodes) was configured to only start the front-end of the cluster and a working node in charge of performing the job executions. This is a conservative strategy that aims to minimize energy consumption in an on-premises Cloud and only reactively provision additional resources whenever they are needed. Since CLUES rules can be configured, the user may prefer to have a pre-provisioned fleet of VMs that are immediately available upon moderate changes in the workload to be processed.

The use of an open-source stack that can be fully configured by the user in order to seamlessly perform both infrastructure provision along the Cloud continuum and data-driven workflow enactment using a serverless approach is an important step forward in widespreading the adoption of this techniques for scientific computing. Traditional serverless use cases focused on unpredictable bursts of short-lived requests, as is the case of web applications. However, we have demonstrated that compute-intensive, workflow-based applications can also benefit from the event-driven capabilities and automated resource management provided by serverless computing.

5 Conclusions

This paper has introduced an open-source platform that supports the definition of event-driven file-processing workflows that can execute across the Cloud computing continuum that features underlying elasticity in the provisioning of resources. The ability to Cloud burst into a public Cloud using a serverless approach introduces an unprecedented level of elasticity when compared to traditional approaches based exclusively on Virtual Machines.

The seamless integration between SCAR, which supports the execution of containers within AWS Lambda to bring serverless for scientific computing, and OSCAR, which provides the FaaS computing model for file-processing applications on Kubernetes clusters, has allowed to create hybrid data processing workflows across the Cloud continuum. These workflows can orchestrate automated provisioning of resources both in the on-premises Cloud, through elastic Kubernetes clusters and in the public Cloud, through the use of serverless services such as AWS Lambda.

A use case based on smart camera networks with applications in smart cities for video surveillance has been envisaged and assessed, in order to efficiently determine the usage of face masks across the population out of processed videos using Artificial Intelligence models. The use case has been made publicly available in GitHub[7] in order to guarantee its reproducibility. The experiments show that it is affordable and efficient to deviate a computing intensive part of the processing to AWS Lambda, rather than processing it on limited-scale, on-premises clusters, even if those clusters would have better network connectivity. This fact is more evident as the scale factor increases

Future works include dynamic resource orchestration across the Cloud-to-Things continuum, where the workflow can anticipate the expected incoming workload in order to further adapt the resources. This would minimize the amount of time invested in provisioning additional nodes within the on-premises Cloud and the cold-start incurred by the Lambda functions once they have scaled-to-zero. We also plan to adapt OSCAR to minimalistic Kubernetes distribution to move part of the event-driven functionality of OSCAR closer to the edge, by enabling it to run on IoT devices, allowing the composition of workflows that begin the processing on the data gathering device itself.

Acknowledgements The authors would like to thank the European Union for the project "Artificial Intelligence in Secure PRIvacy-preserving computing coNTinuum" (AI-SPRINT), with code 101016577, funded under the H2020 Framework Programme and also the regional government of the Comunitat Valenciana (Spain) for the project IDIFEDER/2018/032 (High-Performance Algorithms for the Modeling, Simulation and early Detection of diseases in Personalized Medicine),

[7]Mask detector workflow - https://github.com/grycap/scar/tree/master/examples/mask-detector-workflow

co-funded by the European Union ERDF funds (European Regional Development Fund) of the Comunitat Valenciana 2014–2020.

Funding Open Access funding provided thanks to the CRUE-CSIC agreement with Springer Nature.

References

1. Agache, A., Brooker, M., Iordache, A., Liguori, A., Neugebauer, R., Piwonka, P., Popa, D.M.: Firecracker: lightweight virtualization for serverless applications. In: 17th USENIX Symposium on Networked Systems Design and Implementation (NSDI 20), pp. 419–434. USENIX Association, Santa Clara, CA. https://www.usenix.org/conference/nsdi20/presentation/agache (2020)
2. Al Nuaimi, E., Al Neyadi, H., Mohamed, N., Al-Jaroodi, J.: Applications of big data to smart cities. Journal of Internet Services and Applications **6**(1), 25 (2015). https://doi.org/10.1186/s13174-015-0041-5.
3. de Alfonso, C., Caballer, M., Calatrava, A., Moltó, G., Blanquer, I.: Multi-elastic Datacenters: auto-scaled virtual clusters on energy-aware physical infrastructures. Journal of Grid Computing **17**(1), 191–204 (2019). https://doi.org/10.1007/s10723-018-9449-z.
4. Amazon Web Services: Amazon EC2. https://aws.amazon.com/ec2/
5. Amazon Web Services: AWS Batch — Easy and Efficient Batch Computing Capabilities. https://aws.amazon.com/batch/
6. Amazon Web Services: AWS Lambda. https://aws.amazon.com/lambda
7. Apache: OpenWhisk - Open Source Serverless Cloud Platform. https://openwhisk.apache.org/
8. Argo: Workflows & Pipelines. https://argoproj.github.io/projects/argo/
9. Baldini, I., Castro, P., Chang, K., Cheng, P., Fink, S., Ishakian, V., Mitchell, N., Muthusamy, V., Rabbah, R., Slominski, A., Suter, P.: Serverless computing: Current trends and open problems. In: Research Advances in Cloud Computing, pp. 1–20. Springer, Singapore (2017). https://doi.org/10.1007/978-981-10-5026-8_1.
10. Baldini, I., Cheng, P., Fink, S.J., Mitchell, N., Muthusamy, V., Rabbah, R., Suter, P., Tardieu, O.: The serverless trilemma: function composition for serverless computing. In: Proceedings of the 2017 ACM SIGPLAN International Symposium on New Ideas, New Paradigms, and Reflections on Programming and Software - Onward! 2017, pp. 89–103. ACM Press, New York (2017). https://doi.org/10.1145/3133850.3133855. http://dl.acm.org/citation.cfm?doid=3133850.3133855
11. Balouek-Thomert, D., Renart, E.G., Zamani, A.R., Simonet, A., Parashar, M.: Towards a computing continuum: Enabling edge-to-cloud integration for data-driven workflows. International Journal of High Performance Computing Applications **33**(6), 1159–1174 (2019). https://doi.org/10.1177/1094342019877383.
12. Baresi, L., Mendonça, D.F., Garriga, M., Guinea, S., Quattrocchi, G.: A unified model for the mobile-edge-cloud continuum. ACM Transactions on Internet Technology **19**(2), 1–21 (2019). https://doi.org/10.1145/3226644
13. Beckman, P., Dongarra, J., Ferrier, N., Fox, G., Moore, T., Reed, D., Beck, M.: Harnessing the computing continuum for programming our world. In: Fog Computing, pp. 215–230. Wiley (2020). https://doi.org/10.1002/9781119551713.ch7.
14. Bello, J.P., Mydlarz, C., Salamon, J.: Sound analysis in smart cities. In: Computational Analysis of Sound Scenes and Events, pp. 373–397. Springer International Publishing, Cham (2018). https://doi.org/10.1007/978-3-319-63450-0_13
15. Brewer, E.A.: Kubernetes and the path to cloud native. In: Proceedings of the Sixth ACM Symposium on Cloud Computing - SoCC '15, pp. 167–167. Association for Computing Machinery (ACM), New York (2015). https://doi.org/10.1145/2806777.2809955. http://dl.acm.org/citation.cfm?doid=2806777.2809955
16. Caballer, M., Blanquer, I., Moltó, G., de Alfonso, C.: Dynamic management of virtual infrastructures. Journal of Grid Computing **13**(1), 53–70 (2015). https://doi.org/10.1007/s10723-014-9296-5
17. Calatrava, A., Romero, E., Moltó, G., Caballer, M., Alonso, J.M.: Self-managed cost-efficient virtual elastic clusters on hybrid Cloud infrastructures. Future Generation Computer Systems **61**, 13–25 (2016). https://doi.org/10.1016/j.future.2016.01.018. http://authors.elsevier.com/sd/article/S0167739X16300024
18. Camero, A., Alba, E.: Smart City and information technology: A review. Cities **93**, 84–94 (2019). https://doi.org/10.1016/j.cities.2019.04.014
19. Casalboni, A.: AWS Lambda Power Tuning. https://github.com/alexcasalboni/aws-lambda-power-tuning
20. Chard, R., Babuji, Y., Li, Z., Skluzacek, T., Woodard, A., Blaiszik, B., Foster, I., Chard, K.: funcX: a federated function serving fabric for science. In: Proceedings of the 29th International symposium on high-performance parallel and distributed computing, pp. 65–76. ACM, New York (2020). https://doi.org/10.1145/3369583.3392683
21. Chen, C.H., Favre, J., Kurillo, G., Andriacchi, T.P., Bajcsy, R., Chellappa, R.: Camera networks for healthcare, teleimmersion, and surveillance. Computer **47**(5), 26–36 (2014). https://doi.org/10.1109/MC.2014.112. http://ieeexplore.ieee.org/document/6818909/

22. Chen, Q., Wang, W., Wu, F., De, S., Wang, R., Zhang, B., Huang, X.: A survey on an emerging area: deep learning for smart city data. IEEE Trans. Emerg. Topics Comput. Intell. **3**(5), 392–410 (2019). https://doi.org/10.1109/TETCI.2019.2907718. https://ieeexplore.ieee.org/document/8704334/
23. Christidis, A., Davies, R., Moschoyiannis, S.: Serving machine learning workloads in resource constrained environments: A serverless deployment example. In: Proceedings - 2019 IEEE 12th Conference on Service-Oriented Computing and Applications, SOCA 2019, pp. 55–63. Institute of Electrical and Electronics Engineers Inc (2019). https://doi.org/10.1109/SOCA.2019.00016
24. Christidis, A., Moschoyiannis, S., Hsu, C.H., Davies, R.: Enabling Serverless Deployment of Large-Scale AI Workloads. IEEE Access **8**, 70150–70161 (2020). https://doi.org/10.1109/ACCESS.2020.2985282
25. CNCF: Serverless Workflow: A specification for defining declarative workflow models that orchestrate Event-driven, Serverless applications. https://serverlessworkflow.io
26. Couturier, R.: Designing scientific applications on GPUs. Chapman and Hall/CRC. https://doi.org/10.1201/b16051. https://www.taylorfrancis.com/books/designing-scientific-applications-gpus-raphael-couturier/e/10.1201/b16051 (2013)
27. Docker: Enterprise Container Platform. https://www.docker.com/
28. Docker: Docker hub. https://hub.docker.com/ (2019)
29. Dutka, Ł., Wrzeszcz, M., Lichoń, T., Słota, R., Zemek, K., Trzepla, K., Opioła, Ł., Słota, R., Kitowski, J.: Onedata - A step forward towards globalization of data access for computing infrastructures, vol. 51, pp. 2843–2847 (2015). https://doi.org/10.1016/j.procs.2015.05.445. https://www.sciencedirect.com/science/article/pii/S1877050915012533
30. Fouladi, S., Romero, F., Iter, D., Li, Q., Chatterjee, S., Kozyrakis, C., Zaharia, M., Winstein, K.: From laptop to Lambda: Outsourcing everyday jobs to thousands of transient functional containers. In: Proceedings of the 2019 USENIX Annual Technical Conference, USENIX ATC 2019, pp. 475–488 (2019). https://dl.acm.org/doi/10.5555/3358807.3358848
31. Giménez-Alventosa, V., Moltó, G., Caballer, M.: A framework and a performance assessment for serverless MapReduce on AWS Lambda. Future Generation Computer Systems **97**, 259–274 (2019). https://doi.org/10.1016/j.future.2019.02.057. https://linkinghub.elsevier.com/retrieve/pii/S0167739X18325172
32. Giménez-Alventosa, V., Moltó, G., Segrelles, J.D.: RUPER-LB: Load balancing embarrasingly parallel applications in unpredictable cloud environments. In: International Symposium on Cloud Computing and Services for High Performance Computing Systems (as part of the 18th International Conference on High Performance Computing & Simulation (HPCS 2020) (2020)
33. GRyCAP: minicon: minimization containers. https://github.com/grycap/minicon
34. Heath, M.T.: Scientific computing: : an introductory survey, revised second edition. Society for Industrial and Applied Mathematics, Philadelphia, PA. https://doi.org/10.1137/1.9781611975581. (2018)
35. Ishakian, V., Muthusamy, V., Slominski, A.: Serving deep learning models in a serverless platform. In: Proceedings - 2018 IEEE International Conference on Cloud Engineering, IC2E 2018, pp. 257–262. Institute of Electrical and Electronics Engineers Inc (2018). https://doi.org/10.1109/IC2E.2018.00052
36. Ivie, P., Thain, D.: Reproducibility in scientific computing. https://doi.org/10.1145/3186266 (2018)
37. Jonas, E., Pu, Q., Venkataraman, S., Stoica, I., Recht, B.: Occupy the cloud. In: Proceedings of the 2017 Symposium on Cloud Computing, pp. 445–451. ACM, New York (2017). https://doi.org/10.1145/3127479.3128601. arXiv:1702.04024
38. Knative: Kubernetes-based platform to deploy and manage modern serverless workloads. https://knative.dev/
39. Linux Containers: LXC. https://linuxcontainers.org/lxc/introduction/
40. Malawski, M., Gajek, A., Zima, A., Balis, B., Figiela, K.: Serverless execution of scientific workflows: Experiments with HyperFlow, AWS Lambda and Google Cloud functions. Future Generation Computer Systems **110**, 502–514 (2020). https://doi.org/10.1016/j.future.2017.10.029. https://linkinghub.elsevier.com/retrieve/pii/167739X1730047X
41. McCallister, E., Grance, T., Kent, K.: Guide to protecting the confidentiality of personally identifiable information (PII). Special Publication 800-122 Guide pp. 1–59. https://doi.org/10.5555/2206206 (2010)
42. Microsoft Azure: Azure Functions—Develop Faster With Serverless Compute. https://azure.microsoft.com/en-us/services/functions/
43. MinIO: High Performance, Kubernetes Native Object Storage. https://min.io/
44. Mirkhan, A.: BlurryFaces: A tool to blur faces or other regions in photos and videos. https://github.com/asmaamirkhan/BlurryFaces
45. Morris, K.: Infrastructure as code: managing servers in the cloud. O'Reilly Media, Inc. https://www.oreilly.com/library/view/infrastructure-as-code/9781491924334/ (2016)
46. OASIS: TOSCA simple profile in YAML version 1.3. https://docs.oasis-open.org/tosca/TOSCA-Simple-Profile-YAML/v1.3/TOSCA-Simple-Profile-YAML-v1.3.html
47. OpenFaaS: Serverless functions made simple. https://www.openfaas.com/
48. OpenStack: Open Source Cloud Computing Infrastructure. https://www.openstack.org
49. Pavlovic, M., Etsion, Y., Ramirez, A.: On the memory system requirements of future scientific applications: Four case-studies. In: Proceedings - 2011 IEEE International Symposium on Workload Characterization, IISWC - 2011, pp. 159–170 (2011). https://doi.org/10.1109/IISWC.2011.6114176
50. Pérez, A., Moltó, G., Caballer, M., Calatrava, A.: Serverless computing for container-based architectures. Future Generation Computer Systems **83**, 50–59 (2018). https://doi.org/10.1016/j.future.2018.01.022. http://linkinghub.elsevier.com/retrieve/pii/S0167739X17316485
51. Pérez, A., Moltó, G., Caballer, M., Calatrava, A.: Serverless computing for container-based architectures. Future Generation Computer Systems **83**, 50–59 (2018).

https://doi.org/10.1016/j.future.2018.01.022. http://www.sciencedirect.com/science/article/pii/S0167739X17316485
52. Pérez, A., Moltó, G., Caballer, M., Calatrava, A.: A programming model and middleware for high throughput serverless computing applications. In: Proceedings of the 34th ACM/SIGAPP symposium on applied Computing - SAC '19, pp. 106–113. ACM Press, New York (2019). https://doi.org/10.1145/3297280.3297292
53. Perez, A., Risco, S., Naranjo, D.M., Caballer, M., Molto, G.: On-premises serverless computing for event-driven data processing applications. In: 2019 IEEE 12th International Conference on Cloud Computing (CLOUD), pp. 414–421. Institute of Electrical and Electronics Engineers (IEEE). https://doi.org/10.1109/cloud.2019.00073. https://ieeexplore.ieee.org/document/8814513 (2019)
54. Purohit, A.: face-mask-detector: Real-Time Face mask detection using deep learning with Alert system. https://github.com/adityap27/face-mask-detector/
55. Reisslein, M., Rinner, B., Roy-Chowdhury, A.: Smart Camera Networks [Guest editors' introduction]. Computer **47**(5), 23–25 (2014). https://doi.org/10.1109/MC.2014.134. http://ieeexplore.ieee.org/document/6818928/
56. Risco, S., Moltó, G.: GPU-enabled serverless workflows for efficient multimedia processing. Applied Sciences **11**(4), 1438 (2021). https://doi.org/10.3390/app11041438. https://www.mdpi.com/2076-3417/11/4/1438
57. Ristov, S., Pedratscher, S., Fahringer, T.: AFCL: An abstract function choreography language for serverless workflow specification. Future Generation Computer Systems **114**, 368–382 (2021). https://doi.org/10.1016/j.future.2020.08.012. https://linkinghub.elsevier.com/retrieve/pii/S0167739X20302648
58. Sengupta, S.: faas-flow: Function Composition for OpenFaaS. https://github.com/s8sg/faas-flow
59. Sewak, M., Singh, S.: Winning in the era of serverless computing and function as a service. In: 2018 3rd International Conference for Convergence in Technology, I2CT 2018. Institute of Electrical and Electronics Engineers Inc (2018). https://doi.org/10.1109/I2CT.2018.8529465
60. Shields, M.: Control-versus data-driven workflows. In: Workflows for e-Science, pp. 167–173. Springer, London (2007). https://link.springer.com/chapter/10.1007/978-1-84628-757-2_11
61. Spadini, T., Silva, D.L.d.O., Suyama, R.: Sound event recognition in a smart city surveillance context. arXiv:1910.12369 (2019)
62. Vecchiola, C., Pandey, S., Buyya, R.: High-performance cloud computing: A view of scientific applications. In: I-SPAN 2009 - The 10th International Symposium on Pervasive Systems, Algorithms, and Networks, pp. 4–16 (2009). https://doi.org/10.1109/I-SPAN.2009.150

5.1.1.33. TaScaaS: A Multi-Tenant Serverless Task Scheduler and Load Balancer as a Service

V. Gimenez-Alventosa, G. Molto, and J. D. Segrelles, "TaScaaS: A Multi-Tenant Serverless Task Scheduler and Load Balancer as a Service," IEEE Access, vol. 9, pp. 125215–125228, 2021, doi: https://dx.doi.org/10.1109/ACCESS.2021.3109972

Base de datos de indexación	Web of Science / JCR
Índice de impacto	3,367
Año	2020
Categoría	Comp. Science, Information Systems
Posición de la revista en el área	65 de 161
Tercil	T2
Cuartil	Q2
Número de citas en JCR	0
Número de citas totales	0

Comentario. Esta contribución es uno de los resultados del proyecto Retos I+D SERCLOCO (PID2020-113126RB-I00) y uno de los principales resultados de la Tesis Doctoral de Vicent Giménez, dirigida por el candidato. En ella se describe el diseño e implementación de un balanceador de la carga serverless para distribuir tareas para infraestructuras de computación con prestaciones heterogéneas.

IEEE Access
Multidisciplinary : Rapid Review : Open Access Journal

Received July 20, 2021, accepted August 1, 2021, date of publication September 3, 2021, date of current version September 15, 2021.

Digital Object Identifier 10.1109/ACCESS.2021.3109972

TaScaaS: A Multi-Tenant Serverless Task Scheduler and Load Balancer as a Service

VICENT GIMÉNEZ-ALVENTOSA, GERMÁN MOLTÓ, AND J. DAMIAN SEGRELLES
Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC - Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain

Corresponding author: Vicent Giménez-Alventosa (vicent.gimenez@i3m.upv.es)

This work was supported in part by the Spanish "Ministerio de Ciencia e Innovación" for the project Serverless Scientific Computing Across the Hybrid Cloud Continuum (SERCLOCO) under Grant PID2020-113126RB-I00, in part by the program "Ayudas para la contratación de personal investigador en formación de carácter predoctoral, programa VALi+d" from the Conselleria d'Educació of the Generalitat Valenciana, Spain, under Grant ACIF/2018/148, in part by the Fondo Social Europeo (FSE), in part by the project "AI in Secure Privacy-Preserving Computing Continuum (AI-SPRINT)" through the European Union's Horizon 2020 Research and Innovation Programme under Grant 101016577, in part by the European Regional Development Fund (ERDF) of the Comunitat Valenciana 2014–2020, the regional government of the Comunitat Valenciana, Spain, (High-Performance Algorithms for the Modeling, Simulation and early Detection of diseases in Personalized Medicine), under Project IDIFEDER/2018/032, in part by the European Open Science Cloud - Hub (EOSC-Hub) Project under Grant 777536, and in part by the Helix Nebula Science Cloud (HNSciCloud) Project is also sponsoring the service, allowing users to access the HNSciCloud services pilot for limited scale usage using the voucher schemes provided by the two contractors: T-Systems and Exoscale, under Grant 687614.

ABSTRACT A combination of distributed multi-tenant infrastructures, such as public Clouds and on-premises installations belonging to different organisations, are frequently used for scientific research because of the high computational requirements involved. Although resource sharing maximises their usage, it typically causes undesirable effects such as the *noisy neighbour*, producing unpredictable variations of the infrastructure computing capabilities. These fluctuations affect execution efficiency, even of loosely coupled applications, such as many Monte Carlo based simulation programs. This highlights the need of a service capable to handle workload distribution across multiple infrastructures to mitigate these unpredictable performance fluctuations. With this aim, this work introduces TaScaaS, a highly scalable and completely serverless service deployed on AWS to distribute loosely coupled jobs among several computing infrastructures, and load balance them using a completely asynchronous approach to cope with the performance fluctuations with minimum impact in the execution time. We demonstrate how TaScaaS is not only capable of handling these fluctuations efficiently, achieving reduction in execution times up to 45% in our experiments, but also split the jobs to be computed to meet the user-defined execution time.

INDEX TERMS Cloud computing, heterogeneous computing, load balance, serverless.

I. INTRODUCTION

The use of huge computational power is commonly required in science and engineering to be able to perform computational experiments. Many of these experiments are carried out by loosely coupled algorithms which can be easily parallelized to be executed in a distributed environment. However, the high computational power requirements typically forces the researchers to use several infrastructures belonging to different organisations. For instance, in Monte Carlo simulations of radiation transport applied to the calculus of ionisation chamber correction factors, the work presented by Christian *et al.* [1] required more than 30000 CPU hours to simulate a single case consisting on more than $7 \cdot 10^{11}$ primary particles, and Vicent *et al.* [2] reported approximately 13800 CPU hours to simulate each combination of ionisation chamber and photon beam considered in the study, which results in a total of 745200 CPU hours. As consequence, both works have used several independent infrastructures to cope with the huge computational workload of the studies. These cases, and many others, highlights the need to efficiently handle the execution of loosely coupled applications across several computing infrastructures.

However, distributed infrastructures usually involve heterogeneous computing environments. Therefore, a single infrastructure could exhibit disparate performance among its available computing nodes due to differences in the underlying hardware. Moreover, it is common for computing infrastructures to use a multi-tenancy approach i.e. multiple users share the same underlying physical infrastructure in order to

The associate editor coordinating the review of this manuscript and approving it for publication was Fan-Hsun Tseng.

equivalent to the probability to have a single slow partition. To quantify this effect, the Table 4 shows the delay intervals corresponding to 1σ, 2σ, 3σ and greater than 3σ for both groups, the fast and the slow. For each interval, the dependency of the probability with the number of partitions of each group is shown, and the specific probability for 5 partitions has been calculated, which is, approximately, the mean number of partitions used in our experimentation. In the worst case, the delay produced in the whole job execution time will be equal to the top limit of each delay interval, which possibly causes the condition of the equation 19 to not be met.

TABLE 4. Expected delay probabilities caused by performance fluctuations for both groups, fast and slow. The variable *n*, represents the number of partitions belonging to the specific group.

Delay(fast)	Delay(slow)	Probability	Probability $n = 5$
$(0, 2]\%$	$(0, 15]\%$	$1 - (0.659)^n$	87.57%
$(2, 4]\%$	$(15, 30]\%$	$1 - (0.864)^n$	51.85%
$(4, 6]\%$	$(30, 45]\%$	$1 - (0.979)^n$	10.07%
$> 6\%$	$> 45\%$	$1 - (0.999)^n$	0.5%

Notice also that, due the symmetry of the distribution, the same probabilities can be applied to partitions which mean speed is faster than the model prediction. Thus, these analysis can be also used to calculate the probability to have underused resources. Although the mean speed of our model can be artificially decreased to increase the probability to satisfy the time constraint, for example multiplying the speed by a "security" factor $\rho \in (0, 1) \setminus \bar{s}'(t) = \rho\bar{s}(t)$, this will cause an increment of the required resources to perform the calculus, producing an unnecessary resources over-provisioning. Moreover, this method will not handle the differences in partitions execution speeds, remaining faster resources potentially unused when their partial execution finishes. Furthermore, this method will produce an excess of partitions, which will increase the post-processing cost of the partial results. Depending on the application and the quantity of generated data, an excessive partitioning could produce post-processing times comparable to the execution time.

However, notice that if the fluctuations of our infrastructures are sufficiently low, like the faster performance group, the delays could be assumed and the use of a static approach may be good enough. Thus, to evaluate the suitability of using TaScaaS, could be useful to perform a benchmark following the procedure discussed in this section.

VI. CONCLUSION

In this work, we presented TaScaaS an open source serverless job scheduler and load balancer service to distribute and balance jobs among multiple heterogeneous infrastructures deployed or accessed by the user. As it is deployed on AWS Lambda, it benefits from the AWS free tier, minimising the cost of its execution. Also, TaScaaS is created as a serverless application, so it produces a cost only when it is used. Moreover, AWS Lambda provides a highly scalable environment, thus TaScaaS is capable to handle a large number of simultaneous workers.

We have demonstrated how TaScaaS overcomes static partitioning approaches depending on the performance fluctuations of the available infrastructures, which affect not only public cloud providers, but also on-premises and federated cloud infrastructures. In addition, TaScaaS has proved its capabilities to handle efficiently both kinds of heterogeneity, on hardware and due to sharing resources across multiple tenants. Furthermore, TaScaaS correctly handles time constraints in the execution time in this kind of environments.

In future versions of TaScaaS we will implement improvements such as an adaptive system to select the scale step time and change it according to the incoming workload, and support to deploy the TaScaaS service on other cloud providers. As it is accessed via HTTPS requests, the *worker infrastructures* are agnostic about where the TaScaaS back-end is running, and changing the provider require no changes on the infrastructure side. We will also investigate its behaviour in scenarios of computing continuum where resources from the edge are used in coordination with resources from on-premises and public Clouds. This will allow to achieve load balancing across highly heterogeneous computing platforms across a variety of infrastructures.

ACKNOWLEDGMENT

The authors would like to thank the EGI Applications on Demand service to provide part of the resources used for this work.

REFERENCES

[1] C. Valdes-Cortez, F. Ballester, J. Vijande, V. Gimenez, V. Gimenez-Alventosa, J. Perez-Calatayud, Y. Niatsetski, and P. Andreo, "Depth-dose measurement corrections for the surface electronic brachytherapy beams of an Esteya unit: A Monte Carlo study," *Phys. Med. Biol.*, vol. 65, no. 24, Dec. 2020, Art. no. 245026.

[2] V. Giménez-Alventosa, V. Giménez, F. Ballester, J. Vijande, and P. Andreo, "Monte Carlo calculation of beam quality correction factors for PTW cylindrical ionization chambers in photon beams," *Phys. Med. Biol.*, vol. 65, no. 20, Oct. 2020, Art. no. 205005.

[3] J. Ericson, M. Mohammadian, and F. Santana, "Analysis of performance variability in public cloud computing," in *Proc. IEEE Int. Conf. Inf. Reuse Integr. (IRI)*, Aug. 2017, pp. 308–314.

[4] A. Iosup, N. Yigitbasi, and D. Epema, "On the performance variability of production cloud services," in *Proc. 11th IEEE/ACM Int. Symp. Cluster, Cloud Grid Comput.*, May 2011, pp. 104–113.

[5] P. Leitner and J. Cito, "Patterns in the chaos—A study of performance variation and predictability in public IaaS clouds," *ACM Trans. Internet Technol.*, vol. 16, no. 3, pp. 1–23, Aug. 2016.

[6] *AWS*. Accessed: Feb. 18, 2021. [Online]. Available: https://aws.amazon.com/

[7] J. Schad, J. Dittrich, and J. A. Quiané-Ruiz, "Runtime measurements in the cloud: Observing, analyzing, and reducing variance," *Proc. VLDB Endowment*, vol. 3, nos. 1–2, pp. 460–471, Sep. 2010.

[8] S. Shankar, J. M. Acken, and N. K. Sehgal, "Measuring performance variability in the clouds," *IETE Tech. Rev.*, vol. 35, no. 6, pp. 656–660, Nov. 2018.

[9] V. Giménez-Alventosa, G. Moltó, and M. Caballer, "A framework and a performance assessment for serverless MapReduce on AWS Lambda," *Future Gener. Comput. Syst.*, vol. 97, pp. 259–274, Aug. 2019.

[10] A. Abedi and T. Brecht, "Conducting repeatable experiments in highly variable cloud computing environments," in *Proc. 8th ACM/SPEC Int. Conf. Perform. Eng.*, New York, NY, USA, Apr. 2017, pp. 287–292.

[11] V. G. Alventosa, G. M. Martínez, and J. D. S. Quilis, "RUPER-LB: Load balancing embarrasingly parallel applications in unpredictable cloud environments," 2020, *arXiv:2005.06361*. [Online]. Available: https://arxiv.org/abs/2005.06361

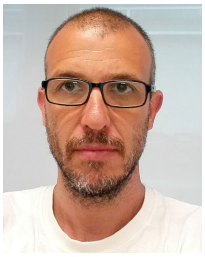
[12] *Serverless Framework*. Accessed: Jan. 25, 2021. [Online]. Available: https://www.serverless.com/
[13] B. Carver, J. Zhang, A. Wang, A. Anwar, P. Wu, and Y. Cheng, "Wukong: A scalable and locality-enhanced framework for serverless parallel computing," in *Proc. 11th ACM Symp. Cloud Comput. (SoCC)*, New York, NY, USA, Oct. 2020, pp. 1–15.
[14] M. Pawlik, P. Banach, and M. Malawski, "Adaptation of workflow application scheduling algorithm to serverless infrastructure," in *Euro-Par 2019: Parallel Processing Workshops*, U. Schwardmann, C. Boehme, D. B. Heras, V. Cardellini, E. Jeannot, A. Salis, C. Schifanella, R. R. Manumachu, D. Schwamborn, L. Ricci, O. Sangyoon, T. Gruber, L. Antonelli, S. L. Scott, Eds. Cham, Switzerland: Springer, 2020, pp. 345–356.
[15] *AWS Lambda Limits*. Accessed: Feb. 18, 2021. [Online]. Available: https://docs.aws.amazon.com/lambda/latest/dg/gettingstarted-limits.html
[16] *Google Cloud Functions Limits*. Accessed: Feb. 18, 2021. [Online]. Available: https://cloud.google.com/functions/quotas
[17] K. Mahajan, D. Figueiredo, V. Misra, and D. Rubenstein, "Optimal pricing for serverless computing," in *Proc. IEEE Global Commun. Conf. (GLOBECOM)*, Dec. 2019, pp. 1–6.
[18] W. Li, Y. Xia, M. Zhou, X. Sun, and Q. Zhu, "Fluctuation-aware and predictive workflow scheduling in cost-effective infrastructure-as-a-service clouds," *IEEE Access*, vol. 6, pp. 61488–61502, 2018.
[19] L. F. Bittencourt and E. R. M. Madeira, "HCOC: A cost optimization algorithm for workflow scheduling in hybrid clouds," *J. Internet Services Appl.*, vol. 2, no. 3, pp. 207–227, Dec. 2011.
[20] M. Taufer and A. L. Rosenberg, "Scheduling DAG-based workflows on single cloud instances: High-performance and cost effectiveness with a static scheduler," *Int. J. High Perform. Comput. Appl.*, vol. 31, no. 1, pp. 19–31, Jan. 2017.
[21] H. Cao, H. Jin, X. Wu, S. Wu, and X. Shi, "DAGMap: Efficient scheduling for DAG grid workflow job," in *Proc. 9th IEEE/ACM Int. Conf. Grid Comput.*, Sep. 2008, pp. 17–24.
[22] *HTCondor*. Accessed: Feb. 17, 2021. [Online]. Available: https://research.cs.wisc.edu/htcondor/index.html
[23] F. Salvat, "PENELOPE-2006: A code system for Monte Carlo simulation of electron and photon transport," in *Proc. OECD/NEA Data Bank*, Issy-Les-Moulineaux, France, 2019, p. 7. [Online]. Available: http://www.nea.fr/lists/penelope.html
[24] S. Agostinelli, J. Allison, K. Amako, J. Apostolakis, H. Araujo, P. Arce, M. Asai, D. Axen, S. Banerjee, G. J. N. I. Barrand, and F. Behner, "GEANT4—A simulation toolkit," *Nucl. Instrum. Methods Phys. Res. A, Accel. Spectrom. Detect. Assoc. Equip.*, vol. 506, no. 3, pp. 250–303, 2003.
[25] A. Ferrari, P. R. Sala, A. Fassò, and J. Ranft, *FLUKA: A Multi-Particle Transport Code (Program Version 2005)* (CERN Yellow Reports: Monographs). Geneva, Switzerland: CERN, 2005. [Online]. Available: http://cds.cern.ch/record/898301, doi: 10.5170/CERN-2005-010.
[26] I. Kawrakow, E. Mainegra-Hing, D. W. O. Rogers, F. Tessier, and B. R. B. Walters, "The EGSnrc code system: Monte Carlo simulation of electron and photon transport," Nat. Res. Council Canada, Ottawa, ON, Canada, Tech. Rep. NRCC Rep. PIRS-701, 2019.
[27] R. A. Forster and T. N. K. Godfrey, "MCNP—A general Monte Carlo code for neutron and photon transport," in *Monte-Carlo Methods and Applications in Neutronics, Photonics and Statistical Physics*, R. Alcouffe, R. Dautray, A. Forster, G. Ledanois, and B. Mercier, Eds. Berlin, Germany: Springer, 1985, pp. 33–55, doi: 10.1007/BFb0049033.
[28] J. Sempau, A. Badal, and L. Brualla, "A PENELOPE-based system for the automated Monte Carlo simulation of clinacs and voxelized geometries—Application to far-from-axis fields," *Med. Phys.*, vol. 38, no. 11, pp. 5887–5895, Oct. 2011.
[29] V. Giménez-Alventosa, V. G. Gómez, and S. Oliver, "PenRed: An extensible and parallel Monte-Carlo framework for radiation transport based on PENELOPE," *Comput. Phys. Commun.*, vol. 267, Oct. 2021, Art. no. 108065.
[30] S. Jan, D. Benoit, E. Becheva, T. Carlier, F. Cassol, P. Descourt, T. Frisson, L. Grevillot, L. Guigues, L. Maigne, C. Morel, Y. Perrot, N. Rehfeld, D. Sarrut, D. R. Schaart, S. Stute, U. Pietrzyk, D. Visvikis, N. Zahra, and I. Buvat, "GATE V6: A major enhancement of the GATE simulation platform enabling modelling of CT and radiotherapy," *Phys. Med. Biol.*, vol. 56, no. 4, pp. 881–901, Jan. 2011.
[31] L. Beaulieu, Å. C. Tedgren, J.-F. Carrier, S. D. Davis, F. Mourtada, M. J. Rivard, R. M. Thomson, F. Verhaegen, T. A. Wareing, and J. F. Williamson, "Report of the task group 186 on model-based dose calculation methods in brachytherapy beyond the TG-43 formalism: Current status and recommendations for clinical implementation," *Med. Phys.*, vol. 39, no. 10, pp. 6208–6236, Sep. 2012.
[32] M. Caballer, I. Blanquer, G. Moltó, and C. de Alfonso, "Dynamic management of virtual infrastructures," *J. Grid Comput.*, vol. 13, no. 1, pp. 53–70, Mar. 2015.
[33] *Terraform*. Accessed: Feb. 18, 2021. [Online]. Available: https://www.terraform.io/
[34] *Amazon Simple Storage Service (Amazon S3)*. Accessed: Feb. 18, 2021. [Online]. Available: https://aws.amazon.com/s3/
[35] *Amazon DynamoDB*. Accessed: Feb. 18, 2021. [Online]. Available: https://aws.amazon.com/dynamodb/
[36] *AWS Lambda*. Accessed: Feb. 18, 2021. [Online]. Available: https://aws.amazon.com/lambda/
[37] *AWS API-Gateway*. Accessed: Feb. 18, 2021. [Online]. Available: https://aws.amazon.com/api-gateway/
[38] *Azure*. Accessed: Feb. 6, 2021. [Online]. Available: https://azure.microsoft.com/es-es/
[39] *Google Cloud*. Accessed: Feb. 6, 2021. [Online]. Available: https://cloud.google.com/
[40] *AWS Spot Instance*. Accessed: Mar. 15, 2021. [Online]. Available: https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/using-spot-instances.html

VICENT GIMÉNEZ-ALVENTOSA received the joint B.Sc. and M.Sc. degrees in physics and the master's degree in advanced physics from the Universitat de València (UV), Spain, in 2014 and 2015, respectively, and the master's degree in parallel and distributed computing from the Universitat Politècnica de València (UPV), Spain, in 2017. He is currently pursuing the Ph.D. degree with the Institute of Instrumentation for Molecular Imaging (I3M).

Since 2018, he has been a member of the Grid and High Performance Computing Research Group (GRyCAP), I3M.

GERMÁN MOLTÓ received the B.Sc. and Ph.D. degrees in computer science from the Universitat Politècnica de València (UPV), Spain, in 2002 and 2007, respectively.

Since 2002, he has been a member of the Grid and High Performance Computing Research Group (GRyCAP), Institute of Instrumentation for Molecular Imaging (I3M). He is currently an Associate Professor with the Department of Computer Systems and Computation (DSIC), UPV. He has participated in several European projects, such as INDIGO-DataCloud, EOSC-HUB, DEEP Hybrid-DataCloud, and AI-SPRINT. He has led national research projects in the area of cloud computing. His broad research interests include cloud computing and scientific computing.



J. DAMIAN SEGRELLES received the B.Sc. and Ph.D. degrees in computer science from the Universitat Politècnica de València (UPV), in 2000 and 2008, respectively.

He is a member of the Grid and High Performance Computing Research Group (GRyCAP), Institute of Instrumentation for Molecular Imaging (I3M), since 2001. He is currently an Associate Professor with the Department of Computer Systems and Computation (DSIC), UPV. He has been involved in grid and cloud technologies and medical image processing, since eight years ago. He has participated more than 20 regional, national, and European research projects. He has coauthored more than 40 papers in international conferences, national conferences, and workshops, as well as more than 15 articles in high-impact journals referenced in the Journal Citation Reports (JCR)/Science Citation Index (SCI). He has also coauthored more than 15 papers in international conferences, national conferences, and workshops related to education. He belongs to the ICAPA Education Research Team.

5.1.1.34. A cloud framework for problem-based learning on grid computing

J. D. Segrelles Quilis, G. Moltó, and I. Blanquer, "A cloud framework for problem-based learning on grid computing," J. Parallel Distrib. Comput., vol. 155, pp. 24–37, Sep. 2021, doi: https://dx.doi.org/10.1016/j.jpdc.2021.04.012

Base de datos de indexación	Web of Science / JCR
Índice de impacto	3.734
Año	2020
Categoría	Comp. Science, Theory & Methods
Posición de la revista en el área	19 de 110
Tercil	T1
Cuartil	Q1
Número de citas en JCR	0
Número de citas totales	0

Comentario. Este artículo es una de las contribuciones principales del proyecto PIME B29 en el que participó el candidato como parte de su liderazgo del Equipo de Innovación y Calidad Educativa (EICE) Metodologías Activas y Tecnologías de la Información (MATI). En el se describe una plataforma Cloud para soportar el aprendizaje basado en proyecto para el aprendizaje de técnicas de Grid Computing. Se trata de un artículo de investigación en educación.

Journal of Parallel and Distributed Computing 155 (2021) 24–37

Contents lists available at ScienceDirect

Journal of Parallel and Distributed Computing

www.elsevier.com/locate/jpdc

A cloud framework for problem-based learning on grid computing

J. Damian Segrelles Quilis *, Germán Moltó, Ignacio Blanquer

Instituto de Instrumentación para Imagen Molecular (I3M), Universitat Politècnica de València (UPV), Camino de Vera S/n, 46022 Valencia, Spain

ARTICLE INFO

Article history:
Received 21 September 2020
Received in revised form 24 February 2021
Accepted 28 April 2021
Available online 4 May 2021

Keywords:
Grid computing
Cloud computing
Project based learning

ABSTRACT

Training on Grid technologies has traditionally used existing Grid infrastructures to implement the hands-on education activities. However, these infrastructures are insufficient to develop all training skills as they can only be employed for the development of Grid applications, and they are limited for learning the management and configuration of Grid resources. The paper presents a set of educational activities grouped on a Project Based Learning (PBL) framework for training on Grid technologies. A Cloud-based tool has been implemented to provide Grid infrastructures as a Service on the cloud, with enhanced scalability and administration capabilities. The PBL has achieved a high impact in the teaching-learning process, addressing the training in all the necessary skills and efficiently providing Grid infrastructure resources on public clouds at a moderate cost. Finally, we evaluated the students' opinion on the activities achieving a very satisfactory result and a reasonable balance on the complexity of the PBL stages.

1. Introduction

Grid computing [7] is a large-scale geographically distributed hardware and software infra-structure composed of heterogeneous networked resources owned and shared by multiple administrative organizations which are coordinated to provide transparent, dependable, pervasive and consistent computing support to a wide range of applications. These applications can perform either distributed computing, high throughput computing, on-demand computing, data-intensive computing, collaborative computing or multimedia computing. During the last two decades, Grid Computing teaching [20] has been fundamental in many areas of knowledge, especially in High Energy Physics [13], Biomedicine [15], Astrophysics [19] and different engineering areas [8,2], fulfilling the high computational and storage demand of resources from such challenges. One key aspect in teaching the basis of Grid Computing is the concept of *Virtual Organisation* (VO), [21] which is defined as a dynamic set of end-users (*Grid Users*) and/or institutions, sharing a set of computational or storage resources (*Grid Infrastructure*) and defining resource-sharing rules. The VOs share common targets and requirements, but may vary in size (users and resources), scope, duration and structure. Teaching Grid Computing is not an easy process, as most of the *Grid Users* (e.g. physicists, astrophysics, engineers) lack skills related to distributed computing technologies. For that, the *Grid Middlewares* (e.g. Globus Toolkit [3] or UMD [16,25]) provide *Grid Users* with access to the resources and services (*Grid Infrastructure*) that support the VOs to which they belong. Grid Middlewares hide the complexity of managing distributed and heterogeneous resources through standard interfaces, thus easing the development and execution of applications that tackle scientific or engineering challenges requiring a large capacity computing [30]. However, *Grid Middlewares* are difficult to use and managing *Grid Infrastructures* still requires learning different roles:

- *Grid Users*, who develop advanced Grid applications and perform scalability studies.
- Administrators of a VO (*VO Admin*), who manage the membership (authentication and authorisation) of *Grid Users* in a VO.
- Resource administrators of an administrative domain (*Domain Admin*), who manage the certification of resources and users of an institution supporting a VO.
- Resource Managers (*Resource Admin*), responsible for configuring the Grid services.

The Universitat Politècnica de València (UPV) offers the Master's Degree in Cloud Computing and High Performance Computing (MUCNAP),[1] where the subject *Grid and Cloud Computing Concepts* (GCCC) instructs students in the roles of *Grid Users*, *VO Admin*, *Domain Admin* and *Resource Admin roles*. This work presents the design of a set of Educational Activities (EAs) in the framework of a Project Based Learning (PBL) [4] methodology that has been im-

* Corresponding author.
E-mail address: dquilis@dsic.upv.es (J.D. Segrelles Quilis).

[1] Master's Degree in Cloud Computing and High Performance Computing: https://www.upv.es/titulaciones/MUCPD.

https://doi.org/10.1016/j.jpdc.2021.04.012
0743-7315/

Table 11
Cost per EA of each EA planned in the PBL. The cost has been computed for 36 students. (R) Running, (P) Paused.

EA	Time (Hours)	Week	VOMS Node	CA Node	Globus Node	Ad. Globus Node	AWS cost ($)
EA1	0.50	1	1 (R)	0	0	0	0.05
EA2	1.50	1	1 (P)	36 (R)	0	0	1.08
EA3	0.50	1	1 (R)	36 (P)	0	0	0.05
EA4	0.75	1	1 (R)	36 (R)	36 (R)	0	2.57
EA5	0.75	1	1 (P)	36 (R)	36 (R)	0	2.52
EA6	0.50	1	1 (P)	0	36 (R)	0	1.80
EA7	1	2	1 (R)	0	36 (R)	0	1.85
EA8	1	2	1 (P)	0	36 (R)	0	1.80
EA9	2.5	2	1 (R)	0	36 (R)	0	5.18
EA10	2	3	1 (P)	0	36 (R)	0	3.60
EA11	2.5	3	1 (R)	0	36 (R)	0	5.18
EA12	2	4	1 (P)	0	36 (R)	0	3.60
EA13	2.5	4	1 (P)	0	36 (R)	0	5.04
EA14	2	5	1 (R)	0	36 (R)	20 (R)	5.70
EA15	1.5	5	1 (R)	0	36 (R)	20 (R)	5.70
EA16	1	5	1 (R)	0	36 (R)	20 (R)	2.85
						TOTAL	48.57

time they are running or stopped. A stopped node generates a marginal cost due to data storage that can be neglected. The costs have been obtained using the AWS Pricing Calculator assuming resources provisioned in the N. Virginia (us-east-1) region. The following instance types have been selected for the different types of nodes (shown in Table 11), depending on the amount of computing and memory resources, and trying to minimise the cost: t2.medium for the *Globus, Advanced Globus and VOMS nodes* and t2.micro for the CA nodes. It can be seen that the total cost is slightly under 50 USD$. A cost analysis comparison of public Cloud computing versus on-premises hardware resources can be found in the work by Chandra et al. [11].

7. Conclusions

This paper has presented a Project Based Learning PBL driven by a Cloud-based Tool to collaboratively create a distributed Grid deployment, on top of virtualised resources, and to carry out a complete training covering learning objectives related to the development of Grid applications and the management and configuration of Grid resources and services. The PBL has some imbalances of complexity among the stages of the PBL but we can conclude that are reasonable and acceptable and feasible for being addressed in the next courses. This experience can be extrapolated to other courses that address distributed computing and that can benefit from an on-demand deployment of configurable computing resources on a Cloud site. The use of Grid as a Service (GaaS) had enabled to carry out educational activities in the context of a PBL from the point of view of both Grid users and Grid administrators, the latter was not possible in the previous approach using existing VOs and production platforms. This Grid as a Service (GaaS) tool has been built on top of ODISEA, an open-source platform based on the Infrastructure Manager, that allows deploying and scaling customised virtual infrastructures. The economic cost assessed using Amazon Web Services indicates that performing the educational activities in a public Cloud provider is both cost-effective and convenient since no investment in hardware is required and no maintenance of the hardware infrastructure is needed by the educational institution. It is clear that combining learning methodologies based on PBLs conducted on a Cloud platform that provisions the computing and storage resources leads to a winning combination in terms of student satisfaction and final assessment results. As future work we plan to evolve towards immutable infrastructures using pre-configured Docker images for the different node types. This would significantly speed up the deployment process of the infrastructure, especially if using an on-premises Docker registry to achieve faster downloads of the Docker images in the different Virtual Machines.

CRediT authorship contribution statement

D.Segrelles, G. Molto, I. Blanque: Conception and design of study, acquisition of data, analysis and/or interpretation of data, drafting the manuscript, revising the manuscript critically for important intellectual content, approval of the version of the manuscript to be published.

Declaration of competing interest

We declare there is no competing or conflict of interest with any of the referees suggested.

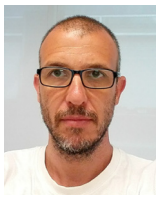
Acknowledgments

The authors wish to thank the financial support received from Vicerrectorado de Estudios, Calidad y Acreditación of the Universitat Politècnica de València to develop the PIME project with reference B29, and to the Conselleria d'Educació, Investigació, Cultura i Esport de la Generalitat Valenciana for the project with reference number AICO/2019/303.

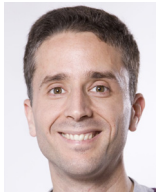
References

[1] G. Andronico, V. Ardizzone, R. Barbera, R. Catania, A. Carrieri, A. Falzone, E. Giorgio, G.L. Rocca, S. Monforte, M. Pappalardo, et al., Gilda: the grid INFN virtual laboratory for dissemination activities, in: First International Conference on Testbeds and Research Infrastructures for the DEvelopment of NeTworks and COMmunities, IEEE, 2005, pp. 304–305.
[2] J. Austin, R. Davis, M. Fletcher, T. Jackson, M. Jessop, B. Liang, A. Pasley, Dame: searching large data sets within a grid-enabled engineering application, Proc. IEEE 93 (3) (2005) 496–509.
[3] A.L. Bazinet, D.S. Myers, J. Fuetsch, M.P. Cummings, Grid services base library: a high-level, procedural application programming interface for writing Globus-based grid services, Future Gener. Comput. Syst. 23 (3) (2007) 517–522.
[4] S. Bell, Project-based learning for the 21st century: skills for the future, Clear. House 83 (2) (2010) 39–43.
[5] R. Berlich, M. Hardt, M. Kunze, M. Atkinson, D. Fergusson, EGEE: building a pan-European grid training organisation, ACM International Conference Proceeding Series, vol. 167, Citeseer, 2006, pp. 105–111.
[6] J. Bester, I. Foster, C. Kesselman, J. Tedesco, S. Tuecke, GASS: a data movement and access service for wide area computing systems, in: Proceedings of the Sixth Workshop on I/O in Parallel and Distributed Systems, 1999, pp. 78–88.
[7] M.L. Bote-Lorenzo, Y.A. Dimitriadis, E. Gómez-Sánchez, Grid characteristics and uses: a grid definition, in: European Across Grids Conference, Springer, 2003, pp. 291–298.

[8] S. Bozhko, G. Asher, R. Li, J. Clare, L. Yao, Large offshore DFIG-based wind farm with line-commutated HVDC connection to the main grid: engineering studies, IEEE Trans. Energy Convers. 23 (1) (2008) 119–127.
[9] J. Bresnahan, M. Link, G. Khanna, Z. Imani, R. Kettimuthu, I. Foster, Globus GridFTP: what's new in 2007, in: Proceedings of the First International Conference on Networks for Grid Applications, 2007, pp. 1–5.
[10] R.M. Capraro, M.M. Capraro, J.R. Morgan, Stem project-based learning, An Integrated Science, Technology, Engineering, and Mathematics (STEM) Approach 2.
[11] D.G. Chandra, M.D. Borah, Cost benefit analysis of cloud computing in education, in: 2012 International Conference on Computing, Communication and Applications, IEEE, 2012, pp. 1–6.
[12] C. Cherubino, L. Ciuffo, A. Fuentes, R. Mayo, et al., EELA training activities in Spain, in: Proceedings of the Spanish Conference on e-Science Grid Computing, March 1-2, 2007, Madrid, Spain, 2007.
[13] A. Chervenak, I. Foster, C. Kesselman, C. Salisbury, S. Tuecke, The data grid: towards an architecture for the distributed management and analysis of large scientific datasets, J. Netw. Comput. Appl. 23 (3) (2000) 187–200.
[14] S. Childs, B. Coghlan, J. McCandless, Gridbuilder: a tool for creating virtual grid testbeds, in: 2006 Second IEEE International Conference on e-Science and Grid Computing, e-Science'06, IEEE, 2006, p. 77.
[15] M. Chillarón, V. Vidal, D. Segrelles, I. Blanquer, G. Verdú, Combining grid computing and docker containers for the study and parametrization of ct image reconstruction methods, Proc. Comput. Sci. 108 (2017) 1195–1204.
[16] M. David, G. Borges, J. Gomes, J. Pina, I.C. Plasencia, E. Fernández-del Castillo, I. Díaz, C. Fernandez, E. Freire, Á. Simón, et al., Validation of grid middleware for the European grid infrastructure, J. Grid Comput. 12 (3) (2014) 543–558.
[17] M. Fargetta, D. Scardaci, R. Barbera, Gilda status and recent activities in grid training, in: Managed Grids and Cloud Systems in the Asia-Pacific Research Community, Springer, 2010, pp. 311–322.
[18] M. Feller, I. Foster, S. Martin, Gt4 gram: a functionality and performance study, in: TeraGrid Conference, Citeseer, 2007.
[19] A. Forti, S. Bavikadi, C. Bigongiari, G. Cabras, A. De Angelis, B. De Lotto, M. Frailis, M. Hardt, H. Kornmayer, M. Kunze, et al., Grid services for the magic experiment, in: Frontiers of Fundamental Physics, Springer, 2006, pp. 333–337.
[20] I. Foster, C. Kesselman, The Grid 2: Blueprint for a New Computing Infrastructure, Elsevier, 2003.
[21] I. Foster, C. Kesselman, S. Tuecke, The anatomy of the grid: enabling scalable virtual organizations, Int. J. High Perform. Comput. Appl. 15 (3) (2001) 200–222.
[22] J.A. González-Martínez, M.L. Bote-Lorenzo, E. Gómez-Sánchez, R. Cano-Parra, Cloud computing and education: a state-of-the-art survey, Comput. Educ. 80 (2015) 132–151.
[23] D. Gorgan, T. Stefanut, V. Bacu, Grid based training environment for earth observation, in: International Conference on Grid and Pervasive Computing, Springer, 2009, pp. 98–109.
[24] I. Gregori, M. Patil, S. Cozzini, Gridseed: a virtual training grid infrastructure, Joint Eu-IndiaGrid/CompChem Grid Turorial on Chemical and Material, Sci. Appl. (2011) 39–53.
[25] E. Laure, A. Edlund, F. Pacini, P. Buncic, M. Barroso, A. Di Meglio, F. Prelz, A. Frohner, O. Mulmo, A. Krenek, et al., Programming the grid with gLite, Tech. rep., 2006.
[26] D. Petcu, Teaching grid technologies to PhD students, part 1: using best practices to build the course, IEEE Distrib. Syst. Online 9 (3) (2008) 2.
[27] J.D. Segrelles, G. Moltó, Assessment of cloud-based computational environments for higher education, in: 2016 IEEE Frontiers in Education Conference, FIE, IEEE, 2016, pp. 1–9.
[28] J.D. Segrelles, G. Moltó, M. Caballer, Remote computational labs for educational activities via a cloud computing platform, in: 2015 Proceedings of the Information Systems Education Conference, ISECON, 2015, pp. 309–321.
[29] M.R. Sheldon, M.J. Fillyaw, W.D. Thompson, The use and interpretation of the Friedman test in the analysis of ordinal-scale data in repeated measures designs, Physiother. Res. Int. 1 (4) (1996) 221–228.
[30] J. Walsh, J. Dukes, Application support for virtual GPGPUs in grid infrastructures, in: 2015 IEEE 11th International Conference on e-Science, IEEE, 2015, pp. 67–77.
[31] X. Zhang, J.M. Schopf, Performance analysis of the Globus toolkit monitoring and discovery service, MDS2, in: IEEE International Conference on Performance, Computing, and Communications, 2004, IEEE, 2004, pp. 843–849.



J. Damian Segrelles received the B.Sc. and Ph.D. degrees in computer science from the Universitat Politècnica de València (UPV) in 2000 and 2008. He is a member of the Grid and High Performance Computing research group (GRyCAP) at the Institute for Molecular Imaging (I3M) since 2001. He is also associate professor at the Department of Computer Systems and Computation (DSIC) at UPV. He has been involved in Grid and Cloud Technologies and Medical Image processing since 8 years ago and participated more than 20 Regional, National and European Research Projects. He has co-authored more than 40 papers in international, national conferences and workshops, as well as more than 15 papers in high-impact journals referenced in the Journal Citation Reports (JCR)/Science Citation Index (SCI). He belongs to the ICAPA education research team. He has co-authored more than 15 papers in international, national conferences and workshops related to education.



Germán Moltó received the B.Sc. and Ph.D. degrees in computer science from the Universitat Politècnica de València (UPV), Spain, in 2002 and 2007. He is a member of the Grid and High Performance Computing research group (GRyCAP) at the Institute for Molecular Imaging (I3M) since 2002. He is also associate professor at the Department of Computer Systems and Computation (DSIC) at UPV. He has participated in several European projects and led National research projects in the area of Cloud Computing. His research interests broadly lie in Cloud Computing, Grid Computing, High Performance Computing, Scientific Computing and Computer-Supported Education. He has co-authored more than 90 papers in international, national conferences and workshops, as well as more than 20 papers in high-impact journals referenced in the Journal Citation Reports (JCR)/Science Citation Index (SCI). As a lecturer, he holds a title of Specialist in Higher Education Pedagogy and a title of University Expert in Online Learning. In 2009, he received an Excellence in Teaching award from the School of Informatics. He co-founded and currently leads the Active Methodologies and Information Technologies (MATI) education research team. He has co-authored more than 25 papers in international, national conferences and workshops related to education.

Ignacio Blanquer is associate professor of the Computer System Department at UPV since 1999 (currently ac-credited to full professor), has been a member of GRyCAP since 1993, and he leads the group since 2016. He has been involved in Parallel Computation and Medical Image processing, participating in more than 55 national and European Research Projects, has authored and co-authored 40 articles in indexed journals and book chapters and in more than 90 papers in national and international journals and conference proceedings. He has served as coordinator of the application area in the Spanish Network for e-Science, including his role in the managerial board was Community Manager in VENUS-C, where he collected and evaluated user requirements and provided hands-on support for migration to the cloud of 27 applications. He has been the project coordinator of EUBrazilCloud Connect (FP7), EUBRazil-BIGSEA (H2020) and CLUVIEM (national research project), and currently is the project coordinator of ATMOSPHERE (H2020) and co-principal investigator in the BigCLOE national research project.

5.1.1.35. GPU-Enabled Serverless Workflows for Efficient Multimedia Processing

S. Risco and G. Moltó, "GPU-Enabled Serverless Workflows for Efficient Multimedia Processing," Appl. Sci., vol. 11, no. 4, p. 1438, Feb. 2021, doi: https://dx.doi.org/10.3390/app11041438

Base de datos de indexación	Web of Science / JCR
Índice de impacto	2.679
Año	2020
Categoría	Engineering, Multidisciplinary
Posición de la revista en el área	38 de 91
Tercil	T2
Cuartil	Q2
Número de citas en JCR	3
Número de citas totales	6

Comentario. Este artículo es una de las contribuciones principales del proyecto BigCLOE (TIN2016-79951-R) y de la Tesis Doctoral de Sebastián Risco, dirigida por el candidato. En él se describe la integración entre las herramientas de código abierto OSCAR (https://oscar.grycap.net) y SCAR (https://github.com/grycap/scar) para soportar la ejecución de aplicaciones computacionalmente intensivas utilizando GPUs, mediante el uso de servicios como AWS Batch.

applied sciences

MDPI

Article

GPU-Enabled Serverless Workflows for Efficient Multimedia Processing

Sebastián Risco * and Germán Moltó

Instituto de Instrumentación para Imagen Molecular (I3M), Centro Mixto CSIC—Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain; gmolto@dsic.upv.es
* Correspondence: serisgal@i3m.upv.es

Abstract: Serverless computing has introduced scalable event-driven processing in Cloud infrastructures. However, it is not trivial for multimedia processing to benefit from the elastic capabilities featured by serverless applications. To this aim, this paper introduces the evolution of a framework to support the execution of customized runtime environments in AWS Lambda in order to accommodate workloads that do not satisfy its strict computational requirements: increased execution times and the ability to use GPU-based resources. This has been achieved through the integration of AWS Batch, a managed service to deploy virtual elastic clusters for the execution of containerized jobs. In addition, a Functions Definition Language (FDL) is introduced for the description of data-driven workflows of functions. These workflows can simultaneously leverage both AWS Lambda for the highly-scalable execution of short jobs and AWS Batch, for the execution of compute-intensive jobs that can profit from GPU-based computing. To assess the developed open-source framework, we executed a case study for efficient serverless video processing. The workflow automatically generates subtitles based on the audio and applies GPU-based object recognition to the video frames, thus simultaneously harnessing different computing services. This allows for the creation of cost-effective highly-parallel scale-to-zero serverless workflows in AWS.

Keywords: cloud computing; serverless computing; multimedia processing; workflows; batch processing; containers

check for updates

Citation: Risco, S.; Moltó, G. GPU-Enabled Serverless Workflows for Efficient Multimedia Processing. *Appl. Sci.* **2021**, *11*, 1438. https://doi.org/10.3390/app11041438

Academic Editor: Miguel García-Pineda
Received: 9 December 2020
Accepted: 2 February 2021
Published: 5 February 2021

1. Introduction

The advent of Cloud Computing introduced the ability to customize the computing infrastructure to the requirements of the applications through the use of virtualization. This resulted in the widespread adoption of Cloud computing for academic, enterprise and scientific workloads. However, migrating an application to a public Cloud required significant expertise in order to adapt the application to the elastic capabilities of the underlying services. In addition, the pay-per-use model typically resulted in a pay-per-deployment, where provisioned Virtual Machines (VMs) are billed regardless of their actual use.

To better accommodate short and spiky workloads, commonly found in microservices architectures, serverless computing was introduced via flagship services such as AWS Lambda [1]. This service allows the execution of user-defined functions coded in certain programming languages supported by the cloud provider in response to certain well-defined events (such as uploading a file to an S3 bucket, i.e., Amazon's object storage system [2] or invoking a REST API provided by API Gateway [3]). A fine-grained pricing scheme billed on milliseconds of execution time resulted in real pay-per-use. In addition, the ability to scale to zero allowed to deploy massively scalable services that can rapidly scale up to 3000 concurrent invocations but incurring in zero cost when the function is not being invoked.

Our previous work in the area is the open-source SCAR tool (SCAR: https://github.com/grycap/scar (accessed on 26 November 2020)) [4] which creates highly-parallel event-

time is reduced. As a result, the platform enables the deployment of serverless workflows in a cost-effective manner under a pay-per-use model.

Table 1. Cost analysis of the first workflow execution distinguishing between the two AWS services used for the processing.

	AWS Lambda	AWS Batch/EC2	Total
FFmpeg	$0.00255510	-	$0.00255510
audio2srt	$0.00758180	-	$0.00758180
YOLOv3	$0.00000258	$0.04687500	$0.04687758
Workflow	$0.01013948	$0.04687500	$0.05701448

Notice that this framework allows to create GPU-enabled data-driven serverless workflows that require no infrastructure preprovision and that are deployed at zero cost when the service is not being used. This rapidly and automatically scales upon uploading a file to the bucket, up to the limits defined by the workflow creator. This flexibility paves the way for increased adoption of event-driven scalable computing for multimedia and scientific applications.

6. Conclusions and Future Work

This paper has described the extension of the SCAR framework to support GPU-enabled serverless workflows for efficient data processing across diverse computing infrastructures. By combining the use of both AWS Lambda, for the execution of a large number of short jobs, and AWS Batch, for the execution of resource-intensive GPU-enabled applications, an open-source event-driven managed platform has been developed to create scale-to-zero serverless workflows. To test its performance, a case study has been defined and deployed on AWS. The behaviour of the platform, along with an analysis of deep learning inference applications running on GPUs and CPUs in the cloud has been exposed, highlighting the contributions of this study. The developments have been released as an open-source contribution to the SCAR tool, publicly available to reproduce the results described in this paper.

Future works involve the integration of the developed platform with on-premises serverless providers, as well as further extending the semantics of the Functions Definition Language (FDL) to accommodate additional workflow operators, thus allowing the definition of enhanced hybrid serverless workflows. In order to avoid failed executions of functions in AWS Lambda when applications reach the timeout and to find the most suitable allocation of memory for the *lambda* and *lambda-batch* execution modes, we consider integrating SCAR with a preprofiling tool such as *AWS Lambda Power Tuning* [37]. In addition, we plan to incorporate external data sources for long-term persistence outside AWS, such as the EGI DataHub [38].

Author Contributions: Conceptualisation, G.M.; methodology, S.R. and G.M.; software, S.R.; validation, S.R.; investigation, S.R.; resources, G.M.; data curation, S.R.; writing—original draft preparation, S.R. and G.M.; writing—review and editing, S.R. and G.M.; visualisation, S.R.; supervision, G.M.; project administration, G.M.; funding acquisition, G.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Spanish "Ministerio de Economía, Industria y Competitividad" for the project "BigCLOE" with reference number TIN2016-79951-R.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Amazon Web Services. AWS Lambda. Available online: https://aws.amazon.com/lambda/ (accessed on 26 November 2020).
2. Amazon Web Services. Amazon Simple Storage Service (S3). Available online: https://aws.amazon.com/s3/ (accessed on 26 November 2020).
3. Amazon Web Services. Amazon API Gateway. Available online: https://aws.amazon.com/api-gateway/ (accessed on 26 November 2020).
4. Pérez, A.; Moltó, G.; Caballer, M.; Calatrava, A. Serverless computing for container-based architectures. *Future Gener. Comput. Syst.* **2018**, *83*, 50–59. [CrossRef]
5. Amazon Web Services. AWS Batch. Available online: https://aws.amazon.com/batch/ (accessed on 26 November 2020).
6. Jonas, E.; Pu, Q.; Venkataraman, S.; Stoica, I.; Recht, B. Occupy the cloud: Distributed computing for the 99%. In Proceedings of the 2017 Symposium on Cloud Computing—SoCC '17, Santa Clara, CA, USA, 25–27 September 2017; ACM Press: New York, NY, USA, 2017; pp. 445–451. [CrossRef]
7. Giménez-Alventosa, V.; Moltó, G.; Caballer, M. A framework and a performance assessment for serverless MapReduce on AWS Lambda. *Future Gener. Comput. Syst.* **2019**, *97*, 259–274. [CrossRef]
8. Malawski, M.; Gajek, A.; Zima, A.; Balis, B.; Figiela, K. Serverless execution of scientific workflows: Experiments with HyperFlow, AWS Lambda and Google Cloud Functions. *Future Gener. Comput. Syst.* **2017**. [CrossRef]
9. Jiang, Q.; Lee, Y.C.; Zomaya, A.Y. *Serverless Execution Of Scientific Workflows*; Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics); Springer: Berlin/Heidelberg, Germany, 2017; Volume 10601 LNCS, pp. 706–721. [CrossRef]
10. Skluzacek, T.J.; Chard, R.; Wong, R.; Li, Z.; Babuji, Y.N.; Ward, L.; Blaiszik, B.; Chard, K.; Foster, I. Serverless Workflows for Indexing Large Scientific Data. In Proceedings of the 5th International Workshop on Serverless Computing (WOSC '19), Davis, CA, USA, 9–13 December 2019; Association for Computing Machinery (ACM): New York, NY, USA, 2019; pp. 43–48. [CrossRef]
11. Chard, R.; Skluzacek, T.J.; Li, Z.; Babuji, Y.N.; Woodard, A.; Blaiszik, B.; Tuecke, S.; Foster, I.T.; Chard, K. Serverless Supercomputing: High Performance Function as a Service for Science. *CoRR* **2019**, arXiv:1908.04907.
12. Akkus, I.E.; Chen, R.; Rimac, I.; Satzke, M.S.K.; Beck, A.; Aditya, P.; Hilt, V. SAND: Towards high-performance serverless computing. In Proceedings of the 2018 USENIX Annual Technical Conference, USENIX ATC 2018, Boston, MA, USA, 11–13 July 2018; pp. 923–935.
13. Sethi, R.J.; Gil, Y.; Jo, H.; Philpot, A. Large-Scale Multimedia Content Analysis Using Scientific Workflows. In Proceedings of the 21st ACM International Conference on Multimedia, Barcelona, Spain, 21–25 October 2013; Association for Computing Machinery: New York, NY, USA, 2013; pp. 813–822. [CrossRef]
14. Gil, Y.; Ratnakar, V.; Kim, J.; Gonzalez-Calero, P.A.; Groth, P.; Moody, J.; Deelman, E. Wings: Intelligent Workflow-Based Design of Computational Experiments. *IEEE Intell. Syst.* **2011**, *26*. [CrossRef]
15. Deelman, E.; Vahi, K.; Juve, G.; Rynge, M.; Callaghan, S.; Maechling, P.J.; Mayani, R.; Chen, W.; Ferreira da Silva, R.; Livny, M.; et al. Pegasus: A Workflow Management System for Science Automation. *Future Gener. Comput. Syst.* **2015**, *46*, 17–35. [CrossRef]
16. Xu, X.; Chen, Y.; Yuan, Y.; Huang, T.; Zhang, X.; Qi, L. Blockchain-based cloudlet management for multimedia workflow in mobile cloud computing. *Multimed. Tools Appl.* **2020**, *79*, 9819–9844. [CrossRef]
17. Zhang, M.; Zhu, Y.; Zhang, C.; Liu, J. Video processing with serverless computing. In Proceedings of the 29th ACM Workshop on Network and Operating Systems Support for Digital Audio and Video—NOSSDAV '19, Amherst, MA, USA, 21 June 2019; ACM Press: New York, NY, USA, 2019; pp. 61–66. [CrossRef]
18. Pérez, A.; Caballer, M.; Moltó, G.; Calatrava, A. A programming model and middleware for high throughput serverless computing applications. In *Proceedings of the ACM Symposium on Applied Computing, Limassol, Cyprus, 8–12 April 2019*; Association for Computing Machinery: New York, NY, USA, 2019; pp. 106–113. [CrossRef]
19. Amazon Web Services. Amazon CloudWatch. Available online: https://aws.amazon.com/cloudwatch/ (accessed on 26 November 2020).
20. Docker. Docker Hub. Available online: https://hub.docker.com/ (accessed on 26 November 2020).
21. Google Cloud. Cloud Computing Services. Available online: https://cloud.google.com/ (accessed on 26 November 2020).
22. Microsoft Azure. Cloud Computing Services. Available online: https://azure.microsoft.com/en-us/ (accessed on 26 November 2020).
23. Amazon Web Services. Amazon EC2. Available online: https://aws.amazon.com/ec2/ (accessed on 26 November 2020).
24. Amazon Web Services. Amazon ECS. Available online: https://aws.amazon.com/ecs/ (accessed on 26 November 2020).
25. NVIDIA. NVIDIA Container Runtime. Available online: https://github.com/NVIDIA/nvidia-container-runtime (accessed on 2 December 2020).
26. Amazon Web Services. AWS SDK for Python. Available online: https://aws.amazon.com/sdk-for-python/ (accessed on 26 November 2020).
27. Gomes, J.; Bagnaschi, E.; Campos, I.; David, M.; Alves, L.; Martins, J.; Pina, J.; López-García, A.; Orviz, P. Enabling rootless Linux Containers in multi-user environments: The udocker tool. *Comput. Phys. Commun.* **2018**, *232*, 84–97. [CrossRef]
28. Canonical. Cloud-Init: The Standard for Customising Cloud Instances. Available online: https://cloud-init.io/ (accessed on 2 December 2020).

29. FFmpeg. FFmpeg—A Complete, Cross-Platform Solution to Record, Convert and Stream Audio and Video. Available online: https://www.ffmpeg.org/ (accessed on 26 November 2020).
30. RunasSudo. audio2srt. Available online: https://gitlab.com/RunasSudo/audio2srt (accessed on 26 November 2020).
31. Shmyrev, N. CMUSphinx Open Source Speech Recognition. Available online: http://cmusphinx.github.io/ (accessed on 26 November 2020).
32. Redmon, J.; Divvala, S.; Girshick, R.; Farhadi, A. You only look once: Unified, real-time object detection. *Proc. IEEE Comput. Soc. Conf. Comput. Vis. Pattern Recognit.* **2016**, *2016*, 779–788. [CrossRef]
33. Redmon, J.; Farhadi, A. YOLOv3: An Incremental Improvement. *CoRR* **2018**, arXiv:1804.02767.
34. Redmon, J. Darknet: Open Source Neural Networks in C. Available online: https://pjreddie.com/darknet/ (accessed on 26 November 2020).
35. NVIDIA. CUDA Zone. Available online: https://developer.nvidia.com/cuda-zone (accessed on 26 November 2020).
36. Agache, A.; Brooker, M.; Iordache, A.; Liguori, A.; Neugebauer, R.; Piwonka, P.; Popa, D.M. Firecracker: Lightweight Virtualization for Serverless Applications. In Proceedings of the 17th USENIX Symposium on Networked Systems Design and Implementation (NSDI 20), Santa Clara, CA, USA, 2 January 2020; USENIX Association: Berkeley, CA, USA, 2020; pp. 419–434.
37. Casalboni, A. AWS Lambda Power Tuning. Available online: https://github.com/alexcasalboni/aws-lambda-power-tuning (accessed on 26 January 2021).
38. Viljoen, M.; Dutka, Ł.; Kryza, B.; Chen, Y. Towards European Open Science Commons: The EGI Open Data Platform and the EGI DataHub. *Procedia Comput. Sci.* **2016**, *97*, 148–152. [CrossRef]

5.1.2. Publicaciones Relevantes

De acuerdo a los criterios de la ANECA para el programa ACADEMIA, las aportaciones *relevantes*, a diferencia de las publicaciones *muy relevantes*, son aquellas que están publicadas en revistas situadas en el cuartil 3 y 4 (Q3, Q4) del Journal Citation Reports (JCR), así como congresos clase 2 del índice GII-GRIN-SCIE.

5.1.2.1. GMarte: Grid middleware to abstract remote task execution

J. M. Alonso, V. Hernández, and G. Moltó, "GMarte: Grid middleware to abstract remote task execution," Concurr. Comput. Pract. Exp., vol. 18, no. 15, pp. 2021–2036, Dec. 2006, doi: https://10.1002/cpe.1052

Base de datos de indexación	Web of Science / JCR
Índice de impacto	1.004
Año	2009
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	51 de 92
Tercil	T2
Cuartil	Q3
Número de citas en JCR	14
Número de citas totales	28

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional GRID-IT (TIC2003–01318). El candidato fue el desarrollador principal y único del software GMarte para la metaplanificación de tareas sobre infraestructuras Grid, como parte de su tesis doctoral. Se integró dicho software con plataformas distribuidas en producción como es el caso de LHC Computing Grid (LCG) middleware, el software que posibilita la ejecución distribuida de trabajos procedentes de experimentos realizados en el Large Hadron Collider (LHC), acelerador de partículas del CERN. Se utilizó orden alfabético de firma.

CONCURRENCY AND COMPUTATION: PRACTICE AND EXPERIENCE
Concurrency Computat.: Pract. Exper. 2006; **18**:2021–2036
Published online 11 May 2006 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/cpe.1052

GMarte: Grid middleware to abstract remote task execution

J. M. Alonso*,†, V. Hernández and G. Moltó

Departamento de Sistemas Informáticos y Computación, Universidad Politécnica de Valencia, Camino de Vera s/n, 46002 Valencia, Spain

SUMMARY

Grid computing technologies are now being largely deployed with the widespread adoption of the Globus Toolkit as the industrial standard Grid middleware. However, its inherent steep learning curve discourages the use of these technologies for non-experts. Therefore, to increase the use of Grid computing, it is important to have high-level tools that simplify the process of remote task execution. In this paper we introduce a middleware, developed on top of the Java Commodity Grid, which offers an object-oriented, user-friendly application programming interface, from the Java language, which eases remote task execution for computationally intensive applications. Copyright © 2006 John Wiley & Sons, Ltd.

Received 1 November 2004; Revised 28 March 2005; Accepted 27 October 2005

KEY WORDS: Grid middleware; scheduling; Grid computing; high-performance computing

1. INTRODUCTION

Grid computing has emerged as a solution for the computational problems of organizations, by enabling the use of remote resources for executing computationally expensive tasks. There are many scientific fields in which time-consuming applications are very common and, therefore, could benefit greatly from Grid computing. However, the complexity of the underlying middleware very often discourages scientists from porting their applications to the Grid.

Among all of the Grid middlewares available, the Globus Toolkit [1] represents the *de facto* standard for deploying large-scale computational Grids. However, the steep learning curve of this middleware prevents the exploitation of its features until a training period with this software has been completed.

*Correspondence to: J. M. Alonso, Departamento de Sistemas Informáticos y Computación, Universidad Politécnica de Valencia, Camino de Vera s/n, 46002 Valencia, Spain.
†E-mail: jmalonso@dsic.upv.es

Contract/grant sponsor: Spanish Ministry of Science and Technology
Contract/grant sponsor: Structural Funds of the ERDF (Project GRID-IT); contract/grant number: TIC2003–01318

10. Thomas M, Dahan M, Mueller K, Mock S, Mills C, Regno R. Application portals: Practice and experience. *Concurrency and Computation: Practice and Experience* 2002; **14**:1427–1444.
11. Schopf JM, Nitzberg B. Grids: The top ten questions. *Scientific Programming (Special Issue on Grid Computing)* 2000; **10**(2):103–111.
12. Lawson CL, Hanson RJ, Kincaid D, Krogh FT. Basic Linear Algebra Subprograms for FORTRAN usage. *ACM Transactions on Mathematical Software* 1979; **5**:308–323.
13. Anderson E *et al*. *LAPACK User's Guide* (3rd edn). SIAM: Philadelphia, PA, 1999.
14. Alonso JM, Hernández V, Moltó G. *Grid Computing Based Simulations of the Electrical Activity of the Heart* (*Lecture Notes in Computer Science*, vol. 3036). Springer: Berlin, 2004; 482–485.
15. Gropp W, Lusk E, Doss N, Skjellum A. A high performance, portable implementation of the Message Passing Interface standard. *Parallel Computing* 1996; **22**(6):789–828.
16. Gropp W, Lusk E. *User's Guide for MPICH, a Portable Implementation of MPI*. Mathematics and Computer Science Division, Argonne National Laboratory: Argonne, IL, 1996.
17. Vadhiyar S, Dongarra J. A metascheduler for the Grid. *Proceedings of the 3rd IEEE/ACM International Symposium on Cluster Computing and the Grid*, vol. 1. IEEE Computer Society Press: Los Alamitos, CA, 2003; 130–137.
18. Bronevetsky G, Marques D, Pingali K, Stodhgill P. Automated application-level checkpointing of MPI programs. *Principles and Practice of Parallel Programming* 2003; **1**:84–94.
19. Foster I, Kesselman C. *The GRID: Blueprint for a New Computing Infrastructure*. Morgan Kauffman: San Franscico, CA, 1999.
20. Hoschek W, Jaen-Martinez J, Samar A, Stockinger H, Stockinger K. Data management in an international Data Grid project. *Proceedings of the 1st IEEE/ACM International Workshop on Grid Computing* (*Lecture Notes in Computer Science*, vol. 1971). Springer: Berlin, 2001; 77–90.
21. LHC Computing Grid Project Web page. http://lcg.web.cern.ch [April 2005].
22. CERN. World's largest computing Grid surpasses 100 Sites. *ERCIM News* **61**:63–63.
23. EGEE Web page. http://www.eu-egee.org [April 2005].
24. Schopf JM. Ten actions when superscheduling. *Scheduling Request for Comments 8.5*, Scheduling Working Group, Argonne National Laboratory, Argonne, IL, July 2001. Available at: http://www-unix.mcs.anl.gov/∼schopf/ggf-sched/WD/schedwd.8.5.pdf [6 April 2006].
25. Montero RS, Huedo E, Llorente IM. *Grid Resource Selection for Opportunistic Job Migration* (*Lecture Notes in Computer Science*, vol. 2790). Springer: Berlin, 2004; 366–373.
26. Alonso JM, Ferrero JM, Hernández V, Moltó G, Monserrat M, Saiz J. Computer simulation of action potential propagation on cardiac tissues: An efficient and scalable parallel approach. *Parallel Computing: Software Technology, Algorithms, Architectures and Applications* (*Advances in Parallel Computing*, vol. 13). Elsevier: Amsterdam, 2004; 339–346.
27. Alonso JM, Alfonso C, García G, Hernández V. *Parallel and Grid Computing in 3D Analysis of Large Dimension Structural Systems* (*Lecture Notes in Computer Science*, vol. 3149). Springer: Berlin, 2004; 487–496.
28. Alonso JM, Hernández V, Moltó G. Experiences on a large scale Grid deployment with a computationally intensive biomedical application. *Proceedings of the 18th IEEE International Symposium on Computer-Based Medical Systems, Special Track on Grids for Biomedicine and Bioinformatics*, vol. 1. IEEE Computer Society Press: Los Alamitos, CA, 2005; 567–569.

DOI: 10.1002/cpe

5.1.2.2. Automatic Consolidation of Virtual Machines in On-Premises Cloud Platforms

[1] C. de Alfonso, I. Blanquer, G. Molto, and M. Caballer, "Automatic Consolidation of Virtual Machines in On-premises Cloud Platforms," in 2017 17th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGRID), 2017, pp. 1070–1079, doi: https://10.1109/CCGRID.2017.128

Base de datos de indexación	GII-GRIN-SCIE
Posición	GGS Class 2, GGS Rating A

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional (RETOS I+D) BigCLOE (TIN2016-79951-R), liderado por el candidato, que describe la implementación de VMCA (Virtual Machine Consolidation Agent), una herramienta de código abierto disponible en GitHub: https://github.com/grycap/vmca para la consolidación de máquinas virtuales (agrupación automatizada mediante migración en vivo en un menor número de nodos para poder eliminar los recursos libres y ahorrar energía). Fue uno de los desarrollos de la Tesis Doctoral de Carlos de Alfonso, titulada "Efficient and elastic management of computing infrastructures", co-dirigida por el candidato.

2017 17th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing

Automatic Consolidation of Virtual Machines in On-Premises Cloud Platforms

Carlos de Alfonso, Ignacio Blanquer, Germán Moltó, Miguel Caballer
Instituto de Instrumentación para Imagen Molecular (I3M)
Centro mixto CSIC - Universidad Politécnica de Valencia - CIEMAT
Camino de Vera s/n, 46022, Valencia
email: caralla@upv.es, iblanque@dsic.upv.es, gmolto@dsic.upv.es, micafer1@upv.es

***Abstract*—After a sequence of creation and destruction of virtual machines (VMs) in an on-premises Cloud computing platform, the scheduling decisions to host the VMs are far from being optimal and the fragmentation of the physical resources may impede the platform to host some VMs despite the free available virtualization resources. This paper describes a Virtual Machine Consolidation Agent that addresses this problem by analyzing the distribution of the VMs in the virtualization platform to migrate some of them among hosts, in order to defragment the physical resources and to enhance the efficiency on their usage. The agent has been validated in a production platform, where it is capable of minimizing the number of servers needed to host the VMs. The algorithms achieve near-optimal values at a very reduced computational cost, thus making it suitable for production platforms.**

***Keywords*-Cloud Computing; Server consolidation; Virtual Machine Migration; Facilitate power management;**

I. Introduction

Cloud Computing resources are typically provisioned from datacenters by means of virtualization, to share computational resources. In particular, users are provided with Virtual Machines (VMs) in the Infrastructure as a Service (IaaS) Cloud model [22], where VMs are used to partition the physical computer resources. A Cloud datacenter is dimensioned to ensure that the expected workload is satisfied, but the peak of the demand is rarely achieved. The mean usage ratio of a datacenter was estimated to be between 10% and 50% [24], and the mean efficiency of datacenters is around 50% [14]. This leads to a waste of energy which gains importance when it is known that the power dedicated to feed the datacenters of the world represents the 0.5% of the total energy consumed, and it is estimated to achieve 2% of the total by 2020 [13].

In order to reduce the wasted energy it is possible to apply Dynamic Power Management (DPM) techniques [27] that consist of adapting the computing infrastructure to the actual workload, whether modifying the components (e.g. using Dynamic Voltage and Frequency Scaling) or enhancing the distribution of the jobs to use part of them and powering off those that are not needed.

In a Cloud platform, the scheduling decision for a VM to be hosted into a specific host may be correct when the VM was created. However, during the lifecycle of the platform (i.e. sequences of creation and destruction of VMs) the distribution of the VMs gets worse and the distribution of the resources may be degraded. Indeed, it is possible to reach inefficient situations: (1) there are physical nodes that are not hosting any VM, or (2) the running VMs could be hosted in few servers or in a more energy efficient subset of them. In the former case, some of the idle hosts can just be powered off. But in the latter case the virtualization resources are fragmented and the VM distribution should be rearranged, if possible, to reduce the number of servers hosting the very same VMs. Such rearrangement will facilitate the automated power management of the servers. An inefficient distribution may prevent the platform from hosting some VMs while there are enough free resources (e.g. trying to host VM_1 that requests 16 GB RAM on a platform in which hosts h_1 and h_2 have 10 GB RAM free each).

The problem addressed in this paper is to rearrange the VMs that are in the hosts of a Cloud Platform, starting from a given distribution. The goal is to defragment the virtualization resources and to stimulate the application of green computing techniques, by getting hosts without VMs, in order to power them off. The main constraint is that the VMs will be rearranged using live-migration techniques to keep them running during the process.

This paper describes the Virtual Machine Consolidation Agent (VMCA), that analyzes the distribution of the VMs of the platform and migrates a set of them to achieve a more efficient usage of the resources of the Cloud platform. VMCA starts from a given distribution of VMs and tries to migrate them to reduce the power consumption or to enhance the usage of the resources of physical hosts. VMCA is not an scheduler, as it does not try to select the host in which a VM should be hosted. Instead, VMCA will select a set of VMs that are candidate to be migrated and will delegate to the scheduler of the Cloud Management Platform (CMP) the decision of selecting the host to which the VMs can be migrated. Then, VMCA will evaluate the different VM movements. In most of the cases it is crucial to delegate the responsibility of scheduling the VMs to the existing scheduler, as it may take into account co-allocation of VMs (e.g. a set of VMs that must be deployed by the same physical host, or in the same virtual network) or other constraints or custom policies.

The remainder of the paper is organized as follows. First,

978-1-5090-6611-7/17 $31.00 © 2017 IEEE
DOI 10.1109/CCGRID.2017.128

Case	Total time	Total migrations	Iterations	Hosts used	FFd_i	OPT(L)
d'_1	1975.46	25	1	4	4	3 (2,45)
d'_2	1574.70	19	1	5	5	4 (3,27)
d'_3	1966.45	24	2	4	4	3 (2,45)
d'_4	2480.83	33	3	3	3	2 (1,64)
d'_5	2477.83	31	2	4	4	3 (2,45)
d'_6	2033.08	25	1	4	4	3 (2,45)
d'_7	926.91	12	1	6	6	5 (4,09)
d'_8	1545.54	18	1	5	5	4 (3,27)
d'_9	1292.61	16	1	6	6	5 (4,09)
d'_{10}	2747.54	33	1	4	4	3 (2,45)

Table V
EVALUATION OF THE RESULTS OBTAINED BY VMCA.

table shows that in each case, the solution is always only one host greater than the theoretical optimal value. That means that VMCA has always obtained a very good solution.

Although we have always obtained the same value than using the FFd algorithm we cannot infer that VMCA will always obtain that value, facing any distribution of VMs. In the use cases, we have obtained that good solution because the platform is not heavily occupied and there was enough empty space to make the needed migrations. Notice that in scenarios with less empty space, VMCA might require an extra number of migrations or may get solutions that are not that close to the theoretical optimal value.

Regarding the total time to reach from use case d_u to d'_u we can see that it represents a large amount of time that ranges from 15,45 minutes in case d'_7 to 41,35 minutes in case d'_4. That is due to the time needed to effectively migrate the VMs (which was 80,59 seconds as a mean in our tests). If VMCA was run more frequently, the subsequent analysis would not imply too many VM movements.

Finally, it is important to highlight that VMCA has got free nodes that range from 2 (in cases d'_7 to d'_9) to 5 (in case d'_4). That means that these nodes could be powered off to save from 25% to 62.5% of energy.

VII. CONCLUSIONS AND FUTURE WORK

In this paper we have presented VMCA, a tool to re-arrange the distribution of the VMs in an on-premises cloud computing deployment to try to more efficiently use the physical resources. We have shown an iterative BFd-FFd algorithm which is based on multidimensional Bin Packing. This algorithm is a contribution to the state-of-the-art algorithms to re-place the VMs. We have also created an iterative FFd-FFd algorithm that reduces the computational cost and enables to introduce VMCA in a production ready platform to get physical hosts idle. The result is that VMCA can be considered as a DPM technique since it has a reduced computational cost, and it can be integrated with green computing techniques so that hosts can be powered off. Furthermore VMCA is not only a theoretical exercice, and we have integrated the results of this paper in an open-source product[5]. Up to our knowledge, there is no open-source project that could be integrated with common on-premise CMPs such as OpenNebula or OpenStack without modifying their scheduling policies.

In this paper we have demonstrated the ability to obtain near-optimal values at a reduced computational cost. The developed algorithms fully integrate with the VM scheduler used in the on-premises cloud platform in order to achieve consolidation of the VMs while preserving the scheduling policies of platform. The use cases shown in this paper demonstrate the real usage of VMCA in a production cloud platform, where VMCA got idle resources that could be powered off to save energy.

Future works involving integrating VMCA with other on-premises cloud management platforms. Also, VMCA will focus on resource defragmentation and integration with elastic infrastructure managers such as CLUES to consider the possibility of powering on hosts that have been powered off because they were empty, to move VMs to them, in order to enhance the distribution of VMs.

ACKNOWLEDGEMENT

The authors wish to thank the ”Ministerio de Economía y Competitividad” for the project TIN2013-44390-R.

REFERENCES

[1] Yasuhiro Ajiro and Atsuhiro Tanaka. Improving packing algorithms for server consolidation. In *Int. CMG Conference*, pages 399–406. Computer Measurement Group, 2007.

[2] Anton Beloglazov, Jemal Abawajy, and Rajkumar Buyya. Energy-aware resource allocation heuristics for efficient management of data centers for cloud computing. *Future Gener. Comput. Syst.*, 28(5):755–768, May 2012.

[3] Anton Beloglazov and Rajkumar Buyya. Energy efficient resource management in virtualized cloud data centers. In *Proceedings of the 2010 10th IEEE/ACM International Conference on Cluster, Cloud and Grid Computing*, CCGRID ’10, pages 826–831, Washington, DC, USA, 2010. IEEE Computer Society.

[4] Josep Ll. Berral, Íñigo Goiri, Ramón Nou, Ferran Julià, Jordi Guitart, Ricard Gavaldà, and Jordi Torres. Towards energy-aware scheduling in data centers using machine learning. In *Proceedings of the 1st International Conference on Energy-Efficient Computing and Networking*, e-Energy ’10, pages 215–224, New York, NY, USA, 2010. ACM.

[5] Alberto Caprara and Paolo Toth. Lower bounds and algorithms for the 2-dimensional vector packing problem. *Discrete Applied Mathematics*, 111(3):231 – 262, 2001.

[6] C. Chu and R. La. Variable-sized bin packing: Tight absolute worst-case performance ratios for four approximation algorithms. *SIAM Journal on Computing*, 30(6):2069–2083, 2001.

[5]https://github.com/grycap/vmca

[7] T. Cioara, I. Anghel, I. Salomie, G. Copil, D. Moldovan, and A. Kipp. Energy aware dynamic resource consolidation algorithm for virtualized service centers based on reinforcement learning. In *Parallel and Distributed Computing (ISPDC), 2011 10th International Symposium on*, pages 163–169, 2011.

[8] Carlos de Alfonso, Miguel Caballer, Fernando Alvarruiz, and Vicente Hernndez. An energy management system for cluster infrastructures. *Computers & Electrical Engineering*, (0):–, 2013.

[9] E. Falkenauer and A. Delchambre. A genetic algorithm for bin packing and line balancing. In *Robotics and Automation, 1992. Proceedings., 1992 IEEE International Conference on*, pages 1186–1192 vol.2, May 1992.

[10] F. Farahnakian, P. Liljeberg, and J. Plosila. Energy-efficient virtual machines consolidation in cloud data centers using reinforcement learning. In *Parallel, Distributed and Network-Based Processing (PDP), 2014 22nd Euromicro International Conference on*, pages 500–507, Feb 2014.

[11] E. Feller, C. Morin, and A. Esnault. A case for fully decentralized dynamic vm consolidation in clouds. In *Cloud Computing Technology and Science (CloudCom), 2012 IEEE 4th International Conference on*, pages 26–33, 2012.

[12] E. Feller, L. Rilling, and C. Morin. Energy-aware ant colony based workload placement in clouds. In *Grid Computing (GRID), 2011 12th IEEE/ACM International Conference on*, pages 26–33, 2011.

[13] W. Forrest. How to cut data centre carbon emissions?, Diciembre 2008.

[14] Lakshmi Ganesh. *Data Center Energy Management*. PhD thesis, Faculty of the Graduate School of Cornell University, 2012.

[15] S.M. Ghafari, M. Fazeli, A. Patooghy, and L. Rikhtechi. Beemmt: A load balancing method for power consumption management in cloud computing. In *Contemporary Computing (IC3), 2013 Sixth International Conference on*, pages 76–80, Aug 2013.

[16] Fabien Hermenier, Xavier Lorca, Jean-Marc Menaud, Gilles Muller, and Julia Lawall. Entropy: A consolidation manager for clusters. In *Proceedings of the 2009 ACM SIGPLAN/SIGOPS International Conference on Virtual Execution Environments*, VEE '09, pages 41–50, New York, NY, USA, 2009. ACM.

[17] Chris Hyser, Bret McKee, Rob Gardner, and Brian J. Watson. Autonomic virtual machine placement in the data center. Technical Report HPL-2007-189, HP Laboratories, February 2008.

[18] Jangha Kang and Sungsoo Park. Algorithms for the variable sized bin packing problem. *European Journal of Operational Research*, 147(2):365 – 372, 2003. Fuzzy Sets in Scheduling and Planning.

[19] G. Keller, M. Tighe, H. Lutfiyya, and M. Bauer. An analysis of first fit heuristics for the virtual machine relocation problem. In *Network and service management (cnsm), 2012 8th international conference and 2012 workshop on systems virtualiztion management (svm)*, pages 406–413, Oct 2012.

[20] Xueping Li, Zhao Zhaoxia, and Zhang Kaike. A genetic algorithm for the three-dimensional bin packing problem with heterogeneous bins. In Y. Guan and H. Liao, editors, *Proceedings of the 2014 Industrial and Systems Engineering Research Conference*, 2014.

[21] S.S. Masoumzadeh and H. Hlavacs. Integrating vm selection criteria in distributed dynamic vm consolidation using fuzzy q-learning. In *Network and Service Management (CNSM), 2013 9th International Conference on*, pages 332–338, Oct 2013.

[22] Peter Mell and Tim Grance. The NIST Definition of Cloud Computing. NIST Special Publication 800-145 (Final). Technical report, 2011.

[23] Cristina Bianca Pop, Ionut Anghel, Tudor Cioara, Ioan Salomie, and Iulia Vartic. A swarm-inspired data center consolidation methodology. In *Proceedings of the 2nd International Conference on Web Intelligence, Mining and Semantics*, WIMS '12, pages 41:1–41:7, New York, NY, USA, 2012. ACM.

[24] M.M. Rafique, N. Ravi, S. Cadambi, A.R. Butt, and S. Chakradhar. Power management for heterogeneous clusters: An experimental study. In *Green Computing Conference and Workshops (IGCC), 2011 International*, pages 1–8, 2011.

[25] Lei Shi, J. Furlong, and Runxin Wang. Empirical evaluation of vector bin packing algorithms for energy efficient data centers. In *Computers and Communications (ISCC), 2013 IEEE Symposium on*, pages 000009–000015, July 2013.

[26] A. Strunk. Costs of virtual machine live migration: A survey. In *Services (SERVICES), 2012 IEEE Eighth World Congress on*, pages 323–329, June 2012.

[27] GiorgioLuigi Valentini, Walter Lassonde, SameeUllah Khan, Nasro Min-Allah, SajjadA. Madani, Juan Li, Limin Zhang, Lizhe Wang, Nasir Ghani, Joanna Kolodziej, Hongxiang Li, AlbertY. Zomaya, Cheng-Zhong Xu, Pavan Balaji, Abhinav Vishnu, Fredric Pinel, JohnatanE. Pecero, Dzmitry Kliazovich, and Pascal Bouvry. An overview of energy efficiency techniques in cluster computing systems. *Cluster Computing*, 16(1):3–15, 2013.

[28] Akshat Verma, Puneet Ahuja, and Anindya Neogi. pmapper: power and migration cost aware application placement in virtualized systems. In *Proceedings of the 9th ACM/IFIP/USENIX International Conference on Middleware*, Middleware '08, pages 243–264, New York, NY, USA, 2008. Springer-Verlag New York, Inc.

[29] Yongqiang Wu, Maolin Tang, and W. Fraser. A simulated annealing algorithm for energy efficient virtual machine placement. In *Systems, Man, and Cybernetics (SMC), 2012 IEEE International Conference on*, pages 1245–1250, Oct 2012.

[30] Gerhard Wscher, Heike Hauner, and Holger Schumann. An improved typology of cutting and packing problems. *European Journal of Operational Research*, 183(3):1109 – 1130, 2007.

[31] Minyi Yue. A simple proof of the inequality ffd (l) 11/9 opt (l) + 1, l for the ffd bin-packing algorithm. *Acta Mathematicae Applicatae Sinica*, 7(4):321–331, 1991.

The GII-GRIN-SCIE Conference Rating

Explore the GII-GRIN-SCIE (GGS) Conference Rating

Menu

Mirror@www.consorzio-cini.it - Mirror@valutazione.unibas.it - Mirror@gii-grin-scie-rating.scie.es

Search Details Previous Versions

Download **The GGS Conference Rating 2018** (Excel .xlsx file) - last updated: May, 30th 2018

This initiative is sponsored by GII (Group of Italian Professors of Computer Engineering), GRIN (Group of Italian Professors of Computer Science), and SCIE (Spanish Computer-Science Society). For details about the rating algorithm and the process, see the Conference Rating description page.

Search Conferences

Name		Search	Sample: *int*conf*data*
Acronym	CCGRID	Search	Sample: vldb or *ubi*
Class		Search	Sample: 1 or 2 or 3
Rating		Search	Sample: A++ or A+ or A or A- or B or B-
Collected Ratings		Search	Sample: A++, A++, A++ or A+, A, A

Legenda

Class	Ratings	Size	Description
Class 1	A++, A+	32 + 50 = **82 conferences**	excellent, top notch conferenc
Class 2	A, A-	82 + 93 = **175 conferences**	very good events
Class 3	B, B-	205 + 161 = **366 conferences**	events of good quality
-	Work in Progress	2172 conferences	work in progress

Your search returned 1 results.

Title	Acronym	GGS Class	GGS Rating	Qualified Classes	Collected Classes
CLUSTER COMPUTING AND THE GRID	CCGRID	2	A	CORE:A, LiveSHINE:A, MA:A	A, A, A

Detailed Ratings (click to expand)

CORE:

Acronym	Title	Class
CCGRID	IEEE International Symposium on Cluster, Cloud and Grid Computing	A

LiveSHINE:

Acronym	Conference	Class	H-Index	RankH-Index	ClassH-Index	AvgCitations	RankAvgCitations	ClassAvgCitations	Publications	Citations
CCGrid	IEEE/ACM International Symposium on Cluster Computing and the Grid	A	68	90	A	18,88	206	A	1351	25506

Microsoft Academic:

Acronym	Conference	Class	FieldRating	RankFieldRating	ClassFieldRating	AvgCitations	RankAvgCitations	ClassAvgCitations	Publications	Citations
CCGRID	Cluster Computing and the Grid	A	84	235	A-	24,16	330	A+	1397	33752

5.1.2.3. Globus-Based Grid Computing Simulations of Action Potential Propagation on Cardiac Tissues

J. M. Alonso, V. Hernández, and G. Moltó, "Globus-based Grid Computing Simulations of Action Potential Propagation on Cardiac Tissues," Lect. Notes Comput. Sci., vol. 3149, pp. 444–451, 2004, doi: https://10.1007/978-3-540-27866-5_58

Base de datos de indexación	GII-GRIN-SCIE
Denominación del congreso	10th International Euro-Par Conference
Posición	GGS Class 2, GGS Rating A-

Comentario. Esta contribución al congreso Euro-Par fue uno de los resultados de la tesis doctoral del candidato mediante la ejecución de simulaciones de propagación eléctrica en tejidos cardiacos sobre infraestructuras Grid

Globus-Based Grid Computing Simulations of Action Potential Propagation on Cardiac Tissues

José M. Alonso, Vicente Hernández, and Germán Moltó*

Departamento de Sistemas Informáticos y Computación,
Universidad Politécnica de Valencia. Camino de Vera s/n 46022 Valencia, Spain
Tel. +34963877356, Fax +34963877359
{jmalonso,vhernand,gmolto}@dsic.upv.es

Abstract. With the advent of Grid technologies, the study of the electrical activity of the heart, by means of concurrent parametric simulations of the action potential propagation on cardiac tissues, can be greatly benefited. Studies of the electrical behaviour, such as late ischemia require the execution of multiple computational and memory intensive parametric simulations. This paper describes the integration, into a Grid infrastructure, of a parallel MPI-based system for the simulation of action potential propagation on a three-dimensional parallelepiped-modelled cardiac tissue. Developed upon the Globus Toolkit, it features state-of-the-art capabilities such as data compression, simulation failure recovery, and the combination of parallel execution on distributed resources, what has enabled an outstanding increase in research productivity.

1 Introduction

The simulation of action potential propagation on cardiac tissues represents a major computational challenge. The fine spatial and time discretization steps required to solve the equation (1) that governs this phenomenon on a monodomain cardiac model makes this problem only affordable with High Performance Computing techniques. This is particularly important for three-dimensional executions, where a simulation of action potential propagation during few milliseconds on a medium-sized tissue may last for several days on a sequential platform.

$$\nabla \cdot \sigma \nabla Vm = C_m \cdot \frac{dVm}{dt} + I_{ion} + I_{st}. \tag{1}$$

The previous equation relates the membrane potential of the cells, Vm, the ionic currents that traverse the membrane, I_{ion}, the membrane capacitance, C_m, the anisotropy tensor, σ, and the electrical stimulus, I_{st}. The comprehensive Luo-Rudy Phase II [1] cellular model has been employed to calculate the I_{ion} term.

* The authors wish to thank the financial support received from The Spanish Ministry of Science and Technology to develop the project GRID-IT (TIC2003-0131). This work has been partially supported by the Structural Funds of the European Regional Development Fund (ERDF).

M. Danelutto, D. Laforenza, M. Vanneschi (Eds.): Euro-Par 2004, LNCS 3149, pp. 444–451, 2004.

Table 3. Distribution of the simulations in the testbed, for each machine. The number in parentheses indicates the number of processors involved in the execution.

Machine	Simulations	Machine	Simulations
Kefren	7 (8 p.), 5 (5 p.), 3 (1 p.), 2 (4 p.), 2 (7 p.)	Hydrus	3 (1 p.)
Ramses	7 (8 p.), 3 (1.p)	Cygnus	3 (1 p.)
Cepheus	2 (1 p.)	Aquila	3 (1 p.)

It can be seen that the scheduler has distributed the tasks proportional to the computational power of each machine, what represents a proper balance loading scheme. Had the machine Bastet been available, it would have received a task load adequate to its computational power. Besides, as the state of the Grid is investigated before each task submission, the job allocation is dynamically adjusted to the computational load of the resources during the scheduling process.

It is important to point out that a Grid execution is ideal for resource-starved cardiac case studies, as it broadens the computing resources available, no longer confined to those belonging to a single organization.

5 Conclusions

This paper has presented the integration of a system for the simulation of action potential propagation on three-dimensional monodomain modelled cardiac tissues, into a Globus-based Grid infrastructure.

The Grid Computing system developed features state-of-the-art capabilities such as data compression, self-contained executable and dependencies migration, cross-linux portability and parallel execution of simulations on cluster nodes of the Grid.

With the execution of cardiac case studies in a Grid environment, productivity has been largely enhanced compared to traditional sequential execution approaches. It is clear that the advent of new Grid technologies is getting possible to increase the research productivity by performing multiple concurrent, geographically distributed, parallel or sequential simulations of action potential propagation on cardiac tissues.

Therefore, having available a parallel simulation system that can be integrated with a Grid infrastructure enables to focus both on speedup, running on a cluster of PCs, and productivity, taking full advantage of the computational power of a Grid.

Acknowledgements

We would like to thank the Distributed Systems Architecture & Security group, belonging to Madrid Complutense University (Spain), for sharing both its computational resources, enlarging our testbed, and its knowledge through the results of the GridWay project [10].

References

1. Luo, C.H., Rudy, Y.: A Dynamic Model of the Cardiac Ventricular Action Potential. I Simulations of Ionic Currents and Concentration Changes. Circulation Research **74** (1994) 1071–1096
2. Vigmond, E.J., Aguel, F., Trayanova, N.A.: Computational Techniques for Solving the Bidomain Equations in Three Dimensions. IEEE Transactions on Biomedical Engineering **49** (2002) 1260–1269
3. Alonso, J.M., Ferrero (Jr.), J.M., Hernández, V., Moltó, G., Monserrat, M., Saiz, J.: High Performance Cardiac Tissue Electrical Activity Simulation on a Parallel Environment. Proceedings of the First European HealthGrid Conference (2003) 84–91
4. Lawson, C.L., Hanson, R.J., Kincaid, D., Krogh, F.T.: Basic Linear Algebra Subprograms for FORTRAN Usage. ACM Trans. Math. Soft. **5** (1979) 308–323
5. Anderson, E., Bai, Z., Bischof, C., Blackford, S., Demmel, J., Dongarra, J., Du Croz, J., Greenbaum, A., Hammarling, S., McKenney, A., Sorensen, D.: LAPACK Users' Guide. Third edn. Society for Industrial and Applied Mathematics, Philadelphia, PA (1999)
6. Gropp, W., Lusk, E., Doss, N., Skjellum, A.: A High-Performance, Portable, Implementation of the MPI Message Passing Interface Standard. Parallel Computing **22** (1996) 789–828
7. Gropp, W.D., Lusk, E.: User's Guide for MPICH, a Portable Implementation of MPI. Mathematics and Computer Science Division, Argonne National Laboratory. (1996)
8. Foster, I., Kesselman, C., Nick, J., Tuecke, S.: The Physiology of the Grid: An Open Grid Services Architecture for the Distributed Systems Integration. Infrastructure WG, Global Grid Forum (2002)
9. Foster, I., Kesselman, C.: Globus: A Metacomputing Infrastructure Toolkit. Intl. J. Supercomputer Applications **11** (1997) 115–128
10. Huedo, E., Montero, R.S., Llorente, I.M.: A Framework for Adaptive Execution on Grids. Software Practice and Experience (2004) To appear.

The GII-GRIN-SCIE Conference Rating

Explore the GII-GRIN-SCIE (GGS) Conference Rating

Menu

Mirror@www.consorzio-cini.it - Mirror@valutazione.unibas.it - Mirror@gii-grin-scie-rating.scie.es

Search Details Previous Versions

Download **The GGS Conference Rating 2018** (Excel .xlsx file) - last updated: May, 30th 2018

This initiative is sponsored by GII (Group of Italian Professors of Computer Engineering), GRIN (Group of Italian Professors of Computer Science), and SCIE (Spanish Computer-Science Society). For details about the rating algorithm and the process, see the Conference Rating description page.

Search Conferences

Name		Search	Sample: *int*conf*data*
Acronym	Euro-Par	Search	Sample: vldb or *ubi*
Class		Search	Sample: 1 or 2 or 3
Rating		Search	Sample: A++ or A+ or A or A- or B or B-
Collected Ratings		Search	Sample: A++, A++, A++ or A+, A, A

Legenda

Class	Ratings	Size	Description
Class 1	A++, A+	32 + 50 = **82 conferences**	excellent, top notch conferenc
Class 2	A, A-	82 + 93 = **175 conferences**	very good events
Class 3	B, B-	205 + 161 = **366 conferences**	events of good quality
-	Work in Progress	2172 conferences	work in progress

Your search returned 1 results.

Title	Acronym	GGS Class	GGS Rating	Qualified Classes	Collected Classes
EUROPEAN CONFERENCE ON PARALLEL PROCESSING	EURO-PAR	2	A-	CORE:A, LiveSHINE:A, MA:B	A, A, B

Detailed Ratings (click to expand)

CORE:

Acronym	Title	Class
Euro-Par	European Conference on Parallel Processing	A

CORE:

Acronym	Title	Class
EuroPar	European Conference on Parallel Processing	A

LiveSHINE:

Acronym	Conference	Class	H-Index	RankH-Index	ClassH-Index	AvgCitations	RankAvgCitations	ClassAvgCitations	Publications	Citations
Euro-Par	European Conference on Parallel Computing	A	48	190	A	11,69	386	B-	1178	13766

Microsoft Academic:

Acronym	Conference	Class	FieldRating	RankFieldRating	ClassFieldRating	AvgCitations	RankAvgCitations	ClassAvgCitations	Publications	Citations
EURO PAR	European Conference on Parallel Processing	B	72	309	B	8,59	925	C	3201	27491

5.1.2.4. A platform to deploy customized scientific virtual infrastructures on the cloud

M. Caballer, D. Segrelles, G. Moltó, and I. Blanquer, "A platform to deploy customized scientific virtual infrastructures on the cloud," Concurr. Comput. Pract. Exp., vol. 27, no. 16, pp. 4318–4329, Nov. 2015, doi: https://10.1002/cpe.3518

Base de datos de indexación	Web of Science / JCR
Índice de impacto	0.943
Año	2015
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	50 de 105
Tercil	T2
Cuartil	Q3
Número de citas en JCR	9
Número de citas totales	14

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional (RETOS I+D) BigCLOE (TIN2016-79951-R), liderado por el candidato, que muestra la aplicabilidad de la herramienta Infrastructure Manager (IM) para el despliegue de infraestructuras de procesado de Big Data. Fue uno de los resultados de la Tesis Doctoral de Miguel Caballer, titulada "Gestión de infraestructuras virtuales configuradas dinámicamente" y co-dirigida por el candidato.

CONCURRENCY AND COMPUTATION: PRACTICE AND EXPERIENCE
Concurrency Computat.: Pract. Exper. 2015; **27**:4318–4329
Published online 20 May 2015 in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/cpe.3518

SPECIAL ISSUE PAPER

A platform to deploy customized scientific virtual infrastructures on the cloud

Miguel Caballer*,†, Damián Segrelles, Germán Moltó and Ignacio Blanquer

Instituto de Instrumentación para Imagen Molecular (I3M). Centro Mixto CSIC – Universitat Politècnica de València – CIEMAT Camino de Vera s/n, 46022 Valencia, Spain

SUMMARY

This paper presents a software platform to dynamically deploy complex scientific virtual computing infrastructures, on top of Infrastructure as a Service Clouds. The platform orchestrates different services to provision the virtual computing resources. It dynamically installs the appropriate software to satisfy the requirements of a researcher, both on public and on-premise Clouds. The platform provides a web interface to enable the users to easily manage the life cycle of virtual infrastructures. It enables users to define infrastructures, share them with other users, deploy and relinquish them, add or remove resources dynamically, create and share application recipes, and so on. The paper also describes three case studies to deploy complex infrastructures, namely, a Hadoop cluster, a single-node to perform Next Generation Sequencing and a gateway for users to access the European Grid Infrastructure. This platform promotes a better use of on-premise hardware resources of a research center by allocating the computing resources just-in-time to the specific life time of the virtual infrastructures as well as the deployment of the very same infrastructures on a public Cloud. Copyright © 2015 John Wiley & Sons, Ltd.

Received 19 December 2014; Revised 11 March 2015; Accepted 24 March 2015

KEY WORDS: cloud computing; virtual infrastructures

1. INTRODUCTION

The diverse computing requirements for scientific applications require complex hardware infrastructure configurations and potentially incompatible specific software requirements. In a multi-disciplinary environment, different researchers typically share the same hardware. Therefore, the adequate provision and configuration of computing resources could be unaffordable or impractical because of the technical overhead of switching among configurations and the effort on the configuration and customization of the infrastructures. Under these circumstances, the use of frameworks to automate the deployment and configuration of virtual computing infrastructures is necessary. Furthermore, to reduce the carbon footprint, it is especially important to properly and efficiently manage the computing resources of a research center so that the level of service and versatility is maintained without requiring additional investments in hardware.

For that purpose, Cloud computing [1, 2] is a paradigm to rapidly provision computing resources, mainly computing and storage, that can be customized and configured to fit a particular research activity. This enables the dynamic deployment of virtual infrastructures on top of a fleet of virtual machines running on a physical hardware, when using the Infrastructure as a Service (IaaS) Cloud service model. The usage of virtualization [3] enables hardware usage to be increased thus reducing

*Correspondence to: Miguel Caballer, Instituto de Instrumentación para Imagen Molecular (I3M). Centro Mixto CSIC – Universitat Politècnica de València – CIEMAT Camino de Vera s/n, 46022 Valencia, Spain.
†E-mail: micafer1@upv.es

gateway to EGI. The ability to dynamically deploy a new UI in a single click out of the existing RADL recipe is very interesting for sysadmins, which can deploy different instances on demand depending, for example, on the number of users that require access to a UI.

5. CONCLUSION AND FUTURE WORK

This paper has presented a software platform to easily create scientific on demand virtual computing infrastructures. First, it should be pointed out that creating a high-level description or recipe (using RADL) of the desired infrastructure is a much more efficient way to provision infrastructures when compared with the traditional way (provision the computational resources, manual installation of software, and configuration, etc.). Second, this enables repetition and automation. The same infrastructure can be deployed as many times as required. Moreover, the RADL description can be reused and shared so that the definition of other infrastructures can build upon the recipes of previously defined infrastructures. Third, the ability of the platform to interact with different IaaS Cloud backends is of special importance.

Notice that the same RADL definition is employed to create the infrastructure on an on-premise Cloud or in a public Cloud. This makes it very easy to perform Cloud bursting, where a Cloud provider is employed in case no spare hardware resources are available in the on-premise Cloud of the research institution. Therefore, there is no need for an institution to over-provision hardware resources to cope with sudden workload peaks, where many researchers are simultaneously requesting computing resources to deploy their virtual infrastructures, because the deployment of some virtual infrastructures can be outsourced to a third-party Cloud provider.

Notice that the usage of dynamically deployed infrastructures enables always to start off with a fresh installation. This means that all the users' data and modifications are lost when the infrastructure is torn down. Any unauthorized modification of the infrastructure (even malware, rootkits, etc.) will be purged when the infrastructure's resources are relinquished. This provides a safe, pristine environment every time an infrastructure is deployed.

The usage of such a platform enables research centers to better take advantage of existing hardware resources. By leveraging the elasticity of the Cloud platform, in terms of rapidly provisioning resources, and the advantages of virtualization, such as isolation and multi-tenancy, the proposed platform paves the way for a versatile creation of scientific infrastructures. The functionality of the platform has been tested with three different use cases. In each use case, a specific infrastructure with a complex configuration has been deployed.

Because the platform API and tools can be considered stable, future works involve improving the web applications of the platform in order to enhance the user interaction for the less experienced users. This opens avenues to democratize the access to computing resources on demand to support research activities, even for scientists that belong to areas different from computer science.

All the software of the platform is provided to the community as open source code. It can be downloaded from the IM web page[‡‡‡‡] or from the GRyCAP public git repository in GitHub.[§§§§] Also, a publicly available deployment of the platform is also available to be freely used from the web interface.[¶¶¶¶]

ACKNOWLEDGEMENTS

The authors would to thank the Spanish "Ministerio de Economía y Competitividad" for the project "Clusters Virtuales Elásticos y Migrables sobre Infraestructuras Cloud Híbridas" with reference TIN2013-44390-R.

[‡‡‡‡]http://www.grycap.upv.es/im
[§§§§]http://github.com/grycap
[¶¶¶¶]http://goo.gl/raSzqq

DOI: 10.1002/cpe

REFERENCES

1. Mell P, Grance T. The NIST definition of Cloud computing. NIST Special Publication 800-145 (Final). *Technical Report*, 2011. (Available from: http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf.) [Accessed on 20 February 2015].
2. Buyya R, Broberg J, Goscinski AM. *Cloud Computing: Principles and Paradigms*. Wiley: Hoboken, New Jersey, 2011.
3. Sahoo J, Mohapatra S, Lath R. Virtualization: a survey on concepts, taxonomy and associated security issues. *2010 Second International Conference on Computer and Network Technology,* IEEE, Bangkok, Thailand, 2010; 222–226.
4. OpenStack. OpenStack, 2013. (Available from: http://openstack.org) [Accessed on 20 February 2015].
5. Sotomayor B, Montero R, Llorente I, Foster I. Capacity leasing in Cloud systems using the OpenNebula engine. *Cloud Computing and Applications* 2008; **2008**:1–5.
6. Nurmi D, Wolski R, Grzegorczyk C, Obertelli G, Soman S, Youseff L, Zagorodnov D. The Eucalyptus open-source Cloud-computing system. *Proceedings of 9th IEEE International Symposium on Cluster Computing and the Grid*, Shanghai, China, 2009; 124–131.
7. Amazon Web Services. AWS CloudFormation. (Available from: http://aws.amazon.com/cloudformation/) [Accessed on 20 February 2015].
8. Amazon Web Services. AWS OpsWorks. (Available from: http://aws.amazon.com/opsworks/) [Accessed on 20 February 2015].
9. Keahey K, Freeman T. Contextualization: providing one-click virtual clusters. *Fourth IEEE International Conference on eScience*, Indianapolis, Indiana, USA, 2008; 301–308.
10. Keahey K, Freeman T. Architecting a large-scale elastic environment: recontextualization and adaptive Cloud services for scientific computing, 2012.
11. Marshall P, Keahey K, Freeman T. Elastic site: using Clouds to elastically extend site resources. *Proceedings of the 2010 IEEE/ACM 10th International Conference on Cluster, Cloud and Grid Computing*, CCGRID '10, IEEE Computer Society, Washington, DC, USA, 2010; 43–52.
12. Bresnahan J, Freeman T, LaBissoniere D, Keahey K. Managing appliance launches in infrastructure Clouds. *Proceedings of the 2011 TeraGrid Conference: Extreme Digital Discovery*, TG '11, ACM, New York, NY, USA, 2011; 12:1–12:7.
13. Apache. Whirr, 2013. (Available from:http://whirr.apache.org/) [Accessed on 20 February 2015].
14. Juve G, Deelman E. Automating application deployment in infrastructure clouds. *Proceedings of the 2011 IEEE Third International Conference on Cloud Computing Technology and Science*, CLOUDCOM '11, IEEE Computer Society, Washington, DC, USA, 2011; 658–665.
15. OASIS. Topology and orchestration specification for cloud applications version 1.0, 2013. (Available from: http://docs.oasis-open.org/tosca/TOSCA/v1.0/TOSCA-v1.0.html) [Accessed on 20 February 2015].
16. Binz T, Breitenbcher U, Haupt F, Kopp O, Leymann F, Nowak A, Wagner S. OpenTOSCA - a runtime for TOSCA-based cloud applications. *ICSOC, Lecture Notes in Computer Science*, Vol. 8274, Springer, 2013; 692–695.
17. Puppet Labs. IT automation software for system administrators, 2013. (Available from: http://www.puppetlabs.com/) [Accessed on 20 February 2015].
18. Opscode. Chef, 2013. (Available from: http://www.opscode.com/chef/) [Accessed on 20 February 2015].
19. DeHaan M. Ansible, 2013. (Available from: http://ansible.cc/) [Accessed on 20 February 2015].
20. Vogels W. Beyond server consolidation. *Queue* 2008; **6**(1):20–26.
21. Carrión JV, Moltó G, De Alfonso C, Caballer M, Hernández V. A generic catalog and repository service for virtual machine images. *2nd International ICST Conference on Cloud Computing (CloudComp 2010)*, Barcelona, Spain, 2010; 1–15.
22. de Alfonso C, Caballer M, Alvarruiz F, Molto G, Hernández V. Infrastructure deployment over the Cloud. *2011 IEEE Third International Conference on Cloud Computing Technology and Science,* IEEE, Athens, Greece, 2011; 517–521.
23. Caballer M, Blanquer I, Molto G, de Alfonso C. Dynamic management of virtual infrastructures. *Journal of Grid Computing* 2014; **13**(1):53-70.
24. Dean J, Ghemawat S. Mapreduce: simplified data processing on large clusters. *Communications of the ACM* 2008; **51**(1):107–113.
25. Shvachko K, Kuang H, Radia S, Chansler R. The Hadoop distributed file system. *2010 IEEE 26th Symposium on Mass Storage Systems and Technologies (MSST)*, Incline Village, NV, USA, 2010; 1–10.
26. Altschul SF, Gish W, Miller W, Myers EW, Lipman DJ. Basic local alignment search tool. *Journal of Molecular Biology* 1990; **215**(3):403–410.

DOI: 10.1002/cpe

5.1.2.5. A Programming Model and Middleware for High Throughput Serverless Computing Applications

A. Pérez, G. Moltó, M. Caballer, and A. Calatrava, "A programming model and middleware for high throughput serverless computing applications," in Proceedings of the 34th ACM/SIGAPP Symposium on Applied Computing, 2019, pp. 106–113, doi:https://10.1145/3297280.3297292

Base de datos de indexación	GII-GRIN-SCIE
Denominación del congreso	ACM/SIGAPP Symposium on Applied Computing
Posición	GGS Class 2, GGS Rating A-

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional (RETOS I+D) BigCLOE (TIN2016-79951-R), liderado por el candidato, y principal resultado de la Tesis Doctoral de Alfonso Pérez, dirigida por el candidato. En ella se describe el modelo de programación de la herramienta de código abierto SCAR – https://github.com/grycap/scar, utilizada para la ejecución de aplicaciones científicas para el procesado dirigido por eventos de ficheros. La ampliación de la funcionalidad de SCAR le permitió una rápida adopción llegando a las 550 estrellas en GitHub y siendo incluida en el landscape de la Cloud Native Computing Foundation : https://landscape.cncf.io/format=serverless&selected=scar.

A Programming Model and Middleware for High Throughput Serverless Computing Applications

Alfonso Pérez
Instituto de Instrumentación para Imagen Molecular (I3M)
Centro mixto CSIC - Universitat Politècnica de València
Valencia, Valencia
alpegon3@upv.es

Germán Moltó
Instituto de Instrumentación para Imagen Molecular (I3M)
Centro mixto CSIC - Universitat Politècnica de València
Valencia, Valencia

Miguel Caballer
Instituto de Instrumentación para Imagen Molecular (I3M)
Centro mixto CSIC - Universitat Politècnica de València
Valencia, Valencia

Amanda Calatrava
Instituto de Instrumentación para Imagen Molecular (I3M)
Centro mixto CSIC - Universitat Politècnica de València
Valencia, Valencia

ABSTRACT

Serverless computing has introduced unprecedented levels of scalability and parallelism for the execution of High Throughput Computing tasks. This represents a challenge and an opportunity for different scientific workloads to be adapted to upcoming programming models that simplify the usage of such platforms. In this paper we introduce a serverless model for highly-parallel file-processing applications. We also describe a middleware implementation that supports the execution of customized execution environments based on Docker images on AWS Lambda, the leading serverless computing platform. Moreover, this middleware offers tools to manage the input/output of the serverless infrastructure and the creation of HTTP endpoints in a transparent way to the user. To test the programming model proposed and the middleware, this paper describes two case studies. The first one analyzes medical images with a high degree of parallelism. The second one presents an architecture to analyze video keyframes. The results from both case studies are analyzed and a cost analysis of the medical image architecture comparing different cloud options is carried out. The results show that the combination of a high-level programming model with the scalable capabilities of AWS Lambda makes it easy for end users to efficiently exploit serverless computing for the optimized and cost-effective execution of loosely-coupled tasks.

CCS CONCEPTS

• **Architectures** → **Cloud computing**; • **Applied computing** → *Event-driven architectures*;

ACM Reference Format:
Alfonso Pérez, Germán Moltó, Miguel Caballer, and Amanda Calatrava. 2019. A Programming Model and Middleware for High Throughput Serverless Computing Applications. In *The 34th ACM/SIGAPP Symposium on Applied Computing (SAC '19), April 8–12, 2019, Limassol, Cyprus.* ACM, New York, NY, USA, Article 4, 8 pages. https://doi.org/10.1145/3297280.3297292

SAC '19, April 8–12, 2019, Limassol, Cyprus

ACM ISBN 978-1-4503-5933-7/19/04…$15.00
https://doi.org/10.1145/3297280.3297292

1 INTRODUCTION

Over the last years the offering made by large enterprises of renting computing, storage and network capacity on a pay-per-use basis has resulted in a tremendous revolution that democratized the access to large-scale enterprise-ready computing infrastructures without large upfront investments. The main public Cloud computing providers are Amazon Web Services [2], Microsoft Azure [27], and Google Cloud Platform [18]. On the other hand, Cloud Management Platforms such as OpenStack [30] and OpenNebula [29] enable system administrators to create on-premises Cloud infrastructures.

In parallel, the evolution of container-based technologies exemplified by Docker [9, 25], LXC [23] and rkt [7] introduced significant advantages with respect to Virtual Machines. There are on-premises Container Orchestration Platforms such as Swarm mode in Docker Engine [10], Nomad [19] or Kubernetes [22], and managed services provided by the leading public Cloud providers. Examples of the latter are Amazon ECS [5], Azure Container Service [26] and Google Container Engine [16]. The main drawback with these services is that they are typically oriented to advanced users, in order to deal with the capacity planning required to deploy the clusters in advance and optimize the allocation of resources to containers.

In the recent years, the term Serverless computing [6] has been coined to embrace an event-driven Functions-as-a-Service (FaaS) approach to computing with a fine-grained cost model. Pioneer services in this area, such as AWS Lambda [1], allow functions to be invoked in response to events such as uploading a file to a *bucket* in Amazon S3 (Simple Storage Service) or also in response to HTTP calls made to a predefined endpoint created with the AWS API Gateway service.

The programming model introduced by AWS Lambda can be effectively exploited for scientific applications and there are few examples in the literature using it for distributed computing such as Bulk Synchronous Processing (e.g. PyWren [21]), or fine-grained video processing (e.g. ExCamera [11]). It is important to note that current serverless platforms are typically focused on Functions-as-a-Service, where applications need to be redesigned as a set of event-triggered functions coded in a supported programming

language. However, many applications cannot be easily redesigned as a set of functions. Indeed, the interface between the user and the serverless platform should not only be based on functions, which suffer from the inherent restrictions of the programming languages chosen. Instead, containers provide users with the ability to run virtually any kind of application without having to introduce changes. Supporting applications defined via container images in a serverless platform would allow the user to: i) easily bring their own applications which may already be packaged as a Docker image, ii) use applications that depend on libraries not available in the runtime environment of the functions, and iii) use programming languages not currently supported by the serverless provider.

To this aim, this paper introduces a High Throughput Computing Programming Model that allows to create highly-parallel event-driven file-processing serverless applications. The programming model is used in combination with a middleware (i.e. SCAR [32]) to simplify and automate the application deployment process and permit the users to execute customized runtime environments in the serverless platforms, thus bypassing some limitations imposed by the Cloud providers. This demonstrates how serverless computing can be effectively employed for many applications to achieve unprecedented scalability for loosely-coupled tasks with almost no configuration provided by the user side.

The remainder of the paper is structured as follows. First, section 2 describes the related work in the area. Next, section 3 introduces the programming model. Then, section 4 describes the updates done to the middleware that provides an implementation of the programming model. Section 5 describes two case studies to assess the usefulness of the proposed programming model and the middleware. Finally, sections 6 and 7 summarize the main achievements and point to future work, respectively.

2 RELATED WORK

The serverless computing model aims to revolutionize the design and development of modern scalable applications, allowing developers to run ephemeral, event-driven code without provisioning or managing servers. This new paradigm is experimenting an industry momentum around the cloud event abstraction [13]. In fact, over the last three years, several event-driven services such as AWS Lambda [1], offered by Amazon Web Services, Google Cloud Functions [17], Microsoft Azure Functions [28], and the open-source Apache OpenWhisk [12], have arisen. These services allow the users to take advantage of the improvements offered by this new computing model. The works presented by McGrath et al. [24] and Gannon [14] performed a review of these services, discussing the recent state of the art in this field.

Indeed, the serverless technology is starting to be employed in several scenarios. For example, in Web environments reduces the infrastructure costs more than 70% achieving a similar level of performance than traditional server-based solutions [35]. There are tools in the literature like Up [4], that facilitates the deployment of vanilla HTTP servers on serverless platforms, and developments like OpenLambda [20] an open-source platform for building web services applications using the serverless computing model. Another area where serverless computing is significantly being adopted is Big Data. Case studies of data analytics over serverless platforms, like [15], where the authors perform data processing with Spark over Apache OpenWhisk, are getting attention of researchers and developers. Some examples of recent works using serverless computing are open-source tools like Ooso [31], a Java library designed to execute MapReduce tasks based on Apache Hadoop and Spark on AWS Lambda, or enterprise solutions like Databricks Serverless [8], a serverless computing platform for complex data science and Apache Spark workloads. Moreover, projects like AWS Serverless Application Model (AWS SAM) [3] attempt to provide the means to define serverless functions for AWS Lambda.

A major requirement for writing serverless code, however, is to express the logic as functions that are instantiated to process a single event triggered by a service. The work by Baldini et al. [6] regarding the open problems of serverless computing identifies several unsolved challenges which include: i) the ability to run legacy code on serverless platforms, and ii) the lack of patterns for building serverless solutions.

In order to contribute to address these open issues, this paper describes a programming model designed specifically to create highly-parallel event-driven file-processing serverless applications for serverless architectures. This programming model, in combination with the SCAR framework, allows the user to run generic applications, even legacy ones, on serverless platforms.

3 PROGRAMMING MODEL

This section describes the proposed programming model used to create highly-parallel event-driven file-processing serverless architectures in combination with generic execution environments (i.e. containers). Containers are used to allow the users to create customized runtime environments, thus bypassing the provider limitations imposed in their execution environments. The infrastructure used to deploy and test the programming model and framework is the serverless computing platform AWS Lambda.

In addition, this programming model assumes that: i) the user wants to process a set of files that could be in a storage service or in a local machine; and ii) after the function execution, the output files will be transferred to a storage service (outside the space allocated to the lambda function). These assumptions are made because lambda functions are stateless by definition so the architecture making use of them must be designed stateless.

Figure 1 shows the proposed programming model. Notice that it allows users to select between different paths to process their files: 1) submit the file to process using an HTTP request through a previously defined and linked API Gateway; 2) upload a file to an S3 bucket that is linked with the lambda function or read the files from a non-linked S3 bucket. Both ways end up creating one event for each file that is going to be processed. Then, this event is sent to AWS Lambda and used to invoke a lambda function that processes it. All the approaches will end up storing the results in an S3 bucket, which in turn leads to the third approach presented to process files: 3) an S3 bucket, that could be connected to AWS Lambda again, and trigger the execution of more lambda functions automatically, thus effectively implementing serverless workflows. In the following subsections, the proposed approaches are described in more detail.

AWS Service	Type	Time to process 1000 images (s)	Cost ($)	Number of machines needed to match lambda execution time	Cost of the machines needed to match lambda execution time ($)
Lambda	3008MB	142 (2.36 min.)	6.934	-	-
EC2	c5.large	102500 (28.47 h.)	2.42	722	-
	c5.18xlarge	2820 (47 min.)	2.397	20	2.414

Table 2: Summary of the costs of the medical image case study. The cost uses data from Table 1, adopting per-minute billing.

The ability to run code in response to events and the large-scale elasticity provided by the underlying serverless platform opens new avenues for efficient High Throughput Computing tasks. This was demonstrated by the case studies where the programming model abstracted away many implementation details typically required on computing frameworks. Several challenges are also identified, such as limitations in the amount of memory allocated to each function invocation and, the most limiting one, the maximum execution time. Moreover a cost analysis was done comparing the serverless programming models presented and the usual Cloud Computing architectures. Although the cost analysis revealed that running a serverless architecture could be costlier than deploying a simple EC2 machine, the savings in configuration and execution time in combination with the pay-per-use model offered by AWS make the serverless architectures a good option to deploy applications that have to deal with a high amount of short lived tasks.

In the future, we plan to simplify the definition of data driven workflows, so the user can define complete applications by using a simple infrastructure definition file. Moreover, we have plans to add support for more cloud providers and also tackle on-premises functions-as-a-service frameworks. This would lead to the deployment of hybrid serverless applications that encompass the high scalability capabilities of the cloud providers and the less restricted environments of the on-premises deployments.

ACKNOWLEDGEMENTS

The authors would like to thank the Spanish "Ministerio de Economía, Industria y Competitividad" for the project "BigCLOE" with reference number TIN2016-79951-R.

REFERENCES

[1] Amazon. Amazon Lambda (AWS Lambda). https://aws.amazon.com/lambda/. [Online; accessed 24-September-2018].
[2] Amazon. Amazon Web Services (AWS). http://aws.amazon.com. [Online; accessed 24-September-2018].
[3] Amazon. AWS Serverless Application Model (AWS SAM). https://github.com/awslabs/serverless-application-model. [Online; accessed 24-September-2018].
[4] Apex. Up, deploy serverless apps in seconds. http://apex.run/. [Online; accessed 24-September-2018].
[5] AWS. Amazon EC2 Container Service (ECS). https://aws.amazon.com/es/ecs/. [Online; accessed 24-September-2018].
[6] I. Baldini, P. Castro, K. Chang, P. Cheng, S. Fink, V. Ishakian, N. Mitchell, V. Muthusamy, R. Rabbah, A. Slominski, and P. Suter. Serverless Computing: Current Trends and Open Problems. pages 1–20, jun 2017.
[7] CoreOS. rkt. https://coreos.com/rkt/. [Online; accessed 24-September-2018].
[8] Databricks. Databricks Serverless. https://goo.gl/uagZ8E. [Online; accessed 24-September-2018].
[9] Docker. Docker. https://www.docker.com/. [Online; accessed 24-September-2018].
[10] Docker. Swarm Mode in Docker Engine. https://docs.docker.com/engine/swarm/. [Online; accessed 24-September-2018].
[11] S. Fouladi, R. S. Wahby, B. Shacklett, K. V. Balasubramaniam, W. Zeng, R. Bhalerao, A. Sivaraman, G. Porter, and K. Winstein. Encoding, fast and slow: Low-latency video processing using thousands of tiny threads. In *14th USENIX Symposium on Networked Systems Design and Implementation (NSDI 17)*, pages 363–376, Boston, MA, 2017. USENIX Association.
[12] T. A. S. Foundation. Apache openwhisk. http://openwhisk.org/. [Online; accessed 24-September-2018].
[13] G. C. Fox, V. Ishakian, V. Muthusamy, and A. Slominski. Status of Serverless Computing and Function-as-a-Service(FaaS) in Industry and Research. aug 2017.
[14] D. Gannon. Observations about Serverless Computing With a few examples from AWS Lambda, Azure Functions and Open Whisk. Technical report, 2017.
[15] A. Glikson. TRANSIT: Flexible pipeline for IoT data with Bluemix and OpenWhisk. https://goo.gl/ThN2TR. [Online; accessed 24-September-2018].
[16] Google. Container Engine. https://cloud.google.com/container-engine. [Online; accessed 24-September-2018].
[17] Google. Google Cloud Functions. https://cloud.google.com/functions/. [Online; accessed 24-September-2018].
[18] Google. Google Cloud Platform. https://cloud.google.com. [Online; accessed 24-September-2018].
[19] Hashicorp. Nomad. https://www.nomadproject.io/. [Online; accessed 24-September-2018].
[20] S. Hendrickson, S. Sturdevant, T. Harter, V. Venkataramani, A. C. Arpaci-Dusseau, and R. H. Arpaci-Dusseau. Serverless computation with openlambda. In *8th USENIX Workshop on Hot Topics in Cloud Computing (HotCloud 16)*, Denver, CO, 2016. USENIX Association.
[21] E. Jonas, Q. Pu, S. Venkataraman, I. Stoica, and B. Recht. Occupy the Cloud: Distributed Computing for the 99%. feb 2017.
[22] Kubernetes. Kubernetes. https://kubernetes.io/. [Online; accessed 24-September-2018].
[23] LXC. LXC. https://linuxcontainers.org/. [Online; accessed 24-September-2018].
[24] G. McGrath, J. Short, S. Ennis, B. Judson, and P. Brenner. Cloud event programming paradigms: Applications and analysis. In *2016 IEEE 9th International Conference on Cloud Computing (CLOUD)*, pages 400–406, June 2016.
[25] D. Merkel. Docker: lightweight Linux containers for consistent development and deployment. *Linux Journal*, 2014(239):2, mar 2014.
[26] Microsoft. Azure Container Service. https://azure.microsoft.com/services/container-service/. [Online; accessed 24-September-2018].
[27] Microsoft. Microsoft Azure. https://azure.microsoft.com. [Online; accessed 24-September-2018].
[28] Microsoft. Microsoft Azure Functions. https://azure.microsoft.com/en-in/services/functions/. [Online; accessed 24-September-2018].
[29] OpenNebula. OpenNebula. https://opennebula.org. [Online; accessed 24-September-2018].
[30] OpenStack. OpenStack. http://openstack.org. [Online; accessed 24-September-2018].
[31] D. O. S. Platform. Ooso, serverless mapreduce. https://github.com/d2si-oss/ooso. [Online; accessed 24-September-2018].
[32] A. Pérez, G. Moltó, M. Caballer, and A. Calatrava. Serverless computing for container-based architectures. *Future Generation Computer Systems*, 83:50 – 59, 2018.
[33] J. Redmon and A. Farhadi. Yolov3: An incremental improvement. *arXiv*, 2018.
[34] F. B. Torro, J. D. S. Quilis, I. B. Espert, A. A. Bayarri, and L. M. Bonmatí. Accelerating the diffusion-weighted imaging biomarker in the clinical practice: comparative study. *Procedia Computer Science*, 108(Supplement C):1185 – 1194, 2017. International Conference on Computational Science, ICCS 2017, 12-14 June 2017, Zurich, Switzerland.
[35] M. Villamizar, O. Garcés, L. Ochoa, H. Castro, L. Salamanca, M. Verano, R. Casallas, S. Gil, C. Valencia, A. Zambrano, and M. Lang. Cost comparison of running web applications in the cloud using monolithic, microservice, and aws lambda architectures. *Service Oriented Computing and Applications*, 11(2):233–247, 2017.
[36] L. Wang, M. Li, Y. Zhang, T. Ristenpart, and M. Swift. Peeking Behind the Curtains of Serverless Platforms. *2018 USENIX Annual Technical Conference (USENIX ATC 18)*, pages 133–146, 2018.

The GII-GRIN-SCIE Conference Rating

Explore the GII-GRIN-SCIE (GGS) Conference Rating

Menu

Mirror@www.consorzio-cini.it - Mirror@valutazione.unibas.it - Mirror@gii-grin-scie-rating.scie.es

Search Details Previous Versions

Download **The GGS Conference Rating 2018** (Excel .xlsx file) - last updated: May, 30th 2018

This initiative is sponsored by GII (Group of Italian Professors of Computer Engineering), GRIN (Group of Italian Professors of Computer Science), and SCIE (Spanish Computer-Science Society). For details about the rating algorithm and the process, see the Conference Rating description page.

Search Conferences

Name	ACM Symposium on Applied Comput	Search	Sample: *int*conf*data*
Acronym		Search	Sample: vldb or *ubi*
Class		Search	Sample: 1 or 2 or 3
Rating		Search	Sample: A++ or A+ or A or A- or B or B-
Collected Ratings		Search	Sample: A++, A++, A++ or A+, A, A

Legenda

Class	Ratings	Size	Description
Class 1	A++, A+	32 + 50 = **82 conferences**	excellent, top notch conferenc
Class 2	A, A-	82 + 93 = **175 conferences**	very good events
Class 3	B, B-	205 + 161 = **366 conferences**	events of good quality
-	Work in Progress	2172 conferences	work in progress

Your search returned 1 results.

Title	Acronym	GGS Class	GGS Rating	Qualified Classes	Collected Classes
ACM SYMPOSIUM ON APPLIED COMPUTING	ACM SAC	2	A-	CORE:B, LiveSHINE:A, MA:A	A, A, B

Detailed Ratings (click to expand)

CORE:

Acronym	Title	Class
ACM SAC	ACM Symposium on Applied Computing	B

LiveSHINE:

Acronym	Conference	Class	H-Index	RankH-Index	ClassH-Index	AvgCitations	RankAvgCitations	ClassAvgCitations	Publications	Citations
ACM SAC	ACM Symposium on Applied Computing	A	67	94	A	10,91	411	B-	4089	44610

Microsoft Academic:

Acronym	Conference	Class	FieldRating	RankFieldRating	ClassFieldRating	AvgCitations	RankAvgCitations	ClassAvgCitations	Publications	Citations
ACM SAC	ACM Symposium on Applied Computing	A	117	122	A	12,54	651	B	7433	93243

5.1.2.6. On-premises Serverless Computing for Event-Driven Data Processing Applications

A. Perez, S. Risco, D. M. Naranjo, M. Caballer, and G. Molto, "On-Premises Serverless Computing for Event-Driven Data Processing Applications," in 2019 IEEE 12th International Conference on Cloud Computing (CLOUD), 2019, pp. 414–421, doi: https://10.1109/CLOUD.2019.00073

Base de datos de indexación	GII-GRIN-SCIE
Denominación del congreso	IEEE International Conference on Cloud Computing (CLOUD) 2019
Posición	GGS Class 2, GGS Rating A-

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional (RETOS I+D) BigCLOE (TIN2016-79951-R), liderado por el candidato, y el principal resultado del proyecto EGI Strategic and Innovation Fund, que dió lugar a la integración de la herramienta de código abierto OSCAR – https://github.com/grycap/oscar con la infraestructura Cloud federada Europea, creando un primer prototipo funcional (TRL6). Confiamos en que la evolución de este prototipo hacia TRL 8 permita la integración completa de esto servicio dentro de EGI, al igual que hemos hecho anteriormente con los desarrollos IM y EC3. Dicha evolución se producirá en el marco del proyecto Europeo H2020 AI-SPRINT, que comienza en Enero de 20201, y que utiliza OSCAR como una de las herramientas para soportar la computación basada en funciones para la ejecución de modelos de inteligencia artificial. Se trata de uno de los principales resultados de la Tesis Doctoral de Alfonso Pérez, dirigida por el candidato y ya defendida, donde también contribuyen los doctorandos Sebastián Risco y Diana María Naranjo, dirigido y co-dirigida respectivamente por el candidato.

2019 IEEE 12th International Conference on Cloud Computing (CLOUD)

On-premises Serverless Computing for Event-Driven Data Processing Applications

Alfonso Pérez, Sebastián Risco, Diana María Naranjo, Miguel Caballer, Germán Moltó
Instituto de Instrumentación para Imagen Molecular (I3M).
Centro mixto CSIC - Universitat Politècnica de València
Camino de Vera s/n, 46022 Valencia, España
Email: alpegon3@upv.es, gmolto@dsic.upv.es,{serisgal,dnaranjo,micafer1}@i3m.upv.es

***Abstract*—The advent of open-source serverless computing frameworks has introduced the ability to bring the Functions-as-a-Service (FaaS) paradigm for applications to be executed on-premises. In particular, data-driven scientific applications can benefit from these frameworks with the ability to trigger scalable computation in response to incoming workloads of files to be processed. This paper introduces an open-source framework to achieve on-premises serverless computing for event-driven data processing applications that features: i) the automated provisioning of an elastic Kubernetes cluster that can grow and shrink, in terms of the number of nodes, on multi-Clouds; ii) the automated deployment of a FaaS framework together with a data storage back-end that triggers events upon file uploads; iii) a service that provides a REST API to orchestrate the creation of such functions and iv) a graphical user interface that provides a unified entry point to interact with the aforementioned services. Together, this provides a framework to deploy a computing platform to create highly-parallel event-driven file-processing serverless applications that execute on customized runtime environments provided by Docker containers that run on an elastic Kubernetes cluster. The usefulness of this framework is exemplified by means of the execution of a data-driven workflow for optimised object detection on video. The workflow is tested under three different workloads which process ten, a hundred and a thousand functions. The results show that the presented architecture is able to process such workloads taking advantage of its elasticity to make a sensible usage of the resources.**

***Index Terms*—Cloud Computing; Scientific Computing; Distributed Infrastructures; Containers; Docker;**

I. Introduction

Cloud computing has introduced the ability to provide a wide variety of well-known service models such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS). The increased levels of automation together with the advent of lightweight workload isolation mechanisms introduced by Linux containers paved the way for the rise of the Functions as a Service (FaaS) service model. This approach involves invoking user-defined functions, coded in certain supported programming languages in response to events that are triggered in a computing and data storage infrastructure and that are typically run on a customized execution environment provided by a Linux container. Although sometimes used interchangeably, FaaS typically represents a subset of Serverless computing, a trend based on creating application architectures that entirely rely on Cloud services that provide automated resource provisioning on behalf of (and transparent to) the user. Thus, by not explicitly managing servers, developers can focus on the definition of the application logic instead of devoting time to infrastructure provision, configuration and scalability. The SPEC Cloud Group [1] defines three key features of serverless cloud architectures: i) granular billing: the user is only charged when the application is running; ii) minimal operational logic: the Cloud provider is responsible for resource management and autoscaling and iii) event-driven: short-lived execution of functions in response to events.

Public Cloud providers include in their portfolios services to support FaaS. As an example, Amazon Web Services (AWS) provides AWS Lambda, a service that can run thousands of parallel invocations to user-defined functions in response to multiple sources of events, such as an HTTP request, a file upload to an Amazon S3 bucket (an object-based data store) or a message sent to Amazon SQS, a service to create elastic message queues. Notwithstanding the large elasticity, several important limitations are currently exhibited by AWS Lambda. The maximum execution time is restricted to 15 minutes; the ephemeral storage space available to the invocations of a Lambda function is restricted to 512 MB and, finally, the runtime environments are pre-defined depending on the programming language used to code the Lambda functions.

Previous work from the authors introduced SCAR (Serverless Container-aware ARchitectures) [2] a framework to transparently execute containers out of Docker images in AWS Lambda, in order to run generic applications on that platform (for example image and video manipulation tools such as ImageMagick and FFmpeg or deep learning frameworks such as Theano and Darknet) and code in virtually any programming language (for example Ruby, R, Erlang and Elixir). This allowed to introduce a High Throughput Computing model [3] to create highly-parallel event-driven file-processing serverless applications that execute on customized runtime environments provided by Docker containers run on AWS Lambda. SCAR provided a convenient approach to run generic applications on AWS Lambda and was rapidly adopted by the community

The authors would like to thank the Spanish "Ministerio de Economía, Industria y Competitividad" for the project "BigCLOE" under grant reference TIN2016-79951-R. This development is partially funded by the EGI Strategic and Innovation Fund and by the Primeros Proyectos de Investigación (PAID-06-18), Vicerrectorado de Investigación, Innovación y Transferencia de la Universitat Politècnica de València (UPV), València, Spain.

2159-6190/19/$31.00 ©2019 IEEE
DOI 10.1109/CLOUD.2019.00073

processing applications. First of all, a plugin to enable horizontal scalability of a Kubernetes cluster has been created, in order to cope with incoming workloads by provisioning additional virtual machines from the underlying Cloud computing platform employed. Second, the automated deployment and orchestration of the multiple services required to support this framework is performed with the help of the EC3 and IM tools, including a FaaS framework, an event-aware data storage back-end, and support for building and storing Docker images. Third, an integrated web-based graphical user interface is provided in order to simplify the interaction with the computing platform and that interacts with the services deployed inside the Kubernetes cluster.

Users are provided with an open-source platform offered via a convenient web interface that simplifies the creation and execution of the functions. The users just need to upload their files in order to trigger the concurrent execution of the application. The application will process the uploaded file and leave the output data files in the corresponding folder for the users to retrieve them. Being able to interact with a computing platform without requiring the definition of jobs using complex domain specific languages (DSLs), and by means of a web browser represents a step forward towards simplifying application execution for data-processing applications.

Finally, due to the resource requirements of the Kubernetes infrastructure, the RAM memory and CPU resources of the working nodes could not be completely used. Further work in the infrastructure refining the requirements and the behaviour of the required pods could lead to a better usage of the cluster resources and thus to a higher throughput when processing functions. Also future work involves integrating additional sources of events for multiple scientific storage back-ends such as Onedata or dCache. In addition, we plan to integrate OSCAR with SCAR in order to achieve event-driven hybrid serverless workloads across on-premises and public Clouds.

References

[1] E. van Eyk, A. Iosup, S. Seif, and M. Thömmes, "The SPEC cloud group's research vision on FaaS and serverless architectures," in *Proceedings of the 2nd International Workshop on Serverless Computing - WoSC '17*. New York, New York, USA: ACM Press, 2017, pp. 1–4. [Online]. Available: http://dl.acm.org/citation.cfm?doid=3154847.3154848

[2] A. Pérez, G. Moltó, M. Caballer, and A. Calatrava, "Serverless computing for container-based architectures," *Future Generation Computer Systems*, vol. 83, pp. 50–59, jun 2018. [Online]. Available: http://linkinghub.elsevier.com/retrieve/pii/S0167739X17316485

[3] A. Pérez, G. Moltó, M. Caballer, and A. Calatrava, "A programming model and middleware for high throughput serverless computing applications," in *Proceedings of the 34th ACM/SIGAPP Symposium on Applied Computing*, ser. SAC '19. New York, NY, USA: ACM, 2019, pp. 106–113. [Online]. Available: http://doi.acm.org/10.1145/3297280.3297292

[4] "CNCF Cloud Native Computing Foundation Interactive Landscape." [Online]. Available: http://s.cncf.io

[5] OpenNebula, "OpenNebula." [Online]. Available: https://opennebula.org

[6] OpenStack, "OpenStack." [Online]. Available: http://openstack.org

[7] E. Jonas, Q. Pu, S. Venkataraman, I. Stoica, and B. Recht, "Occupy the cloud: distributed computing for the 99%," in *Proceedings of the 2017 Symposium on Cloud Computing - SoCC '17*. New York, New York, USA: ACM Press, 2017, pp. 445–451. [Online]. Available: http://dl.acm.org/citation.cfm?doid=3127479.3128601

[8] V. Shankar, K. Krauth, Q. Pu, E. Jonas, S. Venkataraman, I. Stoica, B. Recht, and J. Ragan-Kelley, "numpywren: serverless linear algebra," oct 2018. [Online]. Available: https://arxiv.org/abs/1810.09679

[9] J. Spillner, C. Mateos, and D. A. Monge, "Faaster, better, cheaper: the prospect of serverless scientific computing and HPC," in *Communications in Computer and Information Science*, vol. 796. Springer, Cham, 2018, pp. 154–168. [Online]. Available: http://link.springer.com/10.1007/978-3-319-73353-1_11

[10] V. Giménez-Alventosa, G. Moltó, and M. Caballer, "A framework and a performance assessment for serverless MapReduce on AWS Lambda," *Future Generation Computer Systems*, mar 2019. [Online]. Available: https://linkinghub.elsevier.com/retrieve/pii/S0167739X18325172

[11] I. Baldini, P. Cheng, S. J. Fink, N. Mitchell, V. Muthusamy, R. Rabbah, P. Suter, and O. Tardieu, "The serverless trilemma: function composition for serverless computing," in *Proceedings of the 2017 ACM SIGPLAN International Symposium on New Ideas, New Paradigms, and Reflections on Programming and Software - Onward! 2017*. New York, New York, USA: ACM Press, 2017, pp. 89–103. [Online]. Available: http://dl.acm.org/citation.cfm?doid=3133850.3133855

[12] A. Eivy, "Be Wary of the Economics of Serverless Cloud Computing," *IEEE Cloud Computing*, vol. 4, no. 2, pp. 6–12, mar 2017. [Online]. Available: http://ieeexplore.ieee.org/document/7912239/

[13] "OpenFaaS." [Online]. Available: https://www.openfaas.com/

[14] "Knative." [Online]. Available: https://cloud.google.com/knative/

[15] "Kubeless." [Online]. Available: https://kubeless.io/

[16] "Fission." [Online]. Available: https://fission.io/

[17] "Nuclio." [Online]. Available: https://nuclio.io/

[18] S. Hendrickson, S. Sturdevant, T. Harter, V. Venkataramani, A. C. Arpaci-Dusseau, and R. H. Arpaci-Dusseau, "Serverless Computation with openLambda," in *Proceedings of the 8th USENIX Conference on Hot Topics in Cloud Computing*. USENIX Association, 2016, pp. 33–39. [Online]. Available: https://dl.acm.org/citation.cfm?id=3027047

[19] I. Baldini, P. Castro, K. Chang, P. Cheng, S. Fink, V. Ishakian, N. Mitchell, V. Muthusamy, R. Rabbah, A. Slominski, and P. Suter, "Serverless computing: Current trends and open problems," in *Research Advances in Cloud Computing*. Singapore: Springer Singapore, 2017, pp. 1–20. [Online]. Available: http://link.springer.com/10.1007/978-981-10-5026-8_1

[20] M. Caballer, I. Blanquer, G. Moltó, and C. de Alfonso, "Dynamic Management of Virtual Infrastructures," *Journal of Grid Computing*, vol. 13, no. 1, pp. 53–70, mar 2015. [Online]. Available: http://link.springer.com/article/10.1007/s10723-014-9296-5

[21] "RADL." [Online]. Available: https://imdocs.readthedocs.io/en/latest/radl.html

[22] D. Palma, M. Rutkowski, and T. Spatzier, "TOSCA Simple Profile in YAML Version 1.1," Tech. Rep., 2016. [Online]. Available: http://docs.oasis-open.org/tosca/TOSCA-Simple-Profile-YAML/v1.1/TOSCA-Simple-Profile-YAML-v1.1.html

[23] C. de Alfonso, M. Caballer, A. Calatrava, G. Moltó, and I. Blanquer, "Multi-elastic Datacenters: Auto-scaled Virtual Clusters on Energy-Aware Physical Infrastructures," *Journal of Grid Computing*, jul 2018. [Online]. Available: http://link.springer.com/10.1007/s10723-018-9449-z

[24] M. Caballer, C. de Alfonso, F. Alvarruiz, and G. Moltó, "EC3: Elastic Cloud Computing Cluster," *Journal of Computer and System Sciences*, vol. 79, no. 8, pp. 1341–1351, dec 2013. [Online]. Available: http://authors.elsevier.com/sd/article/S0022000013001141

[25] A. Calatrava, E. Romero, G. Moltó, M. Caballer, and J. M. Alonso, "Self-managed cost-efficient virtual elastic clusters on hybrid Cloud infrastructures," *Future Generation Computer Systems*, vol. 61, pp. 13–25, aug 2016. [Online]. Available: http://authors.elsevier.com/sd/article/S0167739X16300024

[26] E. Fernández-Del-Castillo, D. Scardaci, and Á. L. García, "The EGI Federated Cloud e-Infrastructure," in *Procedia Computer Science*, vol. 68. Elsevier, jan 2015, pp. 196–205. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S187705091503080X

[27] E. Foundation, "EGI Federated Cloud." [Online]. Available: https://www.egi.eu/federation/egi-federated-cloud/

[28] J. Redmon and A. Farhadi, "Yolov3: An incremental improvement," *arXiv*, 2018. [Online]. Available: https://arxiv.org/abs/1804.02767

The GII-GRIN-SCIE Conference Rating

Explore the GII-GRIN-SCIE (GGS) Conference Rating

Menu

Mirror@www.consorzio-cini.it - Mirror@valutazione.unibas.it - Mirror@gii-grin-scie-rating.scie.es

Search Details Previous Versions

Download **The GGS Conference Rating 2018** (Excel .xlsx file) - last updated: May, 30th 2018

This initiative is sponsored by GII (Group of Italian Professors of Computer Engineering), GRIN (Group of Italian Professors of Computer Science), and SCIE (Spanish Computer-Science Society). For details about the rating algorithm and the process, see the Conference Rating description page.

Search Conferences

Name		Search	Sample: *int*conf*data*
Acronym	Cloud	Search	Sample: vldb or *ubi*
Class		Search	Sample: 1 or 2 or 3
Rating		Search	Sample: A++ or A+ or A or A- or B or B-
Collected Ratings		Search	Sample: A++, A++, A++ or A+, A, A

Legenda

Class	Ratings	Size	Description
Class 1	A++, A+	32 + 50 = **82 conferences**	excellent, top notch conferenc
Class 2	A, A-	82 + 93 = **175 conferences**	very good events
Class 3	B, B-	205 + 161 = **366 conferences**	events of good quality
-	Work in Progress	2172 conferences	work in progress

Your search returned 1 results.

Title	Acronym	GGS Class	GGS Rating	Qualified Classes	Collected Classes
IEEE INTERNATIONAL CONFERENCE ON CLOUD COMPUTING	CLOUD	2	A-	CORE:B, LiveSHINE:A, MA:A-	A, A-, B

Detailed Ratings (click to expand)

CORE:

Acronym	Title	Class
CLOUD	IEEE International Conference on Cloud Computing	B

LiveSHINE:

Acronym	Conference	Class	H-Index	RankH-Index	ClassH-Index	AvgCitations	RankAvgCitations	ClassAvgCitations	Publications	Citations
CLOUD	IEEE International Conference on Cloud Computing	A	62	113	A	20,8	171	A	757	15748

Microsoft Academic:

Acronym	Conference	Class	FieldRating	RankFieldRating	ClassFieldRating	AvgCitations	RankAvgCitations	ClassAvgCitations	Publications	Citations
CLOUD	International Conference on Cloud Computing	A-	88	216	A-	9,03	883	C	3636	32828

5.1.2.7. APRICOT: Advanced Platform for Reproducible Infrastructures in the Cloud via Open Tools

V. Giménez-Alventosa, J. D. Segrelles, G. Moltó, and M. Roca-Sogorb, "APRICOT: Advanced Platform for Reproducible Infrastructures in the Cloud via Open Tools," Methods Inf. Med., vol. 59, no. S 02, pp. e33–e45, Dec. 2020, doi: https://10.1055/s-0040-1712460

Base de datos de indexación	Web of Science / JCR
Índice de impacto	1.574
Año	2015
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	115 de 156
Tercil	T3
Cuartil	Q3
Número de citas en JCR	0
Número de citas totales	0

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional (RETOS I+D) BigCLOE (TIN2016-79951-R), liderado por el candidato y es uno de los resultados obtenidos durante la realización de la Tesis Doctoral de Vicent Giménez, donde se crea una plataforma para facilitar el despliegue determinista de infraestructura computacional para facilitar la reproducibilidad de experimentos computacionales. También se trata de un resultado del proyecto Europeo H2020 PRIMAGE, de donde se obtiene el caso de uso. La plataforma se liberó como código abierto en GitHub, disponible en https://github.com/grycap/apricot.

Published online: 2020-08-10

Original Article

APRICOT: Advanced Platform for Reproducible Infrastructures in the Cloud via Open Tools

Vicent Giménez-Alventosa[1] José Damián Segrelles[1] Germán Moltó[1] Mar Roca-Sogorb[2]

[1] Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC—Universitat Politècnica de València, Valencia, Spain
[2] Quantitative Imaging Biomarkers in Medicine (QUIBIM), Valencia, Spain

Address for correspondence Vicent Giménez-Alventosa, Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC—Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain (e-mail: vicent.gimenez@i3m.upv.es).

Methods Inf Med

Abstract

Background Scientific publications are meant to exchange knowledge among researchers but the inability to properly reproduce computational experiments limits the quality of scientific research. Furthermore, bibliography shows that irreproducible preclinical research exceeds 50%, which produces a huge waste of resources on nonprofitable research at Life Sciences field. As a consequence, scientific reproducibility is being fostered to promote Open Science through open databases and software tools that are typically deployed on existing computational resources. However, some computational experiments require complex virtual infrastructures, such as elastic clusters of PCs, that can be dynamically provided from multiple clouds. Obtaining these infrastructures requires not only an infrastructure provider, but also advanced knowledge in the cloud computing field.

Objectives The main aim of this paper is to improve reproducibility in life sciences to produce better and more cost-effective research. For that purpose, our intention is to simplify the infrastructure usage and deployment for researchers.

Methods This paper introduces Advanced Platform for Reproducible Infrastructures in the Cloud via Open Tools (APRICOT), an open source extension for Jupyter to deploy deterministic virtual infrastructures across multiclouds for reproducible scientific computational experiments. To exemplify its utilization and how APRICOT can improve the reproduction of experiments with complex computation requirements, two examples in the field of life sciences are provided. All requirements to reproduce both experiments are disclosed within APRICOT and, therefore, can be reproduced by the users.

Results To show the capabilities of APRICOT, we have processed a real magnetic resonance image to accurately characterize a prostate cancer using a Message Passing Interface cluster deployed automatically with APRICOT. In addition, the second example shows how APRICOT scales the deployed infrastructure, according to the workload, using a batch cluster. This example consists of a multiparametric study of a positron emission tomography image reconstruction.

Conclusion APRICOT's benefits are the integration of specific infrastructure deployment, the management and usage for Open Science, making experiments that involve specific computational infrastructures reproducible. All the experiment steps and details can be documented at the same Jupyter notebook which includes infrastructure

Keywords
- reproducible science
- life science
- cloud computing
- elasticity

received
February 13, 2020
accepted after revision
April 9, 2020

DOI https://doi.org/10.1055/s-0040-1712460.
ISSN 0026-1270.

specifications, data storage, experimentation execution, results gathering, and infrastructure termination. Thus, distributing the experimentation notebook and needed data should be enough to reproduce the experiment.

Introduction

Scientific publications are intended to share knowledge to be used by other researchers on their experiments. However, most publications do not provide the necessary information to verify and reproduce its results.[1] Moreover, Freedman et al[2] claims that "the cumulative prevalence of irreproducible preclinical research exceeds 50%," and Baker[3] shows that more than 90% of researchers consider that a reproducibility crisis exists in scientific publications. Nonreproducible science specially affects Life Sciences research, since these results should not be reused unless they can be trusted to avoid consequences on people's health. This results in a huge waste of resources on nonprofitable research.[2]

As a result, scientific reproducibility has lately become a topic of interest for researchers and institutions which defend an open and reproducible science model. This aims at solving two old problems in scientific research: nonreproducible investigation and fraud. With that purpose, the European Commission introduced Open Science to "promote a new approach to the scientific process based on cooperative work and new ways of diffusing knowledge by using digital technologies and new collaborative tools."[4] In fact, European institutions consider that Open Science is a necessary factor for future research programs. In 2015, the EU Commission set three main goals for future research in the EU: Open Science, Open Innovation, and Open to the world.[4,5] To promote these goals, the EU is promoting the European Open Science Cloud (EOSC), which "aims to create a trusted environment for hosting and processing research data to support EU science in its global leading role."[6] Open Science is not only a European objective, but also for institutions around the world. For example, in the United States, several institutions promote initiatives for Open Science, like the "Berkeley Initiative for Transparency in the Social Sciences,"[7] the Public Library of Science,[8] and the "Center for Open Science."[9]

We focus in this contribution on the reproducibility of computational experiments, where the two basic components required are *data storage* and *computing infrastructure*. The former, data storage, provides a place to store the experiment input, intermediate, and resulting data, analysis code and software, documentation, etc. The latter, computing infrastructure, is where calculations are performed according to the software and hardware requirements. This requires access to some local or external storage to stage in the required data for experimentation.

A general computational experiment workflow is represented in ►**Fig. 1**, where the *input data production* can be experimentally measured or simulated data, configuration values for simulations, input data files, etc. Then, the *data*

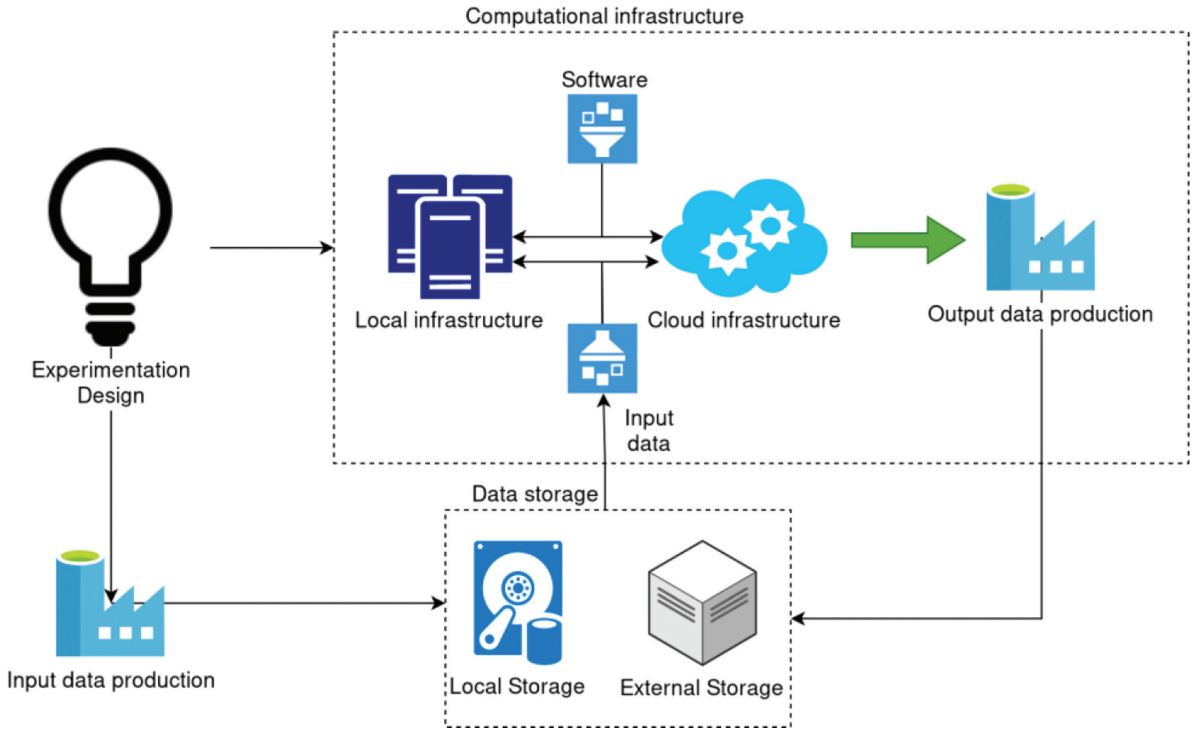


Fig. 1 Computational experimentation components.

knowledge on infrastructure deployment and configuration. Without APRICOT, a researcher would need to deploy and configure the required infrastructure or have access to an existing one with compatible specifications.

At the moment, APRICOT offers a limited amount of preconfigured infrastructure types that may not fit all experiments need, but more configurations will be added in future versions. In addition, the user needs access credentials to a cloud provider supported by APRICOT.

Notice that the whole experiments have been documented in the corresponding Jupyter notebooks including the commands to execute, the required infrastructure, the data processing, the visualization, etc. The notebooks have been distributed in the aforementioned GitHub repository.

Conclusion

This paper has introduced APRICOT, an open source extension for Jupyter that provides users with the ability to deploy complex customized virtual infrastructures across multiple cloud providers to support the requirements of computational experiments. A set of functions have been created to simplify interaction with the virtual infrastructure for data staging as well as application execution. This facilitates the reproducibility of computational experiments on clouds.

The benefits of this extension are the integration of specific infrastructure deployment, the management, and usage for Open Science and making experiments that involve specific computational infrastructures reproducible. All the experiment steps and details can be documented at the same Jupyter notebook which includes infrastructure specifications, data storage, experimentation execution, results gathering, and infrastructure termination. Thus, distributing the experimentation notebook and the needed data should be enough to reproduce the experiment.

Future works include extending APRICOT to use additional cloud providers already compatible with the IM. Also, in addition to MPI and batch clusters we plan to add more preconfigured infrastructure topologies such as Kubernetes clusters. Regarding the infrastructure usage, we will provide more *magic commands* to simplify the execution of other kind of analysis. These are special Jupyter functions that can be executed regardless of the programming language used at the notebook. Integration of additional queue systems and external storage providers will also expand the adoption of the platform by covering different use cases.

Funding

This study was supported by the program "Ayudas para la contratación de personal investigador en formación de carácter predoctoral, programa VALi + d" under grant number ACIF/2018/148 from the Conselleria d'Educació of the Generalitat Valenciana and the "Fondo Social Europeo" (FSE). The authors would like to thank the Spanish "Ministerio de Economía, Industria y Competitividad" for the project "BigCLOE" with reference number TIN2016–79951-R and the European Commission, Horizon 2020 grant agreement No 826494 (PRIMAGE). The MRI prostate study case used in this article has been retrospectively collected from a project of prostate MRI biomarkers validation.

Conflict of Interest

None declared.

References

1 Donoho DL, Maleki A, Rahman IU, Shahram M, Stodden V. Reproducible research in computational harmonic analysis. Comput Sci Eng 2009;11(01):8–18
2 Freedman LP, Cockburn IM, Simcoe TS. The economics of reproducibility in preclinical research. PLoS Biol 2015;13(06):e1002165
3 Baker M. Is there a reproducibility crisis? A nature survey lifts the lid on how researchers view the 'crisis' rocking science and what they think will help. Nature 2016;533(7604):452–455
4 European Commission. Open Innovation Open Science Open to the World. European Commission; 2016
5 Goals of research and innovation policy. European Commission. Available at: https://ec.europa.eu/info/research-and-innovation/strategy/goals-research-and-innovation-policy. Accessed March 5, 2019
6 European Open Science Cloud (EOSC). European Commission. Available at: https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-cloud. Accessed March 5, 2019
7 BITSS. Available at: https://www.bitss.org/. Accessed December 5, 2019
8 Public Library of Science. Available at: https://www.plos.org/. Accessed December 5, 2019
9 COS. Available at: https://cos.io/. Accessed December 5, 2019
10 Onedata. Available at: https://onedata.org/#/home. Accessed March 5, 2019
11 Chillarón M, Vidal V, Verdú G. CT image reconstruction with suite sparse QR factorization package. Radiat Phys Chem 2020;167:108289
12 Reader AJ, Ally S, Bakatselos F, et al. One-pass list-mode em algorithm for high-resolution 3-d pet image reconstruction into large arrays. IEEE Trans Nucl Sci 2002;49:693–699
13 Giménez-Alventosa V, Antunes PC, Vijande J, Ballester F, Pérez-Calatayud J, Andreo P. Collision-kerma conversion between dose-to-tissue and dose-to-water by photon energy-fluence corrections in low-energy brachytherapy. Phys Med Biol 2017;62(01):146–164
14 Wilkinson MD, Dumontier M, Aalbersberg IJ, et al. The FAIR guiding principles for scientific data management and stewardship. Sci Data 2016;3:160018
15 RunMyCode.org. Available at: http://www.runmycode.org/. Accessed March 5, 2019
16 CodeOcean. Available at: https://codeocean.com/. Accessed December 5, 2019
17 Ipol. Available at: https://www.ipol.im/. Accessed March 5, 2019
18 Nüst D, Konkol M, Schutzeichel M, et al. Opening the publication process with executable research compendia. Dlib Mag 2017;23(1/2):1082–9873
19 Kluyver T, Ragan-Kelley B, Pérez F, et al. Jupyter notebooks—a publishing format for reproducible computational workflows. Concurr Comput 2016
20 Galaxy. Available at: https://galaxyproject.org. Accessed: March 5, 2019
21 Calatrava A, Romero E, Caballer M, Moltó G, Alonso JM. Self-managed cost-efficient virtual elastic clusters on hybrid cloud infrastructures. Future Gener Comput Syst 2016;61:13–25
22 Caballer M, Blanquer I, Moltó G, de Alfonso C. Dynamic management of virtual infrastructures. J Grid Comput 2015;13:53–70
23 Open Science Framework. Available at: https://osf.io. Accessed: March 5, 2019
24 Wolstencroft K, Owen S, Krebs O, et al. SEEK: a systems biology data and model management platform. BMC Syst Biol 2015;9(01):33

25 REANA. Available at: http://www.reanahub.io/. Accessed November 4, 2019
26 Stencila. Available at: https://stenci.la. Accessed March 5, 2019
27 de Alfonso C, Caballer M, Calatrava A, Moltó G, Blanquer I. Multi-elastic datacenters: auto-scaled virtual clusters on energy-aware physical infrastructures. J Grid Comput 2019;17(01): 191–204
28 EOSC portal. Available at: https://marketplace.eosc-portal.eu/services/. Accessed October 30, 2019
29 Ansible. Available at: https://www.ansible.com. Accessed April 4, 2019
30 OpenNebula. Available at: https://opennebula.org/. Accessed: May 17, 2019
31 Rawla P. Epidemiology of prostate cancer. World J Oncol 2019;10 (02):63–89
32 Wu X, Reinikainen P, Kapanen M, Vierikko T, Ryymin P, Kellokumpu-Lehtinen PL. Dynamic contrast-enhanced imaging as a prognostic tool in early diagnosis of prostate cancer: correlation with PSA and clinical stage. Contrast Media Mol Imaging 2018; 2018:3181258
33 Bratan F, Niaf E, Melodelima C, et al. Influence of imaging and histological factors on prostate cancer detection and localisation on multiparametric MRI: a prospective study. Eur Radiol 2013;23 (07):2019–2029
34 Le JD, Tan N, Shkolyar E, et al. Multifocality and prostate cancer detection by multiparametric magnetic resonance imaging: correlation with whole-mount histopathology. Eur Urol 2015;67 (03):569–576
35 Kety SS. The theory and applications of the exchange of inert gas at the lungs and tissues. Pharmacol Rev 1951;3(01):1–41
36 Tofts PS, Wicks DA, Barker GJ. The MRI measurement of NMR and physiological parameters in tissue to study disease process. Prog Clin Biol Res 1991;363:313–325
37 Brix G, Semmler W, Port R, Schad LR, Layer G, Lorenz WJ. Pharmacokinetic parameters in CNS Gd-DTPA enhanced MR imaging. J Comput Assist Tomogr 1991;15(04):621–628
38 Larsson HBW, Stubgaard M, Frederiksen JL, Jensen M, Henriksen O, Paulson OB. Quantitation of blood-brain barrier defect by magnetic resonance imaging and gadolinium-DTPA in patients with multiple sclerosis and brain tumors. Magn Reson Med 1990; 16(01):117–131
39 Tofts PS, Kermode AG. Measurement of the blood-brain barrier permeability and leakage space using dynamic MR imaging. 1. Fundamental concepts. Magn Reson Med 1991;17(02):357–367
40 Donahue KM, Weisskoff RM, Burstein D. Water diffusion and exchange as they influence contrast enhancement. J Magn Reson Imaging 1997;7(01):102–110
41 Flouri D, Lesnic D, Sourbron SP. Fitting the two-compartment model in DCE-MRI by linear inversion. Magn Reson Med 2016;76 (03):998–1006
42 Rene Brun and Fons Rademakers. Root—an object oriented data analysis framework. Nucl Instrum Methods Phys Res A 1997;389 (1–2):81–86
43 Liu X, Comtat C, Michel C, Kinahan P, Defrise M, Townsend D. Comparison of 3-d reconstruction with 3D-OSEM and with fore+OSEM for pet. IEEE Trans Med Imaging 2001;20(08): 804–814
44 Singh S, Kalra MK, Hsieh J, et al. Abdominal CT: comparison of adaptive statistical iterative and filtered back projection reconstruction techniques. Radiology 2010;257(02):373–383
45 Shepp LA, Vardi Y. Maximum likelihood reconstruction for emission tomography. IEEE Trans Med Imaging 1982;1(02): 113–122
46 Goo JM, Tongdee T, Tongdee R, Yeo K, Hildebolt CF, Bae KT. Volumetric measurement of synthetic lung nodules with multidetector row CT: effect of various image reconstruction parameters and segmentation thresholds on measurement accuracy. Radiology 2005;235(03):850–856
47 Ravenel JG, Leue WM, Nietert PJ, Miller JV, Taylor KK, Silvestri GA. Pulmonary nodule volume: effects of reconstruction parameters on automated measurements—a phantom study. Radiology 2008; 247(02):400–408
48 Hu Y-H, Zhao B, Zhao W. Image artifacts in digital breast tomosynthesis: investigation of the effects of system geometry and reconstruction parameters using a linear system approach. Med Phys 2008;35(12):5242–5252
49 Lyra M, Ploussi A. Filtering in SPECT image reconstruction. Int J Biomed Imaging 2011;2011:693795
50 Salvat F, Fernández-Varea JM, Sempau J. Penelope. A Code System for Monte Carlo Simulation of Electron and Photon Transport. Issy-Les-Moulineaux: OECD Nuclear Energy Agency; 2014

5.1.2.8. Towards Migratable Elastic Virtual Clusters on Hybrid Clouds

A. Calatrava, G. Molto, E. Romero, M. Caballer, and C. de Alfonso, "Towards Migratable Elastic Virtual Clusters on Hybrid Clouds," in 2015 IEEE 8th International Conference on Cloud Computing, 2015, pp. 1013–1016, doi: https://10.1109/CLOUD.2015.139.

Base de datos de indexación	GII-GRIN-SCIE
Denominación del congreso	IEEE International Conference on Cloud Computing (CLOUD) 2015
Posición	GGS Class 2, GGS Rating A-

Comentario. Esta contribución es uno de los resultados del proyecto de Plan Nacional (RETOS I+D) CLUVIEM (TIN2013-44390-R-AR) y supone la evolución de la herramienta de código abierto EC3 (www.grycap.upv.es/ec3) para el despliegue de clusters elásticos, con el objetivo de soportar clusters migrables entre infraestructuras Cloud. El congreso IEEE Cloud está catalogado como GGS Class 2 y como GGS Rating A- dentro del índice GII-GRIN-SCIE.

2015 IEEE 8th International Conference on Cloud Computing

Towards Migratable Elastic Virtual Clusters on Hybrid Clouds

Amanda Calatrava, Germán Moltó, Eloy Romero, Miguel Caballer, Carlos de Alfonso
Instituto de Instrumentación para Imagen Molecular (I3M).
Centro mixto CSIC - Universitat Politècnica de València - CIEMAT
Camino de Vera s/n, 46022 Valencia, España
Email: {amcaar,elroal,micafer1,caralla}@i3m.upv.es
,gmolto@dsic.upv.es

***Abstract*—This paper describes the research work in the context of the CLUVIEM project towards achieving migratable, self-managed virtual elastic clusters on hybrid Cloud infrastructures. These virtual clusters can span across on-premises and public Cloud infrastructures thus leveraging hybrid Cloud platforms. They are elastic since working nodes are automatically provisioned and relinquished to dynamically adapt the capacity of the virtual cluster (in terms of number of nodes) according to the current workload. They are self-managed since the elasticity rules are managed via the head node without requiring any external software entity for monitoring and deciding when to scale in and out. Finally, they are migratable since they consider both application migration, via application checkpointing, and infrastructure migration, by cloning infrastructures across multi-Clouds. These features introduce unprecedented flexibility for cost-effective cluster-based computing with minimal impact for cluster users. The paper summarises the current state of developments and future roads to achieve this vision.**

***Keywords*-Cloud computing; High Performance Computing; Virtualization; Elasticity;**

I. Introduction

Clusters are one of the most widely used computing facilities across the world. They can be used for High Performance Computing (HPC), where tightly-coupled tasks require intensive communication, and for High Throughput Computing (HTC), where loosely-coupled tasks are typically executed as a Bag of Tasks (BoT) or a parameter sweep application. However, physical clusters suffer from several drawbacks which include, but are not limited to, an initial large capital investment, electricity costs for operation and refrigeration and the inability to cost-effectively enlarge and decrease the number of nodes according to the workload.

With the introduction of virtualization and the advent of Cloud Computing, the idea of deploying virtual clusters on computational resources provisioned from Cloud infrastructures took shape in the form of tools such as StarCluster [1] or Elasticluster [2]. StarCluster enables to provision a virtual cluster on top of Amazon Web Services (AWS). It also supports to automatically scale out the cluster (and scale in) considering the number of jobs queued up at the LRMS (Local Resource Management System). However, since this tool can only provision clusters from AWS, no virtual clusters can be deployed on on-premises Cloud platforms created with Cloud Management Platforms (CMPs) such as OpenNebula or OpenStack. In addition, the scaling capabilities of the virtual cluster require a client-side monitoring application that is always running and periodically polls the cluster. Therefore, the cluster is not self-managed and requires the StarCluster application running on the client side. In contrast, Elasticluster can be employed to create virtual clusters on several Cloud providers (Amazon EC2 and Google Compute Engine) as well as on-premises Cloud platforms (OpenStack supported). The clusters support elasticity but, unfortunately, the user decides when to scale the cluster by using the appropriate command. Therefore no automated elasticity is supported.

Other tools to deploy virtual clusters can be found in the literature, such as Wrangler [3] or the work by Niu et al. [4]. The former does not support elasticity while the latter, although it does include elasticity rules to scale the clusters, it does not consider support for *spot instances*, which is a cost-effective mechanism to provision computational resources for interruptible tasks, supported by Amazon EC2. In addition, none of the aforementioned tools support hybrid virtual clusters, where resources can span several Clouds (either on-premises or public).

In this paper we build on the state of the art and describe the goals, the road map and the milestones achieved so far in the CLUVIEM project. The project, funded by the Spanish government, aims at developing software (accessible via SaaS and CLI) to create migratable self-managed cost-effective virtual elastic clusters on hybrid Cloud infrastructures which, for the sake of brevity, will be named enhanced virtual clusters. After the introduction, the remainder of the paper is structured as follows. First, section II introduces the main architecture of the platform to be developed featuring capabilities such as automated elasticity, hybrid scenarios and migration. Next, section III addresses different scenarios in which these virtual clusters introduce significant benefits. Finally, section IV summarizes the paper and points to future work.

2159-6190/15 $31.00 © 2015 IEEE
DOI 10.1109/CLOUD.2015.139

coordinated by the Migration Manager (MM). Since clusters are created out of a high level language called RADL (Resource Application and Description Language; see [7] for details) it is possible to replicate the infrastructure into another Cloud provider by using the multi-Cloud capabilities of the IM. This involves deploying a new infrastructure with the same characteristics in another Cloud back-end. Transitioning from a physical cluster to a virtual one requires abstracting its hardware, software and data configuration to be expressed in RADL, what we intend to provide in a semi-automatic way but it is currently under research.

Second, the migration of running applications requires the introduction of application-independent checkpointing techniques in order to be able to resume a running application on the target virtual machine instance. For that purpose we have been using BLCR (Berkeley Lab Checkpoint/Restart for LINUX), a tool that introduces checkpoint capabilities both for sequential and parallel applications based on MPI. We use checkpointing both for migration of applications and as an application survival mechanism when using spot instances in Amazon EC2. A spot instance can be terminated if its price exceeds the bid of the user. For that, we developed a Checkpoint Manager that interacts with the SLURM LRMS supporting BLCR in order to checkpoint the jobs both at periodic interval and considering the evolution of the prices of the spot instances. This way, interrupted jobs can be resumed in newly deployed instances, which may be on a different Cloud (with the same virtual hardware).

Migrating workloads, such as independent jobs that arise from Hight Throughput Computing, can be efficiently achieved by deploying hybrid virtual clusters that dynamically remove and add nodes, from different Clouds, that are activated/deactivated from the LRMS so that jobs can be balanced across the working nodes without any user intervention, as performed in [6].

III. Discussion and Application Scenarios

These enhanced virtual clusters can be employed for many applications in which cost-effective cluster-based computing is required. In particular, we are focusing on the following scenarios. First, the non-linear and dynamic structural analysis of buildings, where it is required to accurately simulate how a building is affected by external dynamic loads, such as an earthquake. This involves a parallel MPI-based applications. Second, the execution of Monte-Carlo simulations to describe the trajectories of particles used in radiotherapy dosimetry and PET devices. Finally, the deployment of virtual clusters as educational infrastructures for HPC-related subjects in Master's Degree.

IV. Conclusion

This paper has summarised the developments towards self-managed cost-effective elastic virtual clusters on hybrid Cloud infrastructures. So far, the developments of this vision are based on the open source EC3[2] tool, which enables to provision virtual hybrid elastic clusters that span public Clouds (AWS and Google Compute Engine) and on-premises CMPs (OpenNebula, OpenStack and any other OCCI-compliant software), featuring checkpointing capabilities and spot instances support. Supporting OCCI enables the user to provision resources from EGI FedCloud, one of the largest scientific computing platforms. We have released an early version of this tool to the academic community together with the main underlying software components.

We expect to continue our early developments on migration of infrastructures and applications, which will introduce unprecedented flexibility for cluster-based computing.

Acknowledgments

AC would like to thank the program "Ayudas para la contratación de personal investigador en formación de carcter predoctoral, programa VALi+d", grant number ACIF/2013/003, from the Conselleria d'Educació of the Generalitat Valenciana. Also, the authors would like to thank the Spanish "Ministerio de Economía y Competitividad" for the CLUVIEM project with reference TIN2013-44390-R.

References

[1] MIT, "StarCluster." [Online]. Available: http://web.mit.edu/stardev/cluster/

[2] U. of Zurich, "Elasticluster." [Online]. Available: http://gc3-uzh-ch.github.io/elasticluster/

[3] G. Juve and E. Deelman, "Wrangler: Virtual Cluster Provisioning for the Cloud," in *Proceedings of the 20th international symposium on High performance distributed computing - HPDC '11*. New York, New York, USA: ACM Press, Jun. 2011, p. 277. [Online]. Available: http://dl.acm.org/citation.cfm?id=1996130.1996173

[4] S. Niu, J. Zhai, X. Ma, X. Tang, and W. Chen, "Cost-effective cloud HPC resource provisioning by building semi-elastic virtual clusters," in *Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis on - SC '13*. New York, New York, USA: ACM Press, Nov. 2013, pp. 1–12. [Online]. Available: http://dl.acm.org/citation.cfm?id=2503210.2503236

[5] G. Moltó, M. Caballer, E. Romero, and C. de Alfonso, "Elastic Memory Management of Virtualized Infrastructures for Applications with Dynamic Memory Requirements," in *Proceedings of the International Conference on Computational Science (ICCS 2013)*. Elsevier, 2013, pp. 159–168.

[6] A. Calatrava, G. Moltó, M. Caballer, and C. D. Alfonso, "Virtual Hybrid Elastic Clusters in the Cloud," in *8th Iberian Grid Infrastructure Conference (IberGrid 2014)*, 2014, pp. 103–114.

[7] M. Caballer, I. Blanquer, G. Moltó, and C. de Alfonso, "Dynamic management of virtual infrastructures," *Journal of Grid Computing*, 2014. [Online]. Available: http://link.springer.com/article/10.1007/s10723-014-9296-5

[2]EC3 - http://www.grycap.upv.es/ec3

The GII-GRIN-SCIE Conference Rating

Explore the GII-GRIN-SCIE (GGS) Conference Rating

Menu

Mirror@www.consorzio-cini.it - Mirror@valutazione.unibas.it - Mirror@gii-grin-scie-rating.scie.es

Search Details Previous Versions

Download **The GGS Conference Rating 2018** (Excel .xlsx file) - last updated: May, 30th 2018

This initiative is sponsored by GII (Group of Italian Professors of Computer Engineering), GRIN (Group of Italian Professors of Computer Science), and SCIE (Spanish Computer-Science Society). For details about the rating algorithm and the process, see the Conference Rating description page.

Search Conferences

Name		Search	Sample: *int*conf*data*
Acronym	Cloud	Search	Sample: vldb or *ubi*
Class		Search	Sample: 1 or 2 or 3
Rating		Search	Sample: A++ or A+ or A or A- or B or B-
Collected Ratings		Search	Sample: A++, A++, A++ or A+, A, A

Legenda

Class	Ratings	Size	Description
Class 1	A++, A+	32 + 50 = **82 conferences**	excellent, top notch conferenc
Class 2	A, A-	82 + 93 = **175 conferences**	very good events
Class 3	B, B-	205 + 161 = **366 conferences**	events of good quality
-	Work in Progress	2172 conferences	work in progress

Your search returned 1 results.

Title	Acronym	GGS Class	GGS Rating	Qualified Classes	Collected Classes
IEEE INTERNATIONAL CONFERENCE ON CLOUD COMPUTING	CLOUD	2	A-	CORE:B, LiveSHINE:A, MA:A-	A, A-, B

Detailed Ratings (click to expand)

CORE:

Acronym	Title	Class
CLOUD	IEEE International Conference on Cloud Computing	B

LiveSHINE:

Acronym	Conference	Class	H-Index	RankH-Index	ClassH-Index	AvgCitations	RankAvgCitations	ClassAvgCitations	Publications	Citations
CLOUD	IEEE International Conference on Cloud Computing	A	62	113	A	20,8	171	A	757	15748

Microsoft Academic:

Acronym	Conference	Class	FieldRating	RankFieldRating	ClassFieldRating	AvgCitations	RankAvgCitations	ClassAvgCitations	Publications	Citations
CLOUD	International Conference on Cloud Computing	A-	88	216	A-	9,03	883	C	3636	32828

5.1.2.9. A Serverless Gateway for Event-driven Machine Learning Inference in Multiple Clouds

D. M. Naranjo, S. Risco, G. Moltó, and I. Blanquer, "A serverless gateway for event-driven machine learning inference in multiple clouds," Concurr. Comput. Pract. Exp., Dec. 2021, doi: https://10.1002/cpe.6728

Received: 26 April 2021 | Revised: 1 September 2021 | Accepted: 13 October 2021
DOI: 10.1002/cpe.6728

SPECIAL ISSUE PAPER

WILEY

A serverless gateway for event-driven machine learning inference in multiple clouds

Diana M. Naranjo | **Sebastián Risco** | **Germán Moltó** | **Ignacio Blanquer**

Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC - Universitat Politècnica de València, Valencia, Spain

Correspondence
Diana M. Naranjo, Instituto de Instrumentación para Imagen Molecular (I3M), Centro mixto CSIC - Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain.
Email: dnaranjo@i3m.upv.es

Funding information
AI-SPRINT "Artificial Intelligence in Secure PRIvacy-preserving computing coN- Tinuum", Grant/Award Number: 101016577; DEEP-Hybrid-DataCloud "Designing and Enabling E-infrastructures for intensive Processing in a Hybrid DataCloud", Grant/Award Number: 777435; SERCLOCO, Grant/Award Numbers: MCIN/AEI/10.13039/501100011033, PID2020-113126RB-I00

Abstract

Serverless computing and, in particular, the functions as a service model has become a convincing paradigm for the development and implementation of highly scalable applications in the cloud. This is due to the transparent management of three key functionalities: triggering of functions due to events, automatic provisioning and scalability of resources, and fine-grained pay-per-use. This article presents a serverless web-based scientific gateway to execute the inference phase of previously trained machine learning and artificial intelligence models. The execution of the models is performed both in Amazon Web Services and in on-premises clouds with the OSCAR framework for serverless scientific computing. In both cases, the computing infrastructure grows elastically according to the demand adopting scale-to-zero approaches to minimize costs. The web interface provides an improved user experience by simplifying the use of the models. The usage of machine learning in a computing platform that can use both on-premises clouds and public clouds constitutes a step forward in the adoption of serverless computing for scientific applications.

KEYWORDS

cloud computing, function as a service, machine learning, serverless computing

1 | INTRODUCTION

The development of cloud computing has introduced a series of service models that provide various abstraction layers with different levels of control. Common service models are IaaS (Infrastructure as a Service), PaaS (Platform as a Service), SaaS (Software as a Service), and FaaS (Functions as a Service).

The FaaS model is a part of serverless computing, which also includes the BaaS (Backend as a Service) category. It is considered an evolution of cloud programming models, with a higher level of abstraction, where the cloud provider dynamically manages the provisioning of resources. Serverless computing, and particularly the FaaS model, has become a paradigm for the deployment of applications in the cloud, primarily because of the advantages it provides to developers with respect to the adoption of containers and microservices-based architectures.[1] Indeed, one of the fundamental challenges in the transition to serverless computing for a microservices-based architectures is that applications must be designed as a set of functions.

The FaaS model reduces infrastructure costs and developers' time, since they only have to focus on the functionalities of their application and not on the administration of the underlying infrastructure. In this model, applications run in stateless environments called functions that are triggered by certain events, such as the upload of a file to a storage system or an HTTP call, and are managed entirely by the cloud service provider.

The fine-grained pay-per-use model of serverless computing is one of the key elements that has led to its adoption by enterprises. This paradigm allows customers to pay only for the amount of resources used from the public cloud provider for the time they have been used. One of the most

the *batch* execution mode. The use of the models is done in a simple way from a web interface, so that users can obtain the result of the prediction without requiring previous skills in the use of AWS or machine learning and artificial intelligence models. One of the main advantages of the proposed platform is the scaling to zero that allows you to pay for services only when they are in use, in addition to automatic scaling when demand increases. The solution proposed in this research facilitates the inference of previously trained machine learning models in the public and on-premises clouds at a reduced cost.

7 | CONCLUSIONS

This article has focused on the development of a web-based scientific gateway for the inference of machine learning and artificial intelligence models on serverless platforms, using the AWS public cloud and on-premises clouds with OSCAR, by using elastic Kubernetes clusters. For deployment on AWS, SCAR is used, which runs applications packaged in Docker containers, such as functions in AWS Lambda that are triggered in response to certain events. Models whose execution characteristics exceeded AWS Lambda's limits were integrated into AWS Batch. This allowed the use of accelerated devices such as GPUs, a feature not yet available in Lambda.

The implemented development is a step forward in the adoption of the serverless model in the machine learning and artificial intelligence environment. The platform, through the web interface, facilitates the use of the models by users, without the need to define complex jobs. The level of abstraction introduced in this platform allows users with no experience in the AWS cloud and machine learning models to interact without the complexity required.

The processing times obtained for this type of applications compared to other systems are acceptable. Depending on the available resources, the user can select the deployment in the AWS cloud or in an on-premises cloud with the OSCAR framework. The inferences are obtained through serverless services, which implies cost reduction since costs are only generated when resources are used. The designed system constitutes a step forward in the simplification and adoption of machine learning models in serverless systems.

In the availability of machine learning and artificial intelligence models on serverless platforms, there are three fundamental lines of action, in which we intend to continue our research. First, additional models will be incorporated. Second, adaptation to other public cloud providers will be included. Finally, we will address including GPU support in AWS Lambda by means of remote GPU acceleration. These will allow a more thorough adoption of serverless technology in machine learning and artificial intelligence applications.

ACKNOWLEDGMENTS

Grant PID2020-113126RB-I00 funded by MCIN/AEI/10.13039/501100011033. This work has also been supported by the project AI-SPRINT "Artificial Intelligence in Secure PRIvacy-preserving computing coNTinuum" that has received funding from the European Union Horizon 2020 research and innovation programme under Grant agreement no. 101016577. This work was also previously supported by the project DEEP-Hybrid-DataCloud "Designing and Enabling E-infrastructures for intensive Processing in a Hybrid DataCloud" that received funding from the European Union's Horizon 2020 research and innovation programme under Grant agreement no. 777435.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in:

1. SCAR at https://github.com/grycap/scar, Reference 37.
2. Web interface at https://github.com/grycap/scar-deepaas-ui, Reference 39.
3. DEEPaaS API at https://github.com/indigo-dc/DEEPaaS, Reference 38.
4. Models at https://marketplace.deep-hybrid-datacloud.eu/, Reference 36.

ENDNOTE

*MARLA - https://github.com/grycap/marla
†Amazon SageMaker - https://aws.amazon.com/sagemaker/
‡BigML - https://bigml.com/
§DEEPaaS API - https://github.com/indigo-dc/DEEPaaS
¶DEEP Hybrid-Datacloud - https://deep-hybrid-datacloud.eu/
#VueJS - https://vuejs.org/
‖Vuetify - https://vuetifyjs.com/
**Web Interface - https://scar-deepaas-ui.grycap.net/
††SCAR - https://github.com/grycap/scar
‡‡API Gateway - https://aws.amazon.com/api-gateway/
§§OSCAR - https://github.com/grycap/oscar
¶¶rCUDA - http://www.rcuda.net/
##MinIO - https://min.io/

ORCID

Diana M. Naranjo https://orcid.org/0000-0002-3306-0435

REFERENCES

1. Fox GC, Ishakian V, Muthusamy V, Slominski A. Status of serverless computing and function-as-a-service(FaaS) in industry and research; 2017. arXiv, abs/1708.08028.
2. Ellis A. OpenFaaS 2020. https://www.openfaas.com/
3. Google. Knative; 2020. https://github.com/knative/
4. Apache. OpenWhisk - open source serverless cloud platform; 2020. https://openwhisk.apache.org/
5. West DM. *The Future of Work: Robots, AI, and Automation*. Brookings Institution Press; 2018.
6. Shafiei H, Khonsari A, Mousavi P. Serverless computing: a survey of opportunities, challenges and applications; 2019. arXiv.
7. Carreira J, Fonseca P, Tumanov A, Zhang A, Katz R. A case for serverless machine learning. Proceedings of the Workshop on Systems for ML and Open Source Software at NeurIPSSemantic Scholar; 2018.
8. Naranjo DM, Risco S, Moltó G, Blanquer I. A serverless gateway for the execution of open machine learning models on AWS. Gateways 2020, OSF; 2020.
9. Naranjo Delgado DM. *Serverless Computing Strategies on Cloud Platforms*. PhD thesis. Universitat Politècnica de ValènciaValencia, Spain; 2021.
10. Spillner J, Mateos C, Monge DA. Faaster, better, cheaper: the prospect of serverless scientific computing and HPC. *Communications in Computer and Information Science*. Springer; 2018:154-168.
11. Baldini I, Castro P, Chang K, et al. Serverless computing: current trends and open problems. *Res Adv Cloud Comput*. 2017;1-20.
12. Jonas E, Pu Q, Venkataraman S, Stoica I, Recht B. Occupy the cloud: distributed computing for the 99%. Proceedings of the 2017 Symposium on Cloud Computing – SoCC '17; 2017:445-451; ACM Press, New York, NY.
13. Shankar V, Krauth K, Pu Q, et al. Numpywren: serverless linear algebra; 2018. arXiv.
14. Eismann S, Scheuner J, Eyk E, et al. A review of serverless use cases and their characteristics; 2020. arXiv.
15. Jindal A, Gerndt M, Chadha M, Podolskiy V, Chen P. Function delivery network: extending serverless computing for heterogeneous platforms. *Softw Pract Exper*. 2021;2966. doi:10.1002/spe.2966
16. Mahmoudi N, Khazaei H. SimFaaS: a performance simulator for serverless computing platforms; 2021. https://arXiv.org/abs/2102.089042021
17. Giménez-Alventosa V, Moltó G, Caballer M. A framework and a performance assessment for serverless MapReduce on AWS lambda. *Future Gener Comput Syst*. 2019;97:259–274. doi:10.1016/j.future.2019.02.057
18. Opara-Martins J, Sahandi R, Tian F. Critical analysis of vendor lock-in and its impact on cloud computing migration: a business perspective. *J Cloud Comput*. 2016;5(1):4. doi:10.1186/s13677-016-0054-z
19. Fission. https://fission.io/, 2020.
20. Nuclio. https://nuclio.io/; 2020.
21. Oracle. Fn Project; 2020. https://fnproject.io/
22. Hendrickson S, Sturdevant S, Harter T, Venkataramani V, Arpaci-Dusseau AC, Arpaci-Dusseau RH. Serverless computation with openLambda. Proceedings of the 8th USENIX Conference on Hot Topics in Cloud Computing; 2016:33-39; USENIX Association.
23. Kaviani N, Kalinin D, Maximilien M. Towards serverless as commodity: a case of Knative. WOSC 2019 - Proceedings of the 2019 5th International Workshop on Serverless Computing, Part of Middleware; 2019:13-18; Association for Computing Machinery, Inc.
24. Palade A, Kazmi A, Clarke S. An evaluation of open source serverless computing frameworks support at the edge. Proceedings of the 2019 IEEE World Congress on Services (SERVICES); 2019:206-211.
25. Li J, Kulkarni SG, Ramakrishnan KK, Li D. Understanding open source serverless platforms: design considerations and performance. WOSC 2019 - Proceedings of the 2019 5th International Workshop on Serverless Computing, Part of Middleware; 2019:37-42; Association for Computing Machinery, Inc.
26. Benedetti P, Femminella M, Reali G, Steenhaut K. Experimental analysis of the application of serverless computing to IoT platforms. *Sensors*. 2021;21(3):928. doi:10.3390/s21030928
27. Corral-Plaza D, Boubeta-Puig J, Resinas M. Un Recorrido por los Principales Proveedores de Servicios de Machine Learning y Predicción en la Nube. Actas de las XIV Jornadas de Ingeniería de Ciencia e Ingeniería de Servicios (JCIS 2018); 2018:1-10.
28. Ishakian V, Muthusamy V, Slominski A. Serving deep learning models in a serverless platform. Proceedings of the 2018 IEEE International Conference on Cloud Engineering (IC2E); 2018:257-262; IEEE.
29. Kodandarama RD, Mohan MD, Patnaik S. *SerFer: Serverless Inference of Machine Learning Models*. University of Wisconsin; 2019.
30. Bhattacharjee A, Chhokra AD, Kang Z, Sun H, Gokhale A, Karsai G. BARISTA: efficient and scalable serverless serving system for deep learning prediction services. Proceedings of the 2019 IEEE International Conference on Cloud Engineering (IC2E); 2019:23-33.
31. Christidis A, Davies R, Moschoyiannis S. Serving machine learning workloads in resource constrained environments: a serverless deployment example. Proceedings of the 2019 IEEE 12th Conference on Service-Oriented Computing and Applications, SOCA; 2019:55-63.
32. Christidis A, Moschoyiannis S, Hsu CH, Davies R. Enabling serverless deployment of large-scale AI workloads. *IEEE Access*. 2020;8:70150-70161. doi:10.1109/ACCESS.2020.2985282
33. Kurz MS. Distributed double machine learning with a serverless architecture; 2021 arXiv.
34. Chernozhukov V, Chetverikov D, Demirer M, et al. Double/Debiased machine learning for treatment and causal parameters; 2016. arXiv.
35. Krizhevsky A, Sutskever I, Hinton GE. ImageNet classification with deep convolutional neural networks. *Commun ACM*. 2017;60(6):84-90. doi:10.1145/3065386
36. DEEP Open catalog; 2020. https://marketplace.deep-hybrid-datacloud.eu/
37. SCAR: serverless container-aware architectures (e.g. Docker in AWS Lambda). 2020. https://github.com/grycap/scar
38. DEEPaaS: a REST API to serve machine learning and deep learning models https://github.com/indigo-dc/DEEPaaS2020.
39. Web Interface https://github.com/grycap/scar-deepaas-ui2020.
40. López GÁ. DEEPaaS API: a REST API for machine learning and deep learning models. *J Open Source Softw*. 2019;4(42):1517. doi:10.21105/joss.01517

41. Sarzyniec L., Buchert T., Jeanvoine E., Nussbaum L.. Design and evaluation of a virtual experimental environment for distributed systems. Proceedings of the 2013 21st Euromicro International Conference on Parallel, Distributed, and Network-Based Processing; 2013:172-179.
42. Kyoreva K. State of the art javascript application development with Vue. js. Proceedings of the International Conference on Application of Information and Communication; 2017:567-572.
43. AWS. Amazon cognito user pools; 2020. https://docs.aws.amazon.com/cognito/latest/developerguide/cognito-user-identity-pools.html
44. AWS. Amazon cognito idenity pools; 2020. https://docs.aws.amazon.com/cognito/latest/developerguide/cognito-identity.html
45. Gomes J, Bagnaschi E, Campos I, et al. Enabling rootless Linux Containers in multi-user environments: the udocker tool. *Comput Phys Commun*. 2018;232:84-97. doi:10.1016/j.cpc.2018.05.021
46. Kurtzer GM, Sochat V, Bauer MW. Singularity: scientific containers for mobility of compute. *PLOS One*. 2017;12(5):e0177459. doi:10.1371/journal.pone.0177459
47. Priedhorsky R, Randles T. Charliecloud: unprivileged containers for user-defined software stacks in HPC. Proceedings of the SC '17International Conference for High Performance Computing, Networking, Storage and Analysis, Association for Computing Machinery; 2017; New York, NY.
48. Jacobsen DM, Canon RS. *Contain This, Unleashing Docker for HPC*. NERSC; 2015.
49. Gantikow H, Walter S, Reich C. Rootless Containers with Podman for HPC. In: Jagode H, Anzt H, Juckeland G, Ltaief H, eds. *High Performance Computing*. Springer International Publishing; 2020:343-354.
50. Pérez A, Moltó G, Caballer M, Calatrava A. Serverless computing for container-based architectures. *Future Gener Comput Syst*. 2018;83:50-59. doi:10.1016/j.future.2018.01.022
51. YAML https://yaml.org/2020.
52. Risco S, Moltó G. GPU-enabled serverless workflows for efficient multimedia processing. *Appl Sci*. 2021;11(4):1438. doi:10.3390/app11041438
53. Pérez A, Risco S, Naranjo DM, Caballer M, Moltó G. Serverless computing for event-driven data processing applications. Proceedings of the 2019 IEEE International Conference on Cloud Computing (CLOUD 2019); 2019.
54. Naranjo DM, Risco S, de Alfonso C, Pérez A, Blanquer I, Moltó G. Accelerated serverless computing based on GPU virtualization. *J Parallel Distrib Comput*. 2020;139:32-42. doi:10.1016/j.jpdc.2020.01.004
55. Reaño C, Silla F, Shainer G, Schultz S. Local and remote GPUs perform similar with EDR 100G InfiniBand. Proceedings of the 16th International Middleware Conference on ZZZ - Middleware Industry '15; 2015:1-7; ACM Press, New York, NY.
56. Reano C, Silla F. A performance comparison of CUDA remote GPU virtualization frameworks. Proceedings of the 2015 IEEE International Conference on Cluster Computing; 2015:488-489; IEEE.
57. EGI DataHub; 2020. https://www.egi.eu/services/datahub/
58. Integration with the EGI Federated Cloud – oscar documentation; 2020. https://o-scar.readthedocs.io/en/latest/egi-integration.html
59. DEEP Open Catalog - model "train an audio classifier"; 2020. https://marketplace.deep-hybrid-datacloud.eu/modules/deep-oc-audio-classification-tf.html; 2020.
60. Audioset; 2020. https://research.google.com/audioset/
61. DEEP Open Catalog - model "plants species classifier"; 2020. https://marketplace.deep-hybrid-datacloud.eu/modules/deep-oc-plants-classification-tf.html
62. A community for naturalists iNaturalist; 2020. https://www.inaturalist.org/.
63. DEEP Open Catalog - model "body pose detection" https://marketplace.deep-hybrid-datacloud.eu/modules/deep-oc-posenet-tf.html; 2020.
64. Darknet; 2020. https://pjreddie.com/darknet/yolo/
65. CLUES - cluster energy saving (for hpc and cloud computing); 2020. https://www.grycap.upv.es/clues/es/index.ph
66. Total Cost of Ownership (TCO) calculator | Microsoft Azure; 2020. https://azure.microsoft.com/en-us/pricing/tco/calculator/

How to cite this article: Naranjo DM, Risco S, Moltó G, Blanquer I. A serverless gateway for event-driven machine learning inference in multiple clouds. *Concurrency Computat Pract Exper*. 2021;e6728. doi: 10.1002/cpe.6728

Base de datos de indexación	Web of Science / JCR
Índice de impacto	1.536
Año	2020
Categoría	Computer Science, Theory & Methods
Posición de la revista en el área	57 de 110
Tercil	T3
Cuartil	Q3
Número de citas en JCR	0
Número de citas totales	0

Comentario.

5.1.3. Otras Publicaciones con Índices de Calidad Relativa

5.1.3.1. TOSCA-based orchestration of complex clusters at the IaaS level

Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

TOSCA-based orchestration of complex clusters at the IaaS level

To cite this article: M Caballer *et al* 2017 *J. Phys.: Conf. Ser.* **898** 082036

IOP Conf. Series: Journal of Physics: Conf. Series **898** (2017) 082036 doi:10.1088/1742-6596/898/8/082036

TOSCA-based orchestration of complex clusters at the IaaS level

M Caballer[1], G Donvito[2], G Moltó[1], R Rocha[3] and M Velten[3]

1 Instituto de Instrumentación para Imagen Molecular (I3M). Centro mixto CSIC Universitat Politècnica de València - CIEMAT, camino de Vera s/n, 46022 Valencia, Spain
2 Istituto Nazionale di Fisica Nucleare (INFN), Via Giovanni Amendola, 173, 70126 Bari, Italy
3 European Organization for Nuclear Research (CERN), CH-1211 Geneva, Switzerland

Abstract. This paper describes the adoption and extension of the TOSCA standard by the INDIGO-DataCloud project for the definition and deployment of complex computing clusters together with the required support in both OpenStack and OpenNebula, carried out in close collaboration with industry partners such as IBM. Two examples of these clusters are described in this paper, the definition of an elastic computing cluster to support the Galaxy bioinformatics application where the nodes are dynamically added and removed from the cluster to adapt to the workload, and the definition of an scalable Apache Mesos cluster for the execution of batch jobs and support for long-running services. The coupling of TOSCA with Ansible Roles to perform automated installation has resulted in the definition of high-level, deterministic templates to provision complex computing clusters across different Cloud sites.

1. Introduction

INDIGO-DataCloud is an European Union's Horizon 2020 funded project whose ultimate goal is to provide a sustainable European software infrastructure for science, spanning multiple computer centers and existing public clouds. The participating sites form a set of heterogeneous cloud infrastructures with different Cloud Management Platforms (CMP), some running OpenNebula, some running OpenStack. INDIGO-DataCloud is introducing innovative advancements at the layer of IaaS (Infrastructure as a Service), e.g., by introducing and supporting containers in the aforementioned CMPs, at the layer of PaaS (Platform as a Service), e.g., by creating SLA-based orchestration components that support deployments on multi-Clouds and, finally, at the layer of SaaS (Software as a Service), e.g., by developing high-level REST and graphical user interfaces to facilitate the usage of computing infrastructures for different scientific communities. Moreover from the point of view of the storage INDIGO-DataCloud pushes forward and greatly simplify the management of heterogeneous storage resources in the cloud environment.

There was the need to find a common denominator for the deployment of both the required PaaS services and the end user application architecture, which typically involve customized virtual infrastructures. In this context TOSCA represents a standard approach to provide descriptions of applications architectures to be deployed on a cloud and was adopted and extended by INDIGO-DataCloud to support the requirements coming from scientific communities.

instantiation, similarly as what we can see in the previous figure 2.

We also instantiate a Compute node to host this software component with a scalable capability. For the translation to HOT this template will result in a set of SoftwareConfig/Deployment with dependencies (for example the role installation needs to happen before executing the playbook) and a Nova server. Those elements are then stored in a substack, that is referenced in a ResourceGroup to provide the scalability part. The passing of parameters is kept. On the IM side all of this happens directly through the IM, by launching new compute nodes via the IaaS API and contextualizing directly with SSH and Ansible.

5. Conclusion and Future Work

This paper has described the adoption of the TOSCA standard, for the description of application architectures to be deployed on a Cloud, in the INDIGO-DataCloud project focusing on the definition of complex computing clusters. Two examples of these complex clusters have been provided, an elastic cluster to support a bioinformatics application and the deployment of a scalable Mesos cluster for the execution of jobs and long-running services.

The extensibility features of the standard has allows to create additional non-normative types to support the specific requirements of the applications supported by the project, such as the automated elasticity required by the underlying virtual computing clusters. The usage of TOSCA templates, being a declarative language, coupled with the automated installation capabilities provided by Ansible Roles has paved the way to provide deterministic high-level declarations of complex clusters that can be deployed across multiple on-premises Clouds (OpenStack and OpenNebula) and public Clouds. By leveraging Heat, in the case of OpenStack and the Infrastructure Manager for OpenNebula and public Clouds, a wide variety of cloud provides on which to orchestrate complex virtual cluster is now possible.

Future work includes addressing other types of complex clusters, such as those required in Big Data involving distributed computing at scale and large volumes of data processing (e.g. Hadoop, Spark, etc.). Also, we plan to introduce support for hybrid deployments of these complex clusters across different Clouds in order to include multi-site orchestration for elastic computing clusters.

Acknowledgments

The authors would like to thank the European Commission for the financial support for project INDIGO-DataCloud (RIA 653549).

Bibliography

[1] Amazon cloud formation. `https://aws.amazon.com/cloudformation/`.
[2] Cloudify. `http://getcloudify.org/`.
[3] Egi federated cloud. `https://www.egi.eu/infrastructure/cloud/`. Accessed: 2017-01-13.
[4] Heat orchestration template. `https://docs.openstack.org/developer/heat/template_guide/hot_guide.html`.
[5] Heat translator. `https://docs.openstack.org/developer/heat-translator/`.
[6] Tosca parser. `https://wiki.openstack.org/wiki/TOSCA-Parser`.
[7] Palma D, Rutkowski M, and Spatzier T. TOSCA Simple Profile in YAML Version 1.0. Technical report, 2016.
[8] de Alfonso C, Caballer M, Alvarruiz F, and Hernández V. An energy management system for cluster infrastructures. *Computers & Electrical Engineering*, 39(8):2579–2590, 2013.
[9] Hochstein L. *Ansible: Up and Running, Automating Configuration Management and Deployment the Easy Way*. O'Reilly Media, 2014.
[10] S Li. TOSCA Simple Profile for Network Functions Virtualization (NFV) Version 1.0. Technical report, 2016.
[11] Caballer M, Blanquer I, Moltó G, and de Alfonso C. Dynamic management of virtual infrastructures. *Journal of Grid Computing*, 13(1):53–70, 2015.

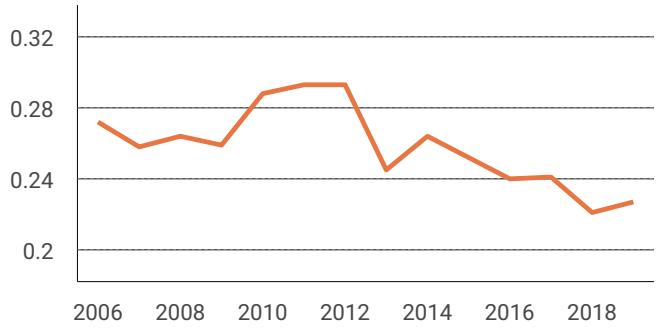
Journal of Physics: Conference Series

Country	United Kingdom - SCIMAGO INSTITUTIONS RANKINGS
Subject Area and Category	Physics and Astronomy Physics and Astronomy (miscellaneous)
Publisher	IOP Publishing Ltd.
Publication type	Conferences and Proceedings
ISSN	17426588, 17426596
Coverage	2005-2020
Scope	The open access Journal of Physics: Conference Series (JPCS) provides a fast, versatile and cost-effective proceedings publication service.
	Homepage How to publish in this journal Contact
	Join the conversation about this journal

70

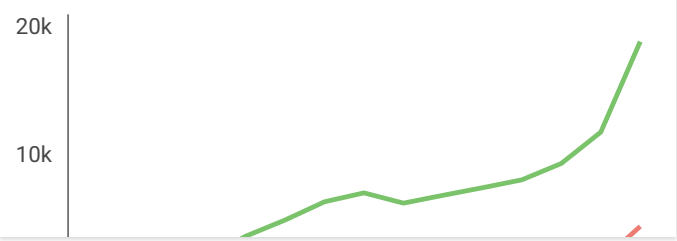
H Index

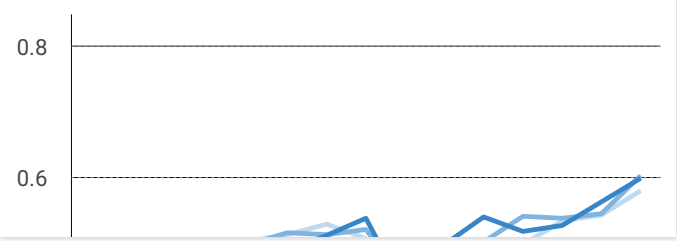
SJR

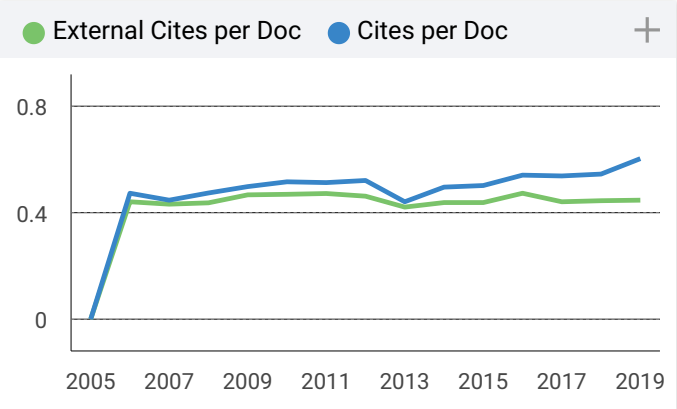


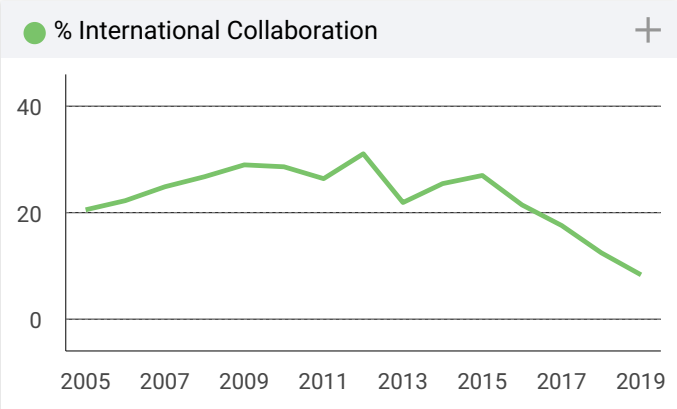
Citations per document

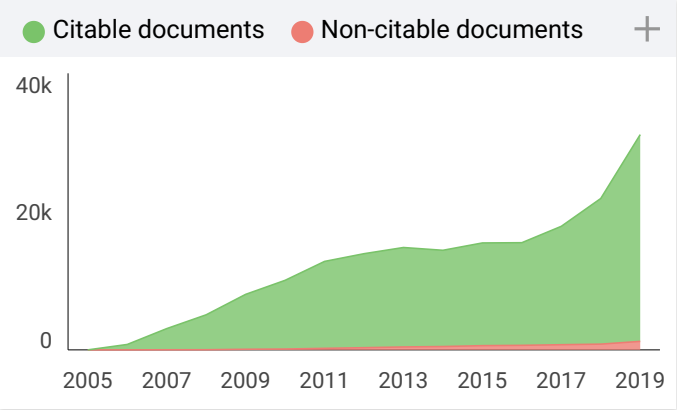
Total Cites Self-Cites

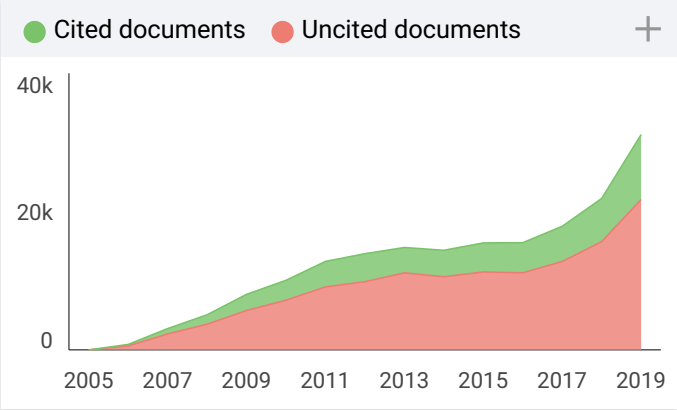


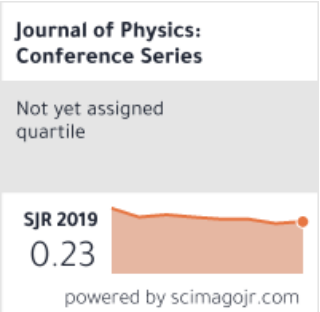












← Show this widget in your own website

Just copy the code below and paste within your html code:

<a href="https://www.scimag

Metrics based on Scopus® data as of April 2020

5.1.4. Premios de Investigación

5.1.4.1. ISECON 2015

ISECON 2015

BEST PAPER AWARD

Remote Computational Labs for Educational Activities via a Cloud Computing Platform

Germán Moltó

presented at the

32nd Annual

Information Systems Education Conference

November 5-7, 2015

Orlando, Florida

ISECON is produced annually by the

FOUNDATION FOR IT EDUCATION

CORE Computing Research & Education

Conference Portal

Back to CORE homepage | search journals

A* - 7%
A - 19%
B - 29%
C - 26%
Other - 17%

ISECON Search by: All Source: CORE2018

Search

Showing results 1 - 1 of 1

Export

Title	Acronym	Source	Rank	DBLP	hasData?	Primary FoR	Comments	Average Rating
Information Systems Education Conference	ISECON	CORE2018	B	none	No	0806	0	N/A

About ISECON

ISECON is the "Information Systems Education Conference". The conference brings together information systems educators from around the world. It is the longest, continuous running conference for IS educators! At ISECON, leading educators and technology experts meet to share information about current and emerging technology, a variety of curricular issues, and development techniques, while establishing and strengthening industry/academic relationships.

ISECON is THE conference educators attend to learn about and contribute to the latest trends and issues in the Information Systems academic field. Topics include model curricula, best practices, pedagogy, program accreditation, and keeping up with technological changes. Held annually since 1982, ISECON is the largest continuously-running conference for IS Education.

ISECON is produced by the Foundation for Information Technology Education. You can learn more about the Foundation and about ISECON's history at the Foundation's website. (http://www.edfoundation.org)

5.2. Comunidad Académica

5.2.1. Editor

5.2.1.1. Computing and Informatics

Editor de la revista Computing and Informatics (JCR) desde 2015

COMPUTING AND INFORMATICS

Previously, COMPUTERS AND ARTIFICIAL INTELLIGENCE

EDITORIAL OFFICE
INSTITUTE OF INFORMATICS, SLOVAK ACADEMY OF SCIENCES
Dúbravská cesta 9, 845 07 Bratislava, Slovakia
Tel. (+4212) 5941 1204 Fax (+4212) 5477 1004 e-mail cai.ui@savba.sk

Dr. Germán Moltó

Dpto. de Sistemas Informáticos y Computación
Universitat Politècnica de València
Camino de Vera S/N
46022 Valencia
Spain

Bratislava, 9 January, 2015

LETTER OF APPOINTMENT

as a member of the Editorial Board of the journal
Computing and Informatics

With reference to your preliminary consent we are writing to let you know that the Institute of Informatics of the Slovak Academy of Sciences, as the Editor, appoints you to be a member of the Editorial Board of the international journal **Computing and Informatics**.

In this occasion please accept my sincere congratulations. I hope our cooperation will be successful and will contribute to further increase the standard of our journal.

As a member of the Editorial Board you will receive the issues of Computing and Informatics regularly.

Sincerely,

Assoc. Prof. Ladislav Hluchý, PhD.
Editor-in-Chief

COMPUTING AND INFORMATICS

EDITORIAL TEAM

EDITOR-IN-CHIEF

Ladislav Hluchý, Institute of Informatics, Slovak Academy of Sciences, Bratislava, Slovakia

ASSOCIATE EDITORS

Jacek Kitowski, Professor of Computer Science, AGH University, Krakow, Poland
Changjun Jiang, Professor, Tongji University, Shanghai, China

EXECUTIVE BOARD

Aleksander Byrski, AGH University of Science and Technology, Poland
Ondrej Habala, UI SAV, Slovakia

EDITORIAL BOARD

Tom Arodz, United States
Piotr Bala, ICM, Warsaw University, Poland
Isabel Campos, Spain
Xiaofeng Chen, Xidian University, China
Paweł Czarnul, Gdansk Uni of Tech., Poland
Zhijun Ding, Department of Computer Science and Technology, Tongji University, China
Witold Dzwinel, Poland
Brij B. Gupta, National Institute of Technology Kurukshetra, India
Ralf Klasing, France
Dušan Kolář, Czech Republic
Ivan Kotuliak, Slovak University of Technology, Slovakia
Dieter Kranzlmüller, Ludwig-Maximilians-University, Germany
Maozhen Li, Brunel University, United Kingdom
Antoni Ligeza, AGH University of Science and Technology, Poland
P K Mahanti, Canada
Maciej Malawski, AGH University, Poland
Stephen John Maybank, Birkbeck College, London, United Kingdom
Gabriele Mencagli, Department of Computer Science, University of Pisa, Italy
Alok Mishra, Atilim University, Turkey
German Molto, Universitat Politècnica de València, Spain
Jaroslav Pokorný, Charles University in Prague, Czech Republic
J Pospíchal, Slovakia
Helmut Reiser, Germany
M Richter, Germany
Gianfranco Rossi, University of Parma, Italy
B. Rovan, Slovakia
Imre Rudas, Obuda University, Hungary

ISSN: 2585-8807

	Title20	Year	Edition	ISO_ABBREV	Country	IssuesYear	Frequency	ISSN
1	COMPUT INFORM	2019	SCI	Comput. Inform.	SLOVAKIA	6	B	1335-9150

	Title20	Language	1stYrPub	Categories	Pubcode	Publisher
1	COMPUT INFORM	ENGLISH	2001	EP	WY005	COMPUTING AND INFORMATICS

	Title20	CATEGORY_DESCRIPTION	CATEGORY_CODE	TOT_CITES	IMPACT_FACTOR
1	COMPUT INFORM	COMPUTER SCIENCE, ARTIFICIAL INTELLIGENCE	EP	350	0,496

	Title20	Number of Journals in Category	ARTL_INFLUENCE	CATEGORY_RANKING	IMMEDIACY_INDEX
1	COMPUT INFORM	N/D	0,082	Q4	0,043

	Title20	CITED_HALF_LIFE	5YR_IMPACT_FACTOR	EIGENFACTOR	Rank by Impact Factor	QUARTILE_RANK
1	COMPUT INFORM	6,7	0,5	0,00031	N/D	134/136

5.2.1.2. Special Issue: Orchestration

J Grid Computing (2018) 16:1–2
https://doi.org/10.1007/s10723-018-9427-5

Guest Editor's Introduction: Special Issue on Cloud Computing Orchestration

Miguel Caballer · Germán Moltó · Ignacio Blanquer

Published online: 17 January 2018

Cloud computing has provided users with access to computing, storage and network resources with unprecedented flexibility both from public Cloud providers and on-premises Cloud infrastructures. Cloud computing features several characteristics that explain its growth and popularity in the last decade. Maybe the most salient ones are flexibility, pay-per-use, and elasticity. The usage of Cloud technologies enables the software requirements to be defined by the user rather than by the infrastructure provider. This is an important point to ease the migration of scientific applications into the cloud. However, the resources have to be properly orchestrated (i.e., provisioned, configured and delivered) for users to leverage the benefits of these elastic infrastructures within their application domains. Complex application topologies, involving multiple Virtual Machines and multiple components with diverse software and configuration dependencies strongly benefit from the advances in orchestration.

M. Caballer · G. Moltó · I. Blanquer
Instituto de Instrumentación para Imagen Molecular (I3M), Centro Mixto CSIC, Universidad Politécnica de Valencia, Valencia, Spain
e-mail: micafer1@upv.es

G. Moltó
e-mail: gmolto@dsic.upv.es

I. Blanquer
e-mail: iblanque@dsic.upv.es

Furthermore, in the last years the mainstream adoption of Linux containers, propelled by the popularity of Docker, enabled users to maintain customized execution environments, in the shape of lightweight container images instead of bulky Virtual Machine Images. Creating distributed applications based on containers required the ability to orchestrate a fleet of Docker container at scale, thus fostering the appearance of Container Management Platforms (CMPs) such as Kubernetes, Apache Mesos or Docker Swarm.

Therefore, orchestration tools are becoming fundamental to automate the deployment and management of application architectures on multiple Clouds. Hybrid scenarios that arise from simultaneously harnessing public and on-premises Clouds are challenges that remain to be solved for the efficient orchestration of applications on multi-Clouds. Also, the deployment of fleets of containers to achieve immutable application architectures on Clouds requires orchestration techniques.

This special issue focuses on novel solutions and innovative approaches that contribute to the field of Cloud Computing orchestration. This includes contributions related to automating the deployment of applications on Clouds, contributions related to the orchestration of scientific workflows and contributions to optimize container allocation for microservices in Cloud infrastructures.

A brief summary of the papers included in this special issue is provided for your convenience. In "Orchestrating complex application architectures in

heterogeneous clouds", Miguel Caballer and co-authors describe the orchestration approach for heterogeneous clouds that has been implemented in the INDIGO-DataCloud project. This orchestration model leverages the OASIS TOSCA standard as the modeling language and uses virtual machines and Docker containers in an homogeneous and transparent way providing consistent application deployment for the users on both on-premises and public Clouds. The paper entitled "QoS-Aware Orchestration of Network Intensive Software Utilities within Software Defined Data Centres" by Uroš Paščinsk and co-authors presents a new architecture for geographic orchestration of network intensive software components, in order to improve QoS in time-critical components, deciding where to run such components considering several factors modeled with qualitative machine learning techniques.

The deployment of complex applications in the Cloud is addressed in the paper "Occopus: a Multi-Cloud Orchestrator to Deploy and Manage complex scientific infrastructures", by József Kovács and co-author, which presents an open source cloud IaaS orchestrator named Occopus. The applications are described using a domain-specific language agnostic to the infrastructure and the architecture and implementation details of the software are addressed and compared to other cloud orchestrator frameworks.

The requirement for high available applications in the Cloud is covered by the paper "Orchestrating the Deployment of High Availability Services on Multi-zone and Multi-cloud Scenarios" by R. Moreno-Vozmediano and co-authors, which introduces a new approach to achieve High Availability (HA) in multi-zone clouds through a matchmaking algorithm that considers affinity and anti-affinity properties of the resource. Rules are then created and analyzed in order to obtain a heuristic for the affinity placement. In "The Flowbster cloud-oriented workflow system to process large scientific data sets", Peter Kacsuk and co-authors detail a new workflow system, called Flowbster, aimed to create data pipelines which efficiently process very large data sets on cloud computing environments. It uses a choreography approach where all the nodes of communicate each other, without the need of a central service. Moreover, through the use of the Occopus cloud orchestrator, it supports several cloud backends Finally, Flowbster includes a graphical user interface that eases the composition of workflows while hiding the complexity beneath the system.

The need to orchestrate fleets of containers for microservices architectures is addressed in the paper "Genetic Algorithm for Multi-Objective Optimization of Container Allocation in Cloud Architecture", by Carlos Guerrero and co-authors. They propose a genetic algorithm for multi-objective optimization of container allocation in cloud architecture. The authors consider the optimizations focusing on a tight use of the resources and a reduction of the network overhead and system failure rate and present a model for cloud cluster, containers, microservices, and four optimization objectives.

Due to the importance of the container platforms in "Transparent Orchestration of Task-based Parallel Applications in Containers Platforms" Daniele Lezzi and co-authors have adapted the COMPSs runtime to support different container platforms such as Mesos, Docker or Singularity.

In summary, after a thorough review procedure, we aimed to compile in this special issue valuable contributions to the state of the art of Cloud computing orchestration, in order to illustrate the current progress and pending issues regarding this topic. Finally, the guest editors would like to thank the Editor in Chief of the Journal of Grid Computing, Prof. Peter Kacsuk, for allowing us to organize this special issue and for his continuous support during the process.

5.2.2. Revisor

Publons CV
Prepared by Publons on December 8th 2020

Germán Moltó

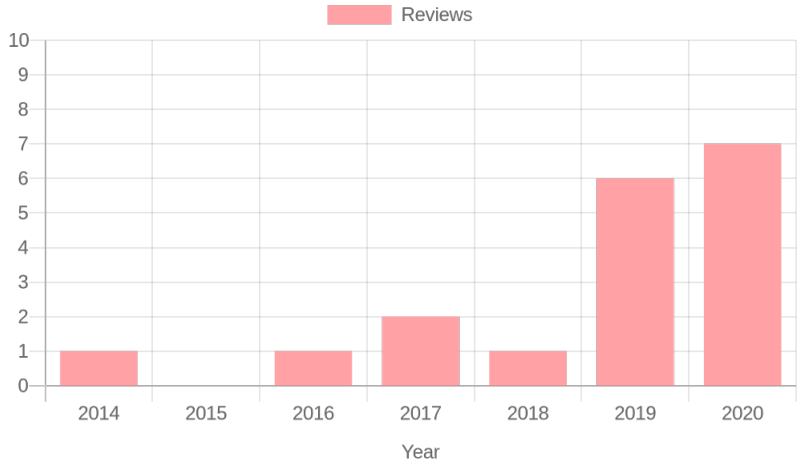
https://publons.com/researcher/C-6994-2008/
Web of Science ResearcherID: C-6994-2008

Current affiliation:

- Universitat Politecnica de Valencia until present

Verified reviews

REVIEW SUMMARY



REVIEWER SUMMARY

(5) IEEE Revista Iberoamericana de Tecnol... WOS	(3) IEEE Access WOS
(2) IEEE Software WOS	(2) Journal of Systems and Software WOS
(2) Journal of Parallel and Distributed Com... WOS	(1) IEEE Transactions on Big Data WOS
(1) Concurrency and Computation: Practic... WOS	(1) Journal of Cloud Computing WOS
(1) Future Generation Computer Systems WOS	

18 REVIEWS OF 14 MANUSCRIPTS

-
2 rounds from Jul 2020 to Nov 2020 for IEEE Revista Iberoamericana de Tecnologías del Aprendizaje

-
2 rounds from Jun 2020 to Aug 2020 for IEEE Software

-
Reviewed: May 2020 for IEEE Access

-
Reviewed: Apr 2020 for IEEE Revista Iberoamericana de Tecnologías del Aprendizaje

-
2 rounds from Dec 2019 to Feb 2020 for IEEE Revista Iberoamericana de Tecnologías del Aprendizaje

-
Reviewed: Nov 2019 for Journal of Systems and Software

-
Reviewed: Nov 2019 for Journal of Cloud Computing

-
Reviewed: Oct 2019 for IEEE Access

-
Reviewed: Jun 2019 for IEEE Access

-
Reviewed: Jan 2019 for Future Generation Computer Systems

-
2 rounds from Nov 2017 to Mar 2018 for Journal of Parallel and Distributed Computing

-
Reviewed: Apr 2017 for Concurrency and Computation: Practice and Experience

-
Reviewed: Jul 2016 for IEEE Transactions on Big Data

-
Reviewed: Feb 2014 for Journal of Systems and Software

5.3. Méritos Docentes

5.3.1. Participación como ponente en congresos de innovación docente

5.3.1.1. III Congreso Internacional UNIVEST

G. Moltó, A. M. Fita, J. F. Monserrat, A. Rodriguez-Burruezo, and E. M. Mestre, "La Tutoría Virtual para la Autogestión del Aprendizaje en las Enseñanzas Técnicas," in III Congreso Internacional UNIVEST, 2011, pp. 1–13.

- Participación: Ponencia
- Título del trabajo presentado: La Tutoría Virtual para la Autogestión del Aprendizaje en las Enseñanzas Técnicas
- Entidad organizadora: Universitat de Girona
- Lugar de celebración: Girona, España
- Publicación: ISSN/ISBN: 978-84-8458-354-7
- Objetivos: III Congreso Internacional UNIVEST
- Perfil de los destinatarios: Docentes internacionales
- Fecha de inicio: 16/06/2011
- Fecha de fin: 17/06/2011

Universitat de Girona
Institut de Ciències de l'Educació
Josep Pallach

UNIVEST 2011

M. Teresa Bardera García, secretaria del Instituto de Ciencias de la Educación Josep Pallach de la **Universitat de Girona**,

CERTIFICO que

GERMÁN MOLTÓ

con documento de identidad 52656437F ha participado en el **III Congreso Internacional UNIVEST'11 "La autogestión del aprendizaje"**, celebrado en Girona los días 16 y 17 de junio de 2011 presentando la comunicación **"La tutoría virtual para la autogestión del aprendizaje en las enseñanzas técnicas"**, de la cual son autores/as: Moltó, Germán; Fita, Ana M.; Monserrat, Jose F.; Rodríguez, Adrián; Mestre, Eva M..

Este Congreso ha sido organizado por el Vicerrectorado de Política Académica y el Instituto de Ciencias de la Educación Josep Pallach de la Universitat de Girona.

I para que así conste, firmo el presente certificado.

Girona, 17 de junio de 2011

Universitat de Girona
Institut de Ciències de l'Educació Josep Pallach

Institut de Ciències de l'Educació Josep Pallach
Carrer Castell de Peralada, núm. 14
17071 Girona
Tel. 972 41 87 02 – 972 41 87 03
Fax 972 48 42 12
univest@udg.edu

Comunicaciones

Propuestas de comunicación

Las propuestas de comunicación se tienen que enviar a la Secretaria del Congreso antes del día **27 de febrero de 2011** (plazo prorrogado) a través de la plataforma de administración de eventos ConfTool, disponible a través de este mismo web.

Los textos serán evaluados por dos miembros del Comité Científico del Congreso. La resolución del comité se podrá consultar a través de la plataforma ConfTool a partir del **28 de marzo de 2011**.

Las aportaciones aprobadas por el Comité Científico serán publicadas en la página web del Congreso para que los asistentes puedan consultarlas con antelación, facilitando así el debate y la discusión a las Mesas de comunicaciones.

En estas sesiones los autores no presentaran individualmente sus comunicaciones, sino que participaran del análisis y el debate conjuntamente con el resto de asistentes.

Características y requisitos de las propuestas de comunicaciones

Las propuestas de comunicación tienen que presentar el resumen de un trabajo o experiencia que se ajuste a los ejes temáticos del Congreso. Su extensión será de entre 7.500 y 10.000 caracteres con espacios.

Tendrán que incluir los siguientes apartados:

- Resumen/Abstract (Extensión mínima: 500 caracteres con espacios. Extensión máxima: 700 caracteres con espacios)
- Título
- Autor/es
- Objetivos
- Desarrollo
- Conclusiones y prospectiva
- Cuestiones y/o consideraciones para el debate

Se valorarán especialmente los siguientes aspectos:

- Definición clara de los objetivos
- Coherencia del contenido
- Presencia de elementos innovadores
- Conclusiones bien definidas
- Formulación de interrogantes para el debate

Para que la propuesta de una comunicación aceptada por el Comité Científico se incorpore a la programación del Congreso hace falta que, como mínimo, uno de sus autores formalice la inscripción.

Publicación digital

La organización tiene previsto entregar a los asistentes al inicio del Congreso una publicación en formato digital con los textos completos de las conferencias y las comunicaciones aceptadas.

Las personas interesadas en que su comunicación sea incluida en esta publicación tendrá que enviar el texto completo correspondiente dentro del plazo establecido. En caso contrario sólo será publicado en el web y el trabajo formará parte de la programación del congreso pero no podrá ser incluido en la publicación digital.

Comunicaciones aceptadas para ser incluidas en la publicación del Congreso

El texto completo de las comunicaciones aceptadas por el Comité se tendrán que remitir a la secretaría del Congreso antes del **26 de abril de 2011**, mediante la plataforma de administración de eventos ConfTool (como documento adjunto en formato .doc, .rtf, .odt o .zip) y será revisado por el Comité Científico del Congreso.

Características y requisitos de los textos completos

Se tendrán que seguir las pautas de presentación. Es importante leerlas antes de utilizar la plantilla recomendada.

Estos textos deberán tener una extensión de entre 25.000 y 35.000 caracteres (con espacios) siguiendo el formato presentado en la plantilla y debe incluir los siguientes apartados:

- Título de la comunicación
- Autores de la comunicación, detallando para cada uno los siguientes datos:
  - Nombre y apellidos
  - Universidad/institución
  - Dirección electrónica
- Resumen (Extensión mínima: 500 caracteres con espacios. Extensión máxima: 700 caracteres con espacios)
- Texto de la comunicación
- Conclusiones
- Bibliografía
- Cuestiones y/o consideraciones para el debate

Descargar plantilla del texto completo de la comunicación

Nota:
- Para obtener el Certificado de Presentación de Comunicación es necesario que el autor/a (inscrito/a en el Congreso) asista a la Mesa de Comunicaciones en la que se incluie su trabajo.

- La organización del Congreso UNIVEST'11 tiene previsto hacer difusión, publicar o comunicar el material de las contribuciones, de forma íntegra o parcial, sin obtener ningún beneficio comercial, exclusivamente con fines de investigación y soporte o ilustración a la docencia. Los/las autores/as participantes al Congreso UNIVEST'11 aceptan, con su participación, ceder de forma no exclusiva y para estas finalidades, los derechos de explotación que le corresponden como autor, sin límite temporal ni territorial, autorizando a UNIVEST'11 a realizar la difusión, publicación o comunicación de la grabación a través de cualquier medio, Internet incluido, y autoriza de forma expresa la incorporación de los documentos en una base de datos electrónica de acceso abierto.

Universitat de Girona
Institut de Ciències de l'Educació
Josep Pallach

UNIVEST 2011

M. Teresa Bardera Garcia, secretària de l'Institut de Ciències de l'Educació Josep Pallach de la **Universitat de Girona**,

CERTIFICO que

GERMÁN MOLTÓ

amb document d'identitat núm. 52656437F ha assistit al **III Congrés Internacional UNIVEST'11 "L'autogestió de l'aprenentatge"**, celebrat a Girona els dies 16 i 17 de juny de 2011 i organitzat pel Vicerectorat de Política Acadèmica i l'Institut de Ciències de l'Educació Josep Pallach de la Universitat de Girona.

I perquè així consti, signo el present certificat.

Universitat
de Girona
Institut de Ciències
de l'Educació Josep Pallach

Girona, 17 de juny de 2011

Institut de Ciències de l'Educació Josep Pallach
Carrer Castell de Peralada, núm. 14
17071 Girona
Tel. 972 41 87 02 – 972 41 87 03
Fax 972 48 42 12
univest@udg.edu

UNIVEST 2011

UNIVEST.UDG.EDU

GIRONA, 16-17/06/2011

III Congrés Internacional
L'AUTOGESTIÓ DE L'APRENENTATGE

III Congreso Internacional
LA AUTOGESTIÓN DEL APRENDIZAJE

III International Conference
THE SELF-REGULATION OF LEARNING

ISBN 978-84-8458-354-7

Universitat de Girona

Organitza / Organiza / Organise:
Universitat de Girona

Amb el suport de / Con el apoyo de / With the support of:
Consell Social de la Universitat de Girona
Fundació Privada: Girona, Universitat i Futur

LA TUTORÍA VIRTUAL PARA LA AUTOGESTIÓN DEL APRENDIZAJE EN LAS ENSEÑANZAS TÉCNICAS

Germán Moltó
Dpto. de Sistemas Informáticos y Computación
Universitat Politècnica de València
gmolto@dsic.upv.es

Ana M. Fita
Dpto. de Biotecnología
Universitat Politècnica de València
anfifer@btc.upv.es

Jose F. Monserrat
Dpto. de Comunicaciones
Universitat Politècnica de València
jomondel@iteam.upv.es

Adrián Rodriguez
Dpto de Biotecnología
Universitat Politècnica de València
adrodbur@upvnet.upv.es

Eva M. Mestre
Dpto. de Lingüística Aplicada
Universitat Politècnica de València
evmesim@upvnet.upv.es

Resumen

Este artículo propone el uso de herramientas de Aprendizaje VIrtual Síncrono (AVIS) para flexibilizar las tutorías. Estas herramientas permiten mantener audio/video conferencias y compartir aplicaciones y documentos. En este trabajo se resumen las experiencias de implantación de la herramienta Poli[ReunióN] (basada en Adobe Connect) para dar soporte a las tutorías virtuales en diferentes enseñanzas técnicas de la Universitat Politècnica de València durante el curso 2010/2011. Se detallan las principales ventajas y oportunidades, se discute el impacto en el profesorado y, finalmente, se analizan los resultados de las encuestas de opinión al alumnado sobre la incorporación de esta herramienta.

1. Introducción

El grado de penetración de las Tecnologías de la Información y de las Comunicaciones (TIC) en la sociedad de los últimos años ha aumentado el número de ordenadores disponibles en las familias. Además, el aumento del ancho de banda de las conexiones ha favorecido la proliferación de herramientas tecnológicas accesibles a través de Internet que pueden suponer un complemento a la práctica docente tradicional.

En este sentido, resulta interesante abordar problemáticas docentes conocidas desde las perspectivas tecnológicas actuales. Hace unos años, el principal acceso a la información de las asignaturas era a través de los servicios de reprografía, con el consiguiente impacto medioambiental, económico y de pérdida de tiempo por parte de los alumnos. Con el auge de Internet, surgieron las páginas webs de asignaturas, donde los profesores colgaban el material para hacerlo disponible a los alumnos. Al no seguir patrones de diseño comunes ni existir una ubicación centralizada, la recopilación de material de asignaturas por parte de los alumnos era bastante costosa y requería visitar diferentes webs.

Para abordar este problema, la Universitat Politècnica de València (UPV) dispone desde hace algunos años de la plataforma de docencia online PoliformaT [1], basada en Sakai [2], que permite la comunicación principalmente asíncrona entre profesores y alumnos, el intercambio de material docente y la evaluación del alumnado. Mediante el uso de estas plataformas se proporciona un acceso

que manda automáticamente un mensaje a la cuenta de correo del profesor para avisarle de que hay una solicitud pendiente.

- **Base de Datos de Sesiones**. Cuando el profesor crea una nueva sesión puede darla de alta para que los alumnos interesados se conecten a la misma.

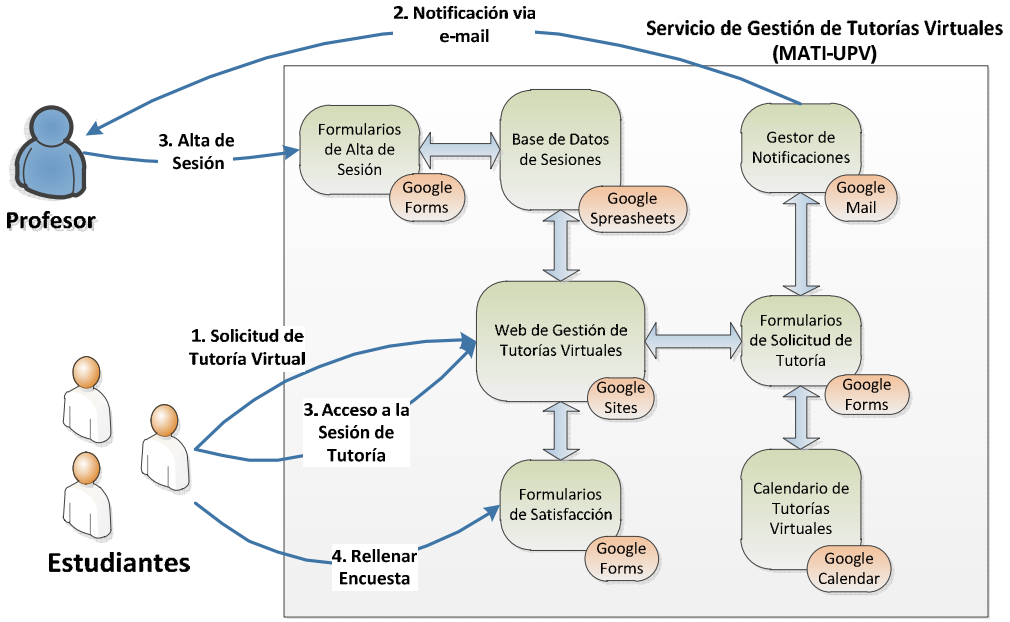


Figura 3. Arquitectura del Sistema de Gestión de Tutorías Virtuales

Un aspecto importante de esta herramienta consiste en la obtención automática de las opiniones de los alumnos, con el objetivo de evaluar el servicio de Poli[ReunióN]. Por ello, se diseñó una encuesta cuyas preguntas más relevantes se muestran en la Tabla 1.

Pregunta	Escala
¿Cómo consideras la calidad del audio durante la sesión?	1-5
¿Cómo consideras la calidad del video durante la sesión?	1-5
¿Qué funcionalidad de Poli[ReunióN] has empleado durante la sesión?	Opción Múltiple
¿Qué grado de utilidad presenta el servicio Poli[ReunióN]?	1-10
¿Crees que su funcionalidad actual es comparable a interactuar directamente con el profesor?	Opciones
Incluye sugerencias de mejoras o problemas que hayas tenido durante la sesión	Texto libre

Tabla 1. Extracto de preguntas sobre uso de Poli[ReunióN]

La recopilación automática y a través de Internet de las opiniones de los alumnos tras mantener las sesiones facilitó el procesado de los resultados y la generación de gráficas que resumen las opiniones de los alumnos. La siguiente sección muestra los resultados obtenidos.

4. Resultados Obtenidos

¿Sería interesante habilitar el acceso a las salas para un uso exclusivo de los alumnos, sin la presencia-coordinación del profesor para realizar trabajos en grupos o colaborativos?

¿Sería conveniente grabar las sesiones de tutorías con el consentimiento del alumno para poder utilizar ese material para futuras consultas?

Comunicaciones

Propuestas de comunicación

Las propuestas de comunicación se tienen que enviar a la Secretaria del Congreso antes del día **27 de febrero de 2011** (plazo prorrogado) a través de la plataforma de administración de eventos ConfTool, disponible a través de este mismo web.

Los textos serán evaluados por dos miembros del Comité Científico del Congreso. La resolución del comité se podrá consultar a través de la plataforma ConfTool a partir del **28 de marzo de 2011**.

Las aportaciones aprobadas por el Comité Científico serán publicadas en la página web del Congreso para que los asistentes puedan consultarlas con antelación, facilitando así el debate y la discusión a las Mesas de comunicaciones.

En estas sesiones los autores no presentaran individualmente sus comunicaciones, sino que participaran del análisis y el debate conjuntamente con el resto de asistentes.

Características y requisitos de las propuestas de comunicaciones

Las propuestas de comunicación tienen que presentar el resumen de un trabajo o experiencia que se ajuste a los ejes temáticos del Congreso. Su extensión será de entre 7.500 y 10.000 caracteres con espacios.

Tendrán que incluir los siguientes apartados:

- Resumen/Abstract (Extensión mínima: 500 caracteres con espacios. Extensión máxima: 700 caracteres con espacios)
- Título
- Autor/es
- Objetivos
- Desarrollo
- Conclusiones y prospectiva
- Cuestiones y/o consideraciones para el debate

Se valorarán especialmente los siguientes aspectos:

- Definición clara de los objetivos
- Coherencia del contenido
- Presencia de elementos innovadores
- Conclusiones bien definidas
- Formulación de interrogantes para el debate

Para que la propuesta de una comunicación aceptada por el Comité Científico se incorpore a la programación del Congreso hace falta que, como mínimo, uno de sus autores formalice la inscripción.

Publicación digital

La organización tiene previsto entregar a los asistentes al inicio del Congreso una publicación en formato digital con los textos completos de las conferencias y las comunicaciones aceptadas.

Las personas interesadas en que su comunicación sea incluida en esta publicación tendrá que enviar el texto completo correspondiente dentro del plazo establecido. En caso contrario sólo será publicado en el web y el trabajo formará parte de la programación del congreso pero no podrá ser incluido en la publicación digital.

Comunicaciones aceptadas para ser incluidas en la publicación del Congreso

El texto completo de las comunicaciones aceptadas por el Comité se tendrán que remitir a la secretaría del Congreso antes del **26 de abril de 2011**, mediante la plataforma de administración de eventos ConfTool (como documento adjunto en formato .doc, .rtf, .odt o .zip) y será revisado por el Comité Científico del Congreso.

Características y requisitos de los textos completos

Se tendrán que seguir las pautas de presentación. Es importante leerlas antes de utilizar la plantilla recomendada.

Estos textos deberán tener una extensión de entre 25.000 y 35.000 caracteres (con espacios) siguiendo el formato presentado en la plantilla y debe incluir los siguientes apartados:

- Título de la comunicación
- Autores de la comunicación, detallando para cada uno los siguientes datos:
  - Nombre y apellidos
  - Universidad/institución
  - Dirección electrónica
- Resumen (Extensión mínima: 500 caracteres con espacios. Extensión máxima: 700 caracteres con espacios)
- Texto de la comunicación
- Conclusiones
- Bibliografía
- Cuestiones y/o consideraciones para el debate

Descargar plantilla del texto completo de la comunicación

Nota:
- Para obtener el Certificado de Presentación de Comunicación es necesario que el autor/a (inscrito/a en el Congreso) asista a la Mesa de Comunicaciones en la que se incluie su trabajo.

- La organización del Congreso UNIVEST'11 tiene previsto hacer difusión, publicar o comunicar el material de las contribuciones, de forma íntegra o parcial, sin obtener ningún beneficio comercial, exclusivamente con fines de investigación y soporte o ilustración a la docencia. Los/las autores/as participantes al Congreso UNIVEST'11 aceptan, con su participación, ceder de forma no exclusiva y para estas finalidades, los derechos de explotación que le corresponden como autor, sin límite temporal ni territorial, autorizando a UNIVEST'11 a realizar la difusión, publicación o comunicación de la grabación a través de cualquier medio, Internet incluido, y autoriza de forma expresa la incorporación de los documentos en una base de datos electrónica de acceso abierto.

5.3.1.2. 3rd International Conference on Education and New Learning Technologies (EDULEARN)

G. Moltó and J. F. Monserrat, "Leveraging Distance Learning Of Engineering Skills Through Video Exercises," in 3rd International Conference on Education and New Learning Technologies (EDULEARN), 2011, pp. 864–871.

- Participación: Ponencia
- Título del trabajo presentado: Leveraging Distance Learning Of Engineering Skills Through Video Exercises
- Entidad organizadora: International Academy of Technology, Education and Development (IATED)
- Lugar de celebración: Barcelona, España
- Publicación: ISSN/ISBN: 978-84-615-0441-1
- Objetivos: 3rd International Conference on Education and New Learning Technologies (EDULEARN)
- Perfil de los destinatarios: Docentes internacionales
- Fecha de inicio: 04/07/2011
- Fecha de fin: 06/07/2011

EDULEARN11

Barcelona . 4th - 6th, July, 2011

iated

INTERNATIONAL CONFERENCE ON EDUCATION AND NEW LEARNING TECHNOLOGIES

Certificate of Participation

This is to certify that:

Germán Moltó Martínez

has participated in the *International Conference on Education and New Learning Technologies*

Barcelona (Spain), 4th-6th of July, 2011.

iated

International Association of Technology, Education and Development

EDULEARN11, Local Organizing Committee

04/07/2011

872

EDULEARN11

Barcelona . 4th - 6th, July, 2011

iated

INTERNATIONAL CONFERENCE ON EDUCATION AND NEW LEARNING TECHNOLOGIES

This is to certify that:

Germán Moltó Martínez

has presented the paper entitled:

LEVERAGING DISTANCE LEARNING OF ENGINEERING SKILLS THROUGH VIDEO EXERCISES

at the *International Conference on Education and New Learning Technologies* held in Barcelona (Spain), 4th-6th of July, 2011.

iated

International Association of Technology, Education and Development

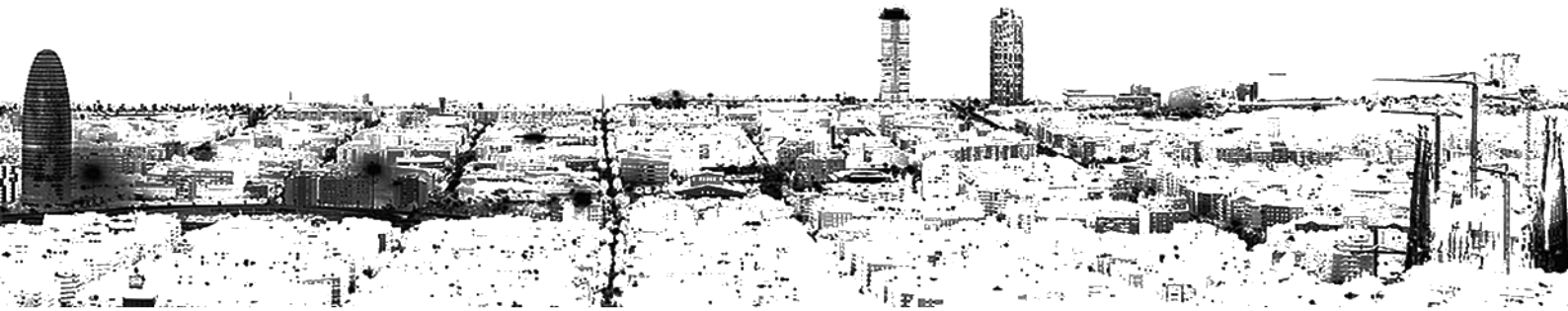
EDULEARN11, Local Organizing Committee

04/07/2011

872

EDULEARN11

CONFERENCE PROCEEDINGS



Published by
International Association of Technology, Education and Development (IATED)
www.iated.org

EDULEARN11 Proceedings CD
Edited by
L. Gómez Chova, D. Martí Belenguer, A. López Martínez
International Association of Technology, Education and Development
IATED, Valencia, Spain

ISBN: 978-84-615-0441-1
Depósito Legal: V-2332-2011

Book cover designed by
J.L. Bernat

LEVERAGING DISTANCE LEARNING OF ENGINEERING SKILLS THROUGH VIDEO EXERCISES

Germán Moltó[1], Jose F. Monserrat[2]

[1]Dpt. of Information Systems and Computation, Universitat Politècnica de València (SPAIN)
[2] Communications Department, Universitat Politècnica de València (SPAIN)
gmolto@dsic.upv.es, jomondel@dcom.upv.es

Abstract

This paper summarizes the initial results of an experience with the usage of video exercises in order to provide learners with supplementary online multimedia material created by the teachers. The video exercises depict the statement and the resolution process of a single problem, being solved by the teacher in a sort of digital whiteboard. These learning objects thus turn into educational pills that can be reused by the teacher in different scenarios such as distance learning, out-of-class material, office hours, etc. This experience has been performed in subjects related to computer science and telecommunications engineering during the 2010/2011 academic course. The paper describes the methodology and process from recording the problem-solving videos to their online delivery. This approach required the combination of different technologies such as a graphics tablet, sketching software, screencasting, video transcodification and closed captioning, among others. These efforts resulted in a pool of online accessible video exercises that can be employed for the students to gain the appropriate skills in order to solve other related problems. In addition, the ubiquity of Internet enables these new materials to outreach potential learners from outside the university.

Keywords: Video, Distance Learning, Engineering.

1 INTRODUCTION

The introduction of technology at the University has traditionally been focused on increasing the computer-per-person ratio in the learning centres. However, the widespread adoption of broadband connections, combined with the fact that hardware prices have plummeted during the last decade, has put technology and online access right in our fingertips. Nowadays, the massive adoption of smartphones, tablets, netbooks and other kinds of equipment by current students forces the professors to adopt new strategies more aligned with their student's digital life.

Many technical degrees require the students to solve problems by applying certain methodologies and techniques that can only be achieved by developing the appropriate skills. These skills are traditionally learned by mimicking professors during problem solving. After exercising these capabilities a certain number of times, students are usually offered with a collection of problems together with their solution. However, the procedure to achieve these solutions, in order to develop the aforementioned skills, is traditionally only carried out during the class lessons. This is a major handicap, especially for distance learners, or in courses with limited time. Those who cannot attend the classes must rely on the office hours or even on other students in order to understand how to solve a certain problem.

In order to leverage distance education, but also as a complementary material to all students, the combined use of graphics tablets and screen recorders arises as a powerful tool to document the process of exercise solving. This produces a win-win situation for teachers and students. On the one hand, teachers only devote time to the creation of the video exercise together with a clear audio explanation of the problem solving approach. On the other hand, making these videos available online enables students to access these educational objects on demand, whenever and wherever they like and on the platform (PC, mobile phone, etc.) they choose.

In the very last few years, there has been a common trend in Spanish universities to produce learning objects in the shape of multimedia material (combining audio, video, diagrams, etc.) that can be seamlessly accessed by the students. This has been the case of the *Universitat Politècnica de València* (UPV), which, for the last years, has encouraged its professors to develop the so-called *Polimedias* [1]. These are 10-minute videos that include a set of slides that are explained by the teacher, who physically appears on the video to better capture the attention of the viewer. These videos have played a fundamental role for distance learners and have also been a crucial

supplementary material for the students that want to complement their attendance to the classroom. We firmly believe that producing learning videos that can be seamlessly accessed by our students paves the way to increase the student's autonomy during their learning process. However, one of the main drawbacks of Polimedias is that they require special equipment for their production and, thus, the videos are recorded in specific installations at the university. In addition, they are recorded as a single entity (no post-editing is available) and require the teachers to arrange an appointment for recording them. Therefore, in this paper we advocate to complement these recordings by videos generated by the teacher specially focused on the resolution of engineering problems. This approach offers greater flexibility to the teacher.

In fact, the usage of video technologies to encourage learners is not a new a topic. In 1989 a study from the Vanderbilt University showed that students working actively and collaboratively with interactive video improve their learning outcomes [2]. From that moment, several research teams from a number of universities have also reported positive findings based on collaborative learning using video technologies [3]-[5]. The DIVER (Digital Interactive Video Exploration and Reflection) platform developed at Stanford was the first attempt to export video learning to the web so that other teachers can observe and comment on the materials [6]. Today, more and more videos are designed for educational purposes, which can help students to build their own knowledge. Commercially, web based video content delivery platforms have attracted an enormous popularity for information spreading, entertainment and social networking areas. This popularity is reflected in the video sharing tool YouTube where complete courses can be followed remotely. There are also several online platforms available based on video e-learning, like Khan Academy [7] or eduFire [8].

This paper summarizes the initial results of an experience in the fields of computer science and telecommunications engineering with the recording and the online delivery of problem solving videos. These efforts resulted in a set of online accessible video exercises that can be employed for the students to gain the appropriate skills in order to solve other related problems. As an additional side product, the use of a graphics tablet allows the professor to create digital diagrams that can be enriched over time and can be delivered to students through digital channels as a replacement of traditional photocopies.

After the introduction, the remainder of the paper is structured as follows. First of all, section 2 summarises the workflow involved in creating and distributing the video exercises, with a special emphasis on the tools and technologies employed. Next, section 3 describes a couple of video exercise samples in the field of computer science and telecommunications engineering. Then, section 4 discusses the impact of the experience both from the perspective of the students and the teachers. Finally, section 5 concludes the paper and proposes future research lines.

2 PROBLEM-SOLVING VIDEO EXERCISES

The learning video exercises that we propose consist of a combination of audio and video in which a white background serves as the canvas for the teacher to propose and solve a problem, just like writing on a paper. The video captures the resolution process of the problem while the teacher creates diagrams, draws equations or sketches an idea in order to clarify the explanation. The video is accompanied by an audio narration of the teacher in which the resolution process is explained. Thus, these video exercises can be considered the digital counterpart of the problem solving process using pen and paper. Adapting these old and well known concepts to the new digital era enables to produce new learning materials that are not disruptive with the procedures already known by the students.

Creating these video exercises requires several hardware and software components. The hardware equipment comprises a computer and, optionally, a digital tablet, which behaves as a mouse, and enables the user to draw just like with a normal pen. The audio input to narrate the video exercise is generated by means of a headset microphone in order to reduce the background noise. Concerning the software requirements, the following items are required. First of all, a screencasting software that allows recording the audio and actions of the computer made by the teacher. Moreover, it is needed a video editing software in charge of post-processing the video. Then, video codification software is required to export the recorded screencast into a suitable format. Finally, an online video distribution platform should be employed to enable access to the recordings through the Internet. The following section describes the underlying technologies employed to support this work.

2.1 Tools and technologies

This section summarises the tools and technologies employed. It provides an overview of some of the currently available software, including the specific tools employed in the experiences.

2.1.1 Sketching Software

Sketching is the typical scribbling of an idea on a piece of paper. It's just a quick way to get an idea down on paper, or to solve a problem on a blackboard. Figure 1 shows an example of what sketching is. Sketching software tools provides the user the capability of drawing sketch using a computer.

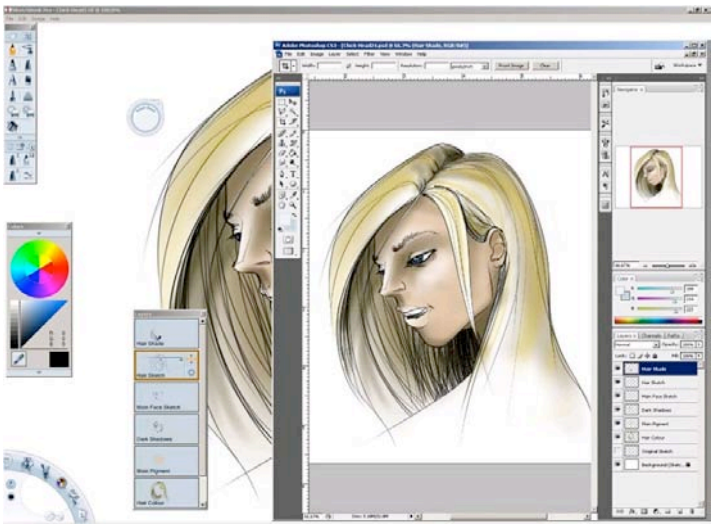


Figure 1. Example of sketch with Adobe and Autodesk tools

The first important element that should be considered for computer-aided sketching is the interface device. Of course a simple mouse could be used, but the manageability is in this case quite limited and our experience advices against this kind of devices. The preferred interface is a graphics tablet that supports both pressure and pen tilt. Pressure is used to control the variable-width brush whereas pen tilt controls the rotation and allows a more personal styling. In the market there are several graphics tablets with a number of sizes that support pressure and tilting. One of the most reputed manufacturers is Wacom and the Intuos series. It is generally a good idea to get a large tablet since this reduces the overhead of time required to manage several sheets along the explanation.

Concerning software tools, there are several alternatives of conventional software and also of online applications. From the former group, *painter sketch pad* from Corel, *SketchBook Pro* from Autodesk and *ideas* from Adobe are probably the best professional tools. All of them reproduce the look of traditional media (pens, chalk, pencils, markers etc.) and they are especially suited to work with pen and drawing tablets that let you control shading and vary stroke width by angling your pen on the tablet. From the latter group, that is, the online applications, there are several ones such as *Odosketch*, *Canvastic* or *Sketchpad*. All of them allow making good sketches, although these tools do not support pressure and pen tilt sensibility, which reduces the quality of the final product. A fairly comprehensive list of online tools can be found in [9].

2.1.2 Screencast Software

Screencasting is the process of recording the computer screen output, typically combined with an audio narration. This process is commonly employed to let others visualize the same set of actions performed with a computer together with a verbalised description of the procedure.

There are different tools currently available for this purpose. The software Camtasia [10], developed by TechSmith, combines in a single software package both screen recording and video editing software. There are versions available both for Windows and for Mac. Jing [11], also developed by TechSmith, is a very simple tool for the Mac that enables screencasting of up to 5 minutes. There is a free version that generates an Adobe Flash-based video. The *pro* version allows exporting the video to MPEG-4 format. ScreenFlow [12], developed by Telestream, is a screencast application for the Mac that includes video editing capabilities and can export the video to both MPEG-4 and Adobe Flash.

2.1.3 Online Video Hosting Services

With the advent of broadband connections, online video hosting services have bloomed. They allow users to upload their videos and make them available to the whole Internet or to a specific set of users. Authors might also try to monetize their videos according to the number of times that they have been watched. There is currently a myriad of different available services. For example, YouTube [13] is a video-sharing website whose content is uploaded both by individuals and media corporations. Blip.tv [14] is a platform for distributing independent shows that consists of different episodes. Some universities are also developing their own video sharing platforms in order to leverage distribution of educational content. This is the case of poli[Tube] [15], created by the Universitat Politècnica de València (UPV) in Spain. This platform enables users to upload videos and provide access control to their content. The videos can be public, i.e. accessible by everybody, private, i.e. the user must be a valid user of the UPV and if the video belongs to a private group, then the user must belong to that group, and, finally, non-advertised, i.e. the video is available by the users that access a specific link but it cannot be searched by other users of the platform.

2.2 Creation and Distribution

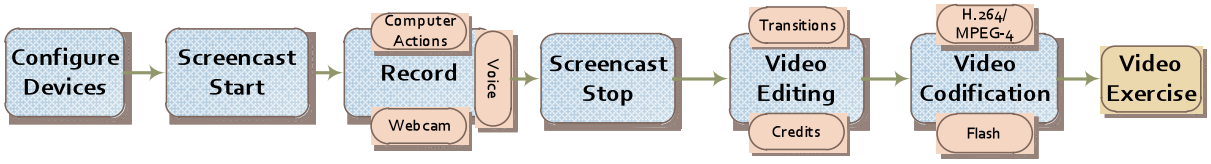


Figure 2. Workflow to generate a video exercise

Figure 2 depicts the typical workflow (from left to right) employed to create the video exercise. First of all, the devices should be properly configured. This includes adjusting the audio settings to the noise level of the room and configuring the virtual pencils in the sketching software. The usage of a set of pencils allow to create more dynamic drawings by combining different pencil widths and colours in order to stress different areas of the problem. After the setting, the screencast session can proceed.

When the screencast session starts, the teacher proceeds to carry out the exercise combining the drawings in the digital tablet and the narration through the headset. The screencast software proceeds to record all this information in the background, while the teacher focuses on the exercise resolution. If the teacher does not feel confident about a certain explanation or simply introduces a mistake during the process, the screencast session can be restarted. This trial and error iterative procedure enables the teacher to gain confidence with the video exercise generation methodology.

When the teacher finishes and the screencast stops, it is time to edit the video. Some screencasting software includes basic video editing tools that allow trimming the video and to include transitions at the beginning and the end of the video. It is also interesting to include a mark in the video to clearly identify its authorship. This can be achieved by means of a watermark introduced in the video during the post-processing stage. However, the author identification can also be created by using different layers in the sketching application. The lowest layer can include the authorship identification details. On top of that, there can be a layer dedicated to state the problem. Finally, the uppermost layer can be devoted to drawing the solution of the problem. The usage of different layers eases the work by the teacher, since a mistake during the resolution only requires erasing a single layer.

Then, the video should be codified with an appropriate codec. Examples of these codecs are H.264 (MPEG-4) or Adobe Flash. The proper choice of the codec should consider the requirements imposed by the online video hosting service to be employed. Most of these providers accept H.264 videos. If the videos are to be put online in a personal web page, then the Flash format should be enough. The final size of the video depends primarily on its length and the quality configuration of the codec. Our experience shows that we should expect a size of approximately 30 Mbytes for a 7-minute video.

It is important to point out that videos should not be longer than 5-10 minutes in order to capture and maintain the attention of the viewer. Given that the exercises must be self-contained, it is important to cut straight to the point when addressing a large problem to be solved.

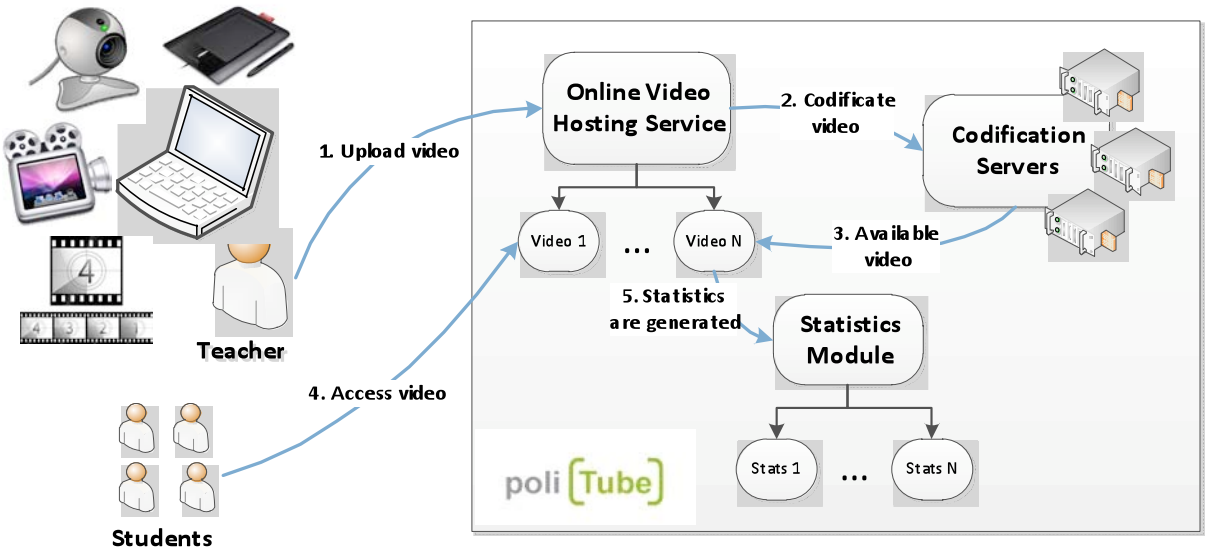


Figure 3. Workflow of video exercise distribution and student's access

Figure 3 depicts the workflow employed for video distribution and its access by the students. The teacher uploads a video to the online video hosting service (step 1). In our case, we are using the poli[Tube] service offered by the UPV. Once the video has been uploaded, the server might decide to encode the video using another codec and, therefore, this process is typically delegated to a group of codification servers (step 2). This process might take several minutes. Once the video is available (step 3), the teacher is notified so that the link to the video can now be accessed. This enables the teacher to publish the video as a new learning object. Then, the students access the video (step 4). This automatically generates access statistics in the poli[Tube] platform. These statistics typically include aggregated data about the number of times a certain video has been viewed and the country of origin of the viewer. These data are of importance for the teacher, who can gain immediate feedback about the impact of the videos.

As an additional side product, the use of the graphics tablet allows the professor to create digital diagrams that can be delivered to students through digital channels in the shape of a PDF document. This has several benefits. On the one hand, the diagrams can be progressively enriched over time by the professors since they always own the digital copy of the diagram. On the other hand, this approach serves as a simple replacement for traditional photocopies. Putting these diagrams online enables students to access this information via their laptops, notebooks and even mobile phone during the classes and as an out-of-class material.

2.2.1 Feedback and Student Assessment

In order to gather feedback from the students we have relied on the Google Apps platform to create an online questionnaire that allows the students to express the good and the bad points regarding each individual video. Using an online platform to gather the opinion of the students offers several benefits. Firstly, there is no paper wasted. Secondly, the poll can remain opened several days for the students to fill in the information. Thirdly, the results can be automatically obtained in a spread sheet from which data analysis can be performed.

This information is of paramount importance for the teachers, who can integrate this feedback into their methodology to progressively improve the quality of the videos. This would enable teachers to refine the pool of video exercises under a survival of the fittest approach, where the lowest ranked videos would be replaced by improved versions. Since this paper focuses on an early experience with these technologies, there is still not enough aggregated data to draw some statistically significant conclusions.

3 EXAMPLES OF VIDEO EXERCISES

This section summarises a couple of video exercises that illustrate the usage of the aforementioned technologies. These are examples that are being used in the degrees of computer science and telecommunications engineering at the UPV.

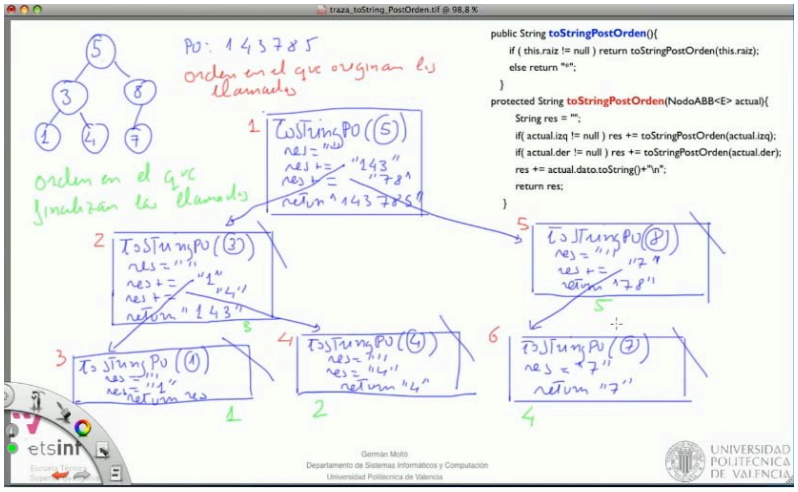


Figure 4. Example of the final result of a video exercise (traversal of a binary search tree)

Figure 4 shows a caption of the final results of a video exercise[1] employed in an undergraduate computer science subject called *Data Structure and Algorithms* to illustrate the post-order traversal of a binary search tree. This involves developing a trace of the execution of a given recursive Java method which, being multiple recursion, ends up creating a tree of activation records in the call stack of the Java Virtual Machine. This procedure is far from being a trivial task and, therefore, requires the students to pay careful attention when these concepts are explained during the class lessons. Creating these videos enables the students to have a second chance (in fact many chances) of understanding the underlying concepts in case they missed the explanation in the class. In particular, this video was created on a Mac using Autodesk SketchBook and Screenflow to create an MPEG-4 encoded video prior to uploading it to poli[Tube].

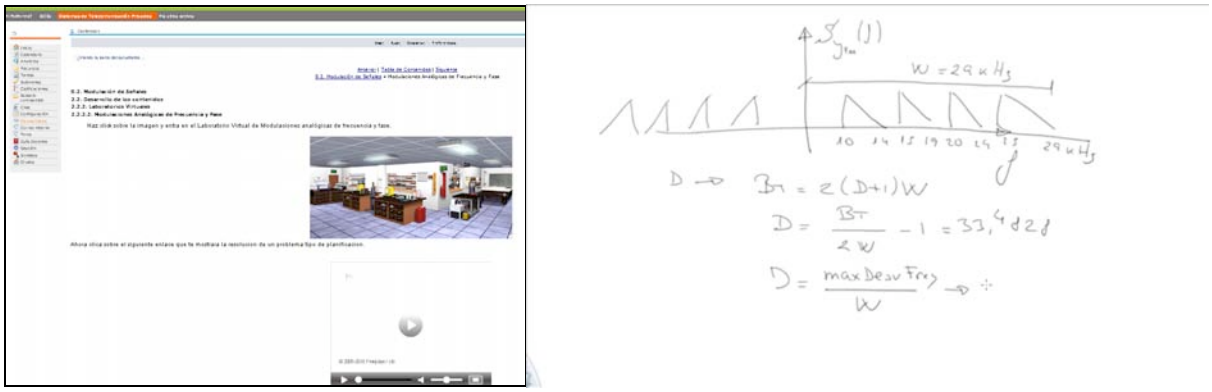


Figure 5. Integration of the video exercises in PoliformaT (left) and capture of frame (right)

As another example, Figure 5 includes another video exercise example[2] that further evolves this strategy, integrating the video exercise with PoliformaT, the Sakai-based Learning Management System (LMS) at the UPV. The video illustrates the solution of a planning exercise using a frequency

[1] The video is available at: http://politube.upv.es/play.php?vid=47794 (in Spanish).

[2] The video is available at: http://politube.upv.es/play.php?vid=47147 (in Spanish).

modulation system within an undergraduate course called Communications Theory in Telecommunications Engineering. This kind of exercises is hard to understand because of the mathematical complexity and the required reasoning capacity. To create this video, the following material was employed: The Intuos 4 Wacom digital tablet for the user interface, the SketchBook Pro to create the drawings and Camtasia as a screen recorder. All the recordings were shared with the students through PoliformaT whereas the poli[Tube] service was employed as the video streaming service. This allows students to watch the videos embedded in the same rich content platform provided by PoliformaT.

On clicking the video the resolution of the problem can be followed including the professor's speech and the reasoning process the solution includes. The student experience is quite similar to a master class in which the professor uses the blackboard to solve an exercise. In this sense the usage of a good graphics tablet is essential to achieve this personal styling that resembles the class sessions together with their familiarity and closeness.

In the course in which this method was used, all partial exams and proposed exercises were digitally solved and made accessible for the online review of the students.

4 DISCUSSION

This section aims at assessing the potential benefits and drawbacks of video exercises from both student's and professor's point of view.

For the students, video exercises have several advantages. For distance learners, or even for those students who missed a lesson, the time required to catch up significantly reduces, since the students can use these videos to develop the required skills. In addition, the students can seamlessly access these recordings on demand through an online video service provider. Therefore, they can repeatedly watch the resolution process of a certain problem until the problem solving skills are acquired. In addition, since they can asynchronously move through the video, they can focus on specific areas of the resolution process that might represent certain difficulties for the student. Moreover, the ubiquity of the Internet enables learners to access these materials on a 24/7 basis from virtually every possible device. Most online video platforms can be accessed from a myriad of different devices such as computers, laptops, netbooks, tablet PCs, mobile phones and the iPad. Therefore, the students no longer have a strong dependence on the schedules of their professors. Instead, since they have instant access to the learning material, they can have a better sense of responsibility of their own learning process.

In addition, digital natives, i.e. our younger students, typically find this learning approach very challenging. The early experiments conducted with students showed that access to the videos was very high and distributed along the course. Videos were watched by almost all the students, but with a higher rate by those who did not strictly comply with the class attendance. Specifically, on average, each student accessed the video exercises 2.3 times what means that the reinforcement learning was not only interesting but also required to understand the explained concepts. Concerning digital immigrants, i.e. those students not familiar with new technologies, the simplicity of the web-based platform guaranteed a reduced learning curve that resulted in a fast assimilation of the concepts.

Concerning teachers, the main advantage of the video exercises lies on the fact that they do not have to repeat the same exercise several times. Video exercises can help to solve common problems, especially for office hours where professors often have to solve the same problem for different students. Besides, the learning success is increased, as experience demonstrated, being also higher the students motivation and hence their course satisfaction.

The main drawback of the video exercises is the additional effort required to get used to the new hardware and software tools. However, after some training, the video generation proved to be as simple as solving a problem on a paper. The time needed to learn compared to the waste of time arising from solving the same problem several times, justifies without any doubt the initial time investment. In addition, the set of video exercises produced (or at least a subset) can certainly be reused for different courses, where the highly ranked videos should be considered an important material to be offered to future students. Finally, we would like to stress that the usage of online video services enables to use this material for foreign learners or even prospective students. Therefore, if the teacher decides so, the produced videos can be released to the worldwide academic community so that others can benefit from the work done.

5 CONCLUSIONS AND FUTURE WORK

This paper has described the early experiences of using video exercises that can be accessed online in which the teacher solves a certain problem using a digital tablet together with a narration of the procedure. These videos can be seamlessly accessed by the students in order to gain the appropriate skills. These techniques have been employed in the degrees of computer science and telecommunications engineering at the Universitat Politècnica de València. The advantages introduced by this approach, both for professors and students, encourages us to continue with this research line.

In the near future, we plan to continue with the development of additional videos, incorporating the feedback gained in the early experiences. It should also be important to address additional techniques such as closed captioning in order to reduce the limiting barriers for students with special requirements. Introducing subtitles in some of the videos could address some of these barriers.

ACKNOWLEDGEMENTS

The authors would like to thank the “Vicerrectorado de Estudios y Convergencia Europea” of the “Universitat Politècnica de València” for the economic support for the project “Aprendizaje virtual síncrono mediante entornos colaborativos en un contexto multidisciplinary (A001/10).”

REFERENCES

[1] Polimedia. http://polimedia.blogs.upv.es/?page_id=105&lang=en

[2] Jasper Woodbury Series. http://peabody.vanderbilt.edu/projects/funded/jasper/intro/Jasperintro.html

[3] G. Rafe, J.H. Manley, "Learning style and instructional methods in a graduate level engineering program delivered by video teleconferencing technology," Frontiers in Education Conference, vol.3, pp.1607-1612, 1997.

[4] Li Bian, "Information Technology and Its Application in E-learning," International Conference on Networking and Digital Society, vol.1, pp.293-296, 2009.

[5] Xiao-Ming Zuo, "An interactive multimedia web-based learning system for Pro/Engineer training," International Conference on Future Information Technology and Management Engineering, vol.1, pp.152-154, 2010.

[6] R. D. Pea, M. Mills, J. Rowsen, K. Dauber, W. Efferlsberg, and E. Hoffert, “The DIVER project: Interactive digital video repurposing”. IEEE Multimedia, 11(1) pp 54-61, 2004.

[7] KhanAcademy official site. http://www.khanacademy.org/

[8] EduFire official site. http://edufire.com/

[9] Top 15 Online Tools For Drawing And Sketching. http://www.smashingapps.com/2010/07/22/top-15-online-tools-for-drawing-and-sketching.html

[10] Camtasia. http://www.techsmith.com/camtasia/

[11] Jing. http://www.techsmith.com/jing/

[12] ScreenFlow. http://www.telestream.net/screen-flow/

[13] YouTube. http://www.youtube.com

[14] Blip.tv. http://blip.tv/

[15] poli[Tube]. http://politube.upv.es/

5.3.1.3. Jornadas de Innovación Educativa de la UPV 2012

G. Moltó et al., "Integración de las Herramientas PoliReunióN y Politube en la Práctica Docente en la UPV," in Jornadas de Innovación Educativa de la UPV 2012, 2012, pp. 197–201.

- Participación: Ponencia
- Título del trabajo presentado: Integración de las Herramientas Poli[ReunióN] y Politube en la Práctica Docente en la UPV
- Entidad organizadora: Universitat Politècnica de València
- Lugar de celebración: Valencia, España
- Publicación: ISSN/ISBN: 978-84-8363-926-9
- Objetivos: Jornadas de Innovación Educativa de la UPV 2012
- Perfil de los destinatarios: Docentes
- Fecha de inicio: 12/07/2012
- Fecha de fin: 13/07/2012

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

VICERECTORAT D'ESTUDIS I CONVERGÈNCIA EUROPEA

Instituto de Ciencias de la Educación

D. Fernando Fargueta Cerdá, Director del Instituto de Ciencias de la Educación de la Universitat Politècnica de València,

CERTIFICA QUE:

D./Dª. **GERMÁN MOLTÓ MARTÍNEZ** con DNI **52656437 F** ha presentado la comunicación titulada **"Integración de las Herramientas Poli[Reunión] y Politube en la Práctica Docente en la UPV** en el PANEL DE RECURSOS TECNOLÓGICOS, incluido en las **Jornadas de Innovación Educativa UPV 2012**, celebradas los días 12 y 13 de julio.

Los coautores de la comunicación son:

ANA MARIA	FITA FERNÁNDEZ	48437724	T
INMACULADA	FITA FERNANDEZ	44790938	W
EVA MARÍA	MESTRE MESTRE	20007915	P
JOSÉ FRANCISCO	MONSERRAT DEL RÍO	24364596	Y
RUBEN	PICO VILA	21502221	G
ADRIAN	RODRIGUEZ BURRUEZO	34812411	W
JUAN CARLOS	RUIZ GARCÍA	52641790	B

Y para que así conste, se firma la presente en Valencia, viernes, 27 de julio de 2012.

INSTITUTO CIENCIAS de la EDUCACIÓN

Fdo.: Fernando Fargueta Cerdá

Director del ICE

Instituto de Ciencias de la Educación

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

EDITORIAL

ISBN 978-84-8363-926-9

Instituto de Ciencias de la Educación

ENSEÑAR *de otra manera* APRENDER

Jornadas dE iNnoVación EduCAtiva de la UPV 12 y 13 de JuliO de 2012

EDITORIAL
UNIVERSITAT POLITÈCNICA DE VALÈNCIA

JORNADAS DE INNOVACIÓN EDUCATIVA DE LA UPV

12 y 13 de Julio de 2012

EDITORIAL

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Duplica: Diazotec

ISBN: 978-84-8363-926-9
Producción bajo demanda
Ref. editorial: 2000

Integración de las Herramientas Poli[ReunióN] y Politube en la Práctica Docente en la UPV

Germán Moltó, Dpto. de Sistemas Informáticos y Computación, gmolto@dsic.upv.es; Ana Fita, Dpto. de Biotecnología, anfifer@btc.upv.es; Inma Fita, Dpto. de Física Aplicada, infifer@fis.upv.es; Eva M. Mestre, Dpto. de Lingüística Aplicada, evmesim@upvnet.upv.es; Jose F. Monserrat, Dpto. de Comunicaciones, jomondel@dcom.upv.es; Rubén Picó, Dpto. de Física Aplicada, rpico@fis.upv.es; Adrián Rodriguez-Burruezo, Dpto. de Biotecnología, adrodbur@doctor.upv.es; Juan Carlos Ruiz, Dpto. de Informática de Sistemas y Computadores, jcruizg@disca.upv.es

***Resumen*—Este artículo resume las experiencias de innovación educativa llevadas a cabo por el Equipo de Innovación y Calidad Educativa (EICE) Metodologías Activas y Tecnologías de la Información (MATI) durante los cursos académicos 2010/2011 y 2011/2012. En ellas se han integrado las principales herramientas y plataformas corporativas tecnológicas de apoyo a la docencia de la Universitat Politècnica de València en un contexto multidisciplinar, con el objetivo de evaluar sus beneficios. Concretamente, Poli[ReunióN] se ha gastado como herramienta de Aprendizaje Virtual Síncrono para fomentar las tutorías virtuales, pero también como herramienta de innovación en la docencia presencial. Por otro lado Politube ha sido la plataforma sobre la que distribuir vídeo-ejercicios didácticos para el fomento del aprendizaje autónomo. Este artículo resume las experiencias llevadas acabo así como los principales resultados obtenidos, con un claro énfasis en facilitar la adopción de estas herramientas por parte de otros docentes.**

***Palabras Claves*— TIC, vídeo-ejercicios, Internet, aprendizaje online**

I. INTRODUCCIÓN

El grupo MATI (Metodologías Activas y Tecnologías de la Información) se constituyó en el año 2010 en la primera convocatoria de creación de Equipos de Innovación y Calidad Educativa (EICE) auspiciados por el Instituto de Ciencias de la Educación (ICE) de la Universitat Politècnica de València (UPV). Se fundó con los siguientes objetivos: i) mejorar la calidad de la enseñanza con el uso de metodologías activas, ii) analizar la utilidad y posibilidades de mejora de las herramientas disponibles en la UPV, iii) identificar metodologías activas útiles para la docencia en diferentes campos, iv) diseñar, desarrollar y probar nuevas herramientas interactivas para los alumnos, v) evaluar el impacto en la mejora del aprendizaje de los alumnos derivado del uso de herramientas tecnológicas aplicadas a la pedagogía universitaria y, vi) favorecer una mayor visibilidad de la innovación docente, desarrollando estrategias de difusión de logros y resultados.

El grupo tiene un carácter altamente multidisciplinar, ya que en él participan profesores de seis departamentos de la UPV (Biotecnología, Comunicaciones, Informática de Sistemas y Computadores, Sistemas Informáticos y Computación, Física Aplicada y, por último, Lingüística Aplicada), que imparten docencia en cuatro escuelas diferentes (EPSG, ETSIAMN, ETSIAYMN, ETSINF).

Las líneas de actividad del equipo se han enmarcado en el contexto de los Proyectos de Innovación y Mejora Educativa (PIME) que, en los dos últimos cursos académicos, han proporcionado el soporte económico para la realización de las actividades y la difusión de los resultados de las innovaciones educativas.

Durante el curso 2010-2011 se llevó a cabo el proyecto "Aprendizaje Virtual Síncrono Mediante Entornos Colaborativos en un Contexto Multidisciplinar (A001/10)". En él se analizaron las posibilidades de la herramienta Poli[ReunióN], que permite la creación de salas virtuales de interacción audiovisual entre profesores y alumnos, en la docencia tanto presencial como a distancia. El proyecto involucró la evaluación de la herramienta desde el punto de vista técnico y también desde el punto de vista del trabajo colaborativo y síncrono en el aula.

Durante el curso 2011-2012, el equipo ha trabajado en el proyecto "Utilización de Vídeos Didácticos para la Mejora de los Procesos de Aprendizaje Autónomo Basados en la Resolución de Ejercicios (A04/11)". Éste tiene como objetivo mejorar los procesos de aprendizaje autónomo a través de la elaboración de vídeos didácticos de resolución de ejercicios utilizando herramientas de tinta digital. El proyecto persigue la creación de vídeo-ejercicios por parte de los miembros del MATI para que los correspondientes alumnos dispongan de material complementario multimedia de ayuda al aprendizaje.

En ambos proyectos, subyace un objetivo adicional consistente en la elaboración de guías de buenas prácticas que fomenten la adopción de estas plataformas corporativas por parte de los profesores de la UPV. El objetivo, por tanto, es que el MATI se posicione como un equipo de referencia y pionero para la evaluación de plataformas tecnológicas de apoyo a la docencia en la UPV.

El objetivo de este artículo consiste en resumir las experiencias de innovación educativa llevadas a cabo en los dos últimos cursos académicos, destacando los principales resultados, con el fin de que otros docentes de la UPV puedan considerar el uso de las tecnologías aquí mencionadas para integrarlas en su práctica docente.

exige una correcta preparación pedagógica para la adecuada presentación de los contenidos en ese medio.

La principal ventaja para el profesor consiste en la disposición de un material de apoyo dinámico y fácilmente accesible complementario a la docencia presencial. En contraste a la tutoría tradicional, este sistema permite evitar la repetición de explicación a múltiples alumnos de los mismos contenidos en situaciones distintas.

C. Discusión General

El uso de herramientas tecnológicas de apoyo a la docencia como es el caso de Poli[ReunióN] permite mejorar el proceso de formación de los estudiantes por tratarse de una herramienta accesible, inmediata, que favorece las tutorías y el debate entre alumnos y profesor. En los últimos años, facilitar como único material de estudio una relación bibliográfica ha quedado obsoleto. En muchos casos los alumnos están desbordados con la cantidad de información y les cuesta filtrarla, por ello solicitan instrucciones más concretas sobre cómo abordar el estudio de una asignatura, piden materiales más escuetos, claros, atractivos y si es posible que se encuentren en Internet.

Tradicionalmente los alumnos se han quejado sobre el gran número de horas que pasan en la universidad. Actualmente los nuevos planes de estudios contemplan los créditos presenciales y no presenciales que un alumno ha de cursar para superar una asignatura. Todos los materiales y herramientas propuestos en este trabajo facilitan que el alumno desarrolle las actividades no presenciales desde su propia casa, sin prescindir de la guía del profesor en todo momento.

Las experiencias realizadas y las evidencias obtenidas a través de encuestas realizadas a los alumnos muestran también que el alumnado expresa el interés por este tipo de herramientas docentes. Sin embargo, también se pone en evidencia que su utilización ha de ser complementaria al resto de actividades docentes y no remplazarlas.

El uso de las tecnologías al servicio de la docencia tiene muchas ventajas, tanto la herramienta Poli[ReunióN] como los vídeo-ejercicios difundidos a través de Politube son complementos perfectos a las clases presenciales. Sin duda, consideramos acertada la apuesta de la UPV por estas plataformas tecnológicas que deben ser convenientemente difundidas entre los profesores para facilitar su adopción y conseguir que su uso en la práctica docente diaria sea tarea habitual.

IV. CONCLUSIONES

Las plataformas digitales, como PoliformaT en la UPV, han permitido la divulgación de un amplio espectro de materiales docentes distintos a los tradicionales apuntes. Sin embargo, las TICs proporcionan un horizonte de innovación docente todavía más interesante. Las herramientas evaluadas por el equipo MATI, Poli[ReunióN] y vídeo-ejercicios apoyan el autoaprendizaje, la educación a distancia y, en algunas ocasiones, el trabajo colaborativo. Además, han demostrado ser útiles en distintos contextos dentro de la educación superior universitaria. En los estudios realizados por el grupo se ha evaluado su posible implantación de manera habitual así como la aceptación por parte del alumnado. Sin embargo, faltaría evaluar si realmente estas técnicas suponen una verdadera ventaja para el aprendizaje en comparación con las técnicas habituales. Si consideramos como ventaja la accesibilidad, por supuesto que estas herramientas confieren un beneficio. Por lo tanto sólo faltaría estudiar el impacto real de estas herramientas en el aprendizaje útil de los alumnos. Este tipo de estudios sólo se pueden hacer a largo plazo y cuando las herramientas estén perfectamente implantadas, pues en caso contrario los resultados de la comparación entre aprendizaje convencional *versus* aprendizaje con TICs no serían adecuados.

Por último cabe destacar que el grado de aceptación de estas herramientas por parte del alumnado invita a continuar con estas líneas de trabajo e incorporar nuevas herramientas para futuras innovaciones docentes.

AGRADECIMIENTOS

Los autores desean expresar su agradecimiento al Vicerrectorado de Estudios y Convergencia Europea de la Universitat Politècnica de València por los proyectos PIME (A001/10) y (A04/11).

REFERENCIAS

[1] Adobe Connect. www.adobe.com/products/adobeconnect.html

[2] G. Moltó, A. M. Fita, J.F. Monserrat, A. Rodriguez-Burruezo, E. M. Mestre, "*La Tutoría Virtual para la Autogestión del Aprendizaje en las Enseñanzas Técnicas*", en III Congreso Internacional UNIVEST 2011.

[3] J.C. Ruiz, G. Moltó, J. Monserrat, A. Fita, A. Rodriguez, E. Mestre, M.C. Poveda, "*Aprendizaje Virtual Síncrono Mediante Entornos Colaborativos en un Contexto Multidisciplinar*", en III Jornada de Innovación Docente en Informática (JIDINF'10).

[4] A. Fita, J.F. Monserrat, G. Moltó, E.M. Mestre, A. Rodriguez-Burruezo, "*Multidisciplinary Experiences at University Degrees in the Use of Synchronous E-learning*", en International Conference The Future of Education, 2011, pp. 121-127.

[5] G. Moltó, J.F. Monserrat, "*Leveraging Distance Learning Of Engineering Skills Through Video Exercises"*, en 3rd International Conference on Education and New Learning Technologies (EDULEARN), 2011, pp. 864-871.

[6] J. F. Monserrat, A.M. Fita, G. Moltó, E.M. Mestre, A. Rodriguez-Burruezo, "*Experiencias de Uso de la Herramienta de Aprendizaje Virtual Síncrono Poli[ReunióN]*", en Jornada de Innovación Docente ICE-UPV. Valencia, 2011.

[7] I. Fita, J.F. Monserrat, J.C. Ruiz, A. Fita, E.M. Mestre, A. Rodríguez-Burruezo, R. Picó, G. Moltó, "Experiencias en el Uso de Vídeo-Ejercicios en la Docencia Universitaria", International Congress on University Teaching and Innovation (CIDUI 2012).

[8] T. Traphagan, J.V. Kucsera, and K. Kishi,"*Impact of class lecture webcasting on attendance and learning*", en Educational Technology Research and Development 58 (1), 2009, pp. 19-37.

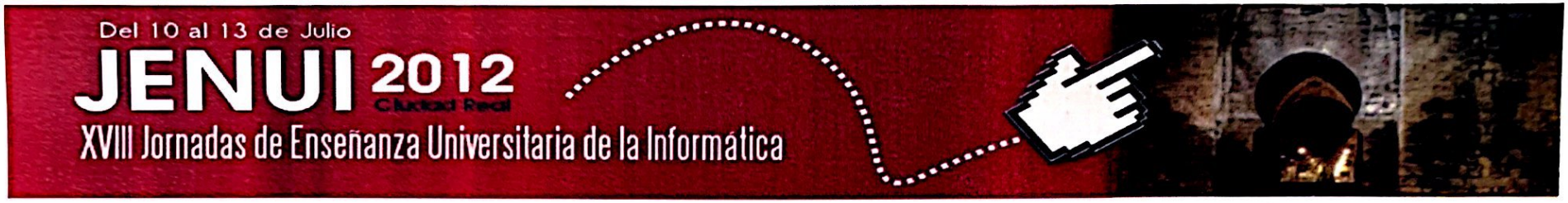
[9] M.B. Wieling, W.H.A. Hofman, "*The impact of online video lecture recordings and automated feedback on student performance*", Computers & Education 54 (4), 2009, pp. 992-998.

[10] Y.J. Park, C.J. Bonk, "*Synchronous learning experiences: Distance and residential learners*' perspectives in a blended graduate course", en Journal of Interactive Online Learning 6 (3), 2007, pp. 245-264.

5.3.1.4. XVIII Jornadas de Enseñanza Universitaria de la Informática (JENUI 2012)

G. Moltó, "Producción y Uso de Vídeo-Ejercicios Didácticos en Asignaturas de Programación," in XVIII Jornadas de Enseñanza Universitaria de la Informática (JENUI 2012), 2012, pp. 255–262.

- Participación: Ponencia
- Título del trabajo presentado: Producción y Uso de Vídeo-Ejercicios Didácticos en Asignaturas de Programación
- Entidad organizadora: Universidad de Castilla – La Mancha
- Lugar de celebración: Ciudad Real, España
- Publicación: ISSN/ISBN: 84-615-7157-6
- Objetivos: XVIII Jornadas de Enseñanza Universitaria de la Informática (JENUI 2012)
- Perfil de los destinatarios: Docentes universitarios de informática.
- Contribución a las XVIII Jornadas sobre la Enseñanza Universitaria de la Informática. JENUI es una conferencia que se celebra anualmente, auspiciada por AENUI (Asociación de Enseñantes Universitarios de la Informática) y que dispone de un riguroso proceso de evaluación por pares doble ciego. Se lleva celebrando desde el año 1994. Se aporta certificado de presentación de comunicación y la contribución de acuerdo a las indicaciones de la Guía de Ayuda.
- Fecha de inicio: 10/07/2012
- Fecha de fin: 13/07/2012



AENUI

Asociación de Enseñantes Universitarios de la Informática

Escuela Superior de Informática

UCLM
UNIVERSIDAD DE CASTILLA-LA MANCHA

Los coordinadores del Comité de Organización de JENUI 2012

CERTIFICAN que,

D/Dña **GERMÁN MOLTÓ MARTÍNEZ** ha participado como **ASISTENTE** en las XVIII Jornadas de Enseñanza Universitaria de la Informática (JENUI), celebradas del 10 al 13 de Julio de 2012 en la Escuela Superior de Informática en el Campus de Ciudad Real de la Universidad de Castilla-La Mancha.

Ciudad Real, a 10 de julio de 2012

Dr. Marcela Genero Bocco
Profesora Titular de Universidad

Dr. Luis Jiménez Linares
Profesor Titular de Universidad

Dr. Miguel A. Redondo Duque
Profesor Titular de Universidad

Del 10 al 13 de Julio

JENUI 2012 Ciudad Real

XVIII Jornadas de Enseñanza Universitaria de la Informática

AENUI

Asociación de Enseñantes Universitarios de la Informática

Escuela Superior de Informática

UCLM UNIVERSIDAD DE CASTILLA-LA MANCHA

Los coordinadores del Comité de Organización de JENUI 2012

CERTIFICAN que,

D. **GERMÁN MOLTÓ MARTÍNEZ** ha presentado el artículo titulado **"Producción y Uso de Video-Ejercicios Didácticos en Asignaturas de Programación"** en las XVIII Jornadas de Enseñanza Universitaria de la Informática (JENUI), celebradas del 10 al 13 de Julio de 2012 en la Escuela Superior de Informática en el Campus de Ciudad Real de la Universidad de Castilla-La Mancha.

Ciudad Real, a 10 de julio de 2012

Dr. Marcela Genero Bocco
Profesora Titular de Universidad

Dr. Luis Jiménez Linares
Profesor Titular de Universidad

Dr. Miguel A. Redondo Duque
Profesor Titular de Universidad

ACTAS

XVIII Jornadas de Enseñanza Universitaria de la Informática

Ciudad Real, del 10 al 13 de Julio de 2012

Escuela Superior de Informática

Universidad de Castilla – La Mancha

Asociación de Enseñantes Universitarias de la Informática

Luis Jiménez Linares
Marcela Genero Bocco
Miguel Ángel Redondo Duque
(Editores)

AENUI
Asociación de Enseñantes Universitarios de la Informática

Escuela Superior de Informática

UCLM
UNIVERSIDAD DE CASTILLA-LA MANCHA

Edita: Comité de Organización de las XVIII Jornadas de Enseñanza Universitaria de la Informática

Depósito Legal:

I.S.B.N. - 10: 84-615-7157-6

I.S.B.N. – 13: 978-84-615-7157-4

Libro de Actas de JENUI 2012

Las contribuciones que a continuación se presentan están recogidas en las Actas de las XVIII Jornadas de Enseñanza Universitaria de la Informática, celebradas en la Escuela Superior de Informática de la Universidad de Castilla - La Mancha en el campus de Ciudad Real, durante los días 11 a 13 de julio de 2012.

ISBN: 84-615-7157-6 / 978-84-615-7157-4

Portada

Presentación

Comités

Índice de contenidos

Sección "*Didáctica en los estudios de Ingeniería Informática*"

Sección "*Calidad y evaluación de la docencia*"

Sección "*Evaluación del aprendizaje*"

- Evaluación formativa usando exámenes no presenciales
- Formación de equipos de trabajo basada en factores de la personalidad de los integrantes: un estudio empírico
- Concurso de proyectos en la asignatura "Percepción Visual" del máster en sistemas inteligentes
- Evaluación por Compañeros de Exposiciones Orales
- Evaluación y seguimiento de trabajos en equipo de desarrollo de software a través de la calidad del código fuente
- Una nueva aproximación a la evaluación de laboratorio en programación de sistemas
- Evaluación de competencias en Ingeniería de Software mediante competición
- Métricas para la medición de las Competencias Generales y Específicas para el Grado en Ingeniería Informática

Sección "*Desarrollo de competencias transversales y profesionales*"

- Documentos Representativos y Destrezas de Redacción: simplificando la enseñanza de la comunicación escrita
- Diseño de trabajos basado en aprendizaje por experiencias. Una experiencia concreta
- Incluyendo un puzle en una asignatura de redes de ordenadores
- Reflexiones sobre el desarrollo de competencias y habilidades en alumnos de primer curso
- Desarrollo integral de las competencias genéricas mediante mapas competenciales
- Fomento del auto-aprendizaje y la adquisición de competencias transversales a través de video-tutoriales
- Preguntas para guiar el Trabajo de Fin de Grado
- Dos años y 31.000 líneas de código después: BabeliumProject, una experiencia práctica en el desarrollo de PFCs

Sección "*Aplicación de las TIC al proceso de enseñanza-aprendizaje*"

- Experiencia de organización del Primer Concurso Español de Programación Paralela
- Creaciones de contenidos audiovisuales producidos por los estudiantes como nuevo instrumento en el proceso de la enseñanza y aprendizaje: Metodología y resultados
- Experiencias TIC aplicadas a la gestión de Proyectos Fin de Carrera en el ámbito de la Web
- VGrid: Una Infraestructura Grid Virtual con fines Educacionales
- Enseñando y aprendiendo online: experiencia práctica en el Grado en Ingeniería Informática
- Producción y Uso de Vídeo-Ejercicios Didácticos en Asignaturas de Programación
- VNUML vs GNS3 en el desarrollo de laboratorios de redes virtuales
- Proceso de enseñanza-aprendizaje de los fundamentos de programación mediante metodología ABP aplicando las herramientas ofrecidas por una plataforma de enseñanza virtual en cada fase del proceso
- La plataforma AGORA. Una propuesta para la gestión e intercambio de Objetos de

Aprendizaje

- Enfoque de diseño de herramientas informáticas educativas para metodologías activas de aprendizaje

Sección "*Optimización del tiempo y el trabajo del profesor*"

- Estrategias de aprendizaje activo basado en trabajos de curso
- Un proyecto docente basado en una auténtica evaluación continua utilizando una herramienta software
- Herramientas de Instrucción Masiva: pistas para implantar evaluación continua en grandes grupos

Sección "*Mejoras pedagógicas en las asignaturas*"

- Programación de prototipos físicos como herramienta formativa en Informática
- Enseñando Fundamentos de Computadores con máquinas algorítmicas de interpretación de programas
- La Reingeniería como tópico en la Docencia de la Ingeniería del Software: una Experiencia Práctica

Sección "*Recursos docentes y demos*"

- Plataforma interdisciplinar de soporte para prácticas
- Extensión del Collections Framework de Java con una orientación docente
- Herramienta de soporte a la evaluación del aprendizaje y gestión docente
- LSscheduling: herramienta interdisciplinar de soporte docente para la asignatura de Sistemas Operativos

Sección "*Pósters*"

- Aprendizaje basado en problemas y en comparación de soluciones en un contexto semipresencial
- Análisis de la relación nota-posición en el aula de los alumnos en escuelas de ingeniería
- Diseño de un experimento para el estudio de los factores que influyen en la motivación de los alumnos al realizar actividades de autoevaluación
- Acercando Universidad y Empresa con la Asignatura "La Carrera de Informática Tras la Universidad"
- Experiencia docente con el Bolígrafo Digital en el aula
- Metodología de evaluación continua en la asignatura de Fundamentos de Programación: un cambio de evaluación enfocado al desarrollo de competencias
- El video como instrumento de aprendizaje y evaluación
- Estado del arte de la implantación y uso de plataformas Wiki en Universidades Europeas
- Aprendizaje de sistemas operativos mediante simulaciones interactivas
- Pruebas de software en la enseñanza universitaria de la informática: un título propio
- El método "Software Factory": acciones para realizar prácticas más realistas, usando

herramientas web de trabajo colaborativo, y trabajo a distancia

Actas XVIII JENUI 2012, Ciudad Real, 10-13 de julio 2012
I.S.B.N. 10: 84-615-7157-6 | I.S.B.N. 13:978-84-615-7157-4
Páginas 255-262

Producción y Uso de Vídeo-Ejercicios Didácticos en Asignaturas de Programación

Germán Moltó
Departamento de Sistemas Informáticos y Computación
Universitat Politècnica de València
Camino de Vera S/N
46022 Valencia
gmolto@dsic.upv.es

Resumen

Este artículo describe los resultados de la producción e incorporación de vídeo-ejercicios didácticos en las asignaturas Introducción a la Informática y a la Programación (IIP), Programación (PRG) y Estructuras de Datos y Algoritmos (EDA) en el Grado en Informática de la Universitat Politècnica de València (UPV). Estos vídeos describen el proceso de resolución de un ejercicio bien con ayuda de una tableta digitalizadora o bien mediante un entorno de programación. Se difunden los vídeos usando la plataforma de distribución de contenidos online Politube. Para obtener retroalimentación, se disponen de encuestas de satisfacción para que los alumnos valoren y sugieran mejoras en los vídeo-ejercicios.

Summary

This paper describes the main results of creating and integrating video-exercises in the subjects Introduction to Computer Science and Programming (IIP), Programming (PRG) and Data Structures and Algorithms (EDA) in the Degree of Computer Science at the Universitat Politècnica de València (UPV). These videos describe the resolution process of an exercise with the help of a digital tablet or by means of an Integrated Development Environment. The videos are broadcasted using the Politube online content distribution platform. To obtain feedback, online satisfaction surveys are provided to students so that they can rank the videos and suggest improvements.

Palabras clave

vídeo, ejercicios, programación, Internet

1. Introducción

La mayor parte de los alumnos que ingresan en el Grado en Informática de la Universitat Politècnica de València (UPV), tal y como sucede en otros estudios universitarios, son nativos digitales. Son personas que han conocido la tecnología desde que nacieron y están acostumbrados a ella. Se sienten más cómodos ante un material audiovisual que ante un libro de texto. Por ello, es necesario tratar de acercar algunos contenidos curriculares de las asignaturas al alumno, empleando canales de acceso al conocimiento que les resulten más agradables. Obviamente, esto no debe implicar de ninguna manera sacrificar los resultados de aprendizaje que se pretenden alcanzar con una asignatura, ni la contribución al perfil profesional.

En muchos ámbitos de la ingeniería, y particularmente en el caso de la Informática, los estudiantes deben resolver una serie de problemas mediante la aplicación de metodologías y/o técnicas que generalmente se adquieren tras haber comprendido cómo las aplica el profesor. Para desarrollar estas habilidades, el profesor propone una serie de ejercicios que los alumnos deben resolver aplicando un procedimiento análogo al empleado por el profesor. La resolución de ejercicios a menudo se convierte en un procedimiento mecánico que perfectamente puede ser automatizado.

En los últimos años, la UPV ha fomentado la producción de objetos de aprendizaje, llamados Polimedia [10], compuestos por material multimedia, que incluyen diagramas, audio, vídeo, etc. Los Polimedia son vídeos de menos de 10 minutos donde aparece el profesor explicando un tema concreto con apoyo de material suplementario, como es el caso de unas transparencias. La presencia del profesor en el vídeo, que puede aparecer de cuerpo completo o tras un atril, ayuda a que el alumno mantenga la aten-

5. Trabajo Relacionado

El uso de vídeos didácticos en el ámbito académico es un asunto con una dilatada trayectoria. Por ejemplo, Khan Academy [7] es una colección de más de 2600 vídeos educativos (del orden de unos 10 minutos) de matemáticas, biología, química y física. Se utiliza una aproximación basada en lienzo digital donde el maestro explica conceptos relacionados con las áreas mencionadas previamente. Sin embargo, hay vídeos que hacen referencias a otros videos, por lo que no están descontextualizados completamente. Academic Earth [8] y videolectures.net [9] incluyen vídeos de clases grabadas procedentes de cursos en línea de numerosas universidades del mundo. Por lo tanto, no son vídeo-ejercicios en sí, sino más bien clases magistrales completas.

Quizá el trabajo más relacionado es el de Fonseca [3], que plantea el uso de vídeos didácticos para enseñar ciencias computacionales, aplicado a asignaturas como la Programación de Sistemas Multimedia o un Taller de Programación Orientado a Objetos. En [2] es posible encontrar una colección de vídeo tutoriales de programación Java, donde el autor combina el uso de transparencias para explicar conceptos y programación in situ para ejemplificarlos.

6. Conclusión y Trabajos Futuros

Este articulo ha descrito la experiencia de producción e integración de vídeo-ejercicios didácticos en asignaturas de programación en el Grado en Informática de la UPV. Este tipo de objetos de aprendizaje suponen un excelente material de apoyo para el alumnado, que ve complementado su abanico de material de la asignatura con video-ejercicios disponibles en Internet a cualquier hora.

Los resultados iniciales invitan a continuar con la producción de material. Este es un proceso de mejora continua dedicado a obtener los mejores vídeo-ejercicios para favorecer el aprendizaje del alumno. En este sentido, la obtención de la opinión de los alumnos es crítica para orientar la producción de materiales en aquellos ámbitos de la materia que los alumnos tengan mayores dificultades.

Como trabajos futuros se plantea la incorporación de nuevas herramientas, aparte del lienzo digital y el IDE, como es el caso de las aplicaciones para demostrar el uso de estructuras de datos. También se pretende experimentar con el subtitulado de los vídeo-ejercicios, para poder facilitar el acceso al contenido a alumnos con diversidad funcional.

Agradecimientos

El autor desea agradecer a la Escuela Técnica Superior de Ingeniería Informática de la UPV el soporte económico para la difusión de este trabajo. Este trabajo ha sido financiado en parte por el Vicerrectorado de Estudios y Convergencia Europea de la UPV mediante los proyectos PIME/2011/A04 y PIME B20/11, en el contexto del EICE "Metodologías Activas y Tecnologías de la Información".

Referencias

[1] Academic Earth, 2012. [Online]. Disponible: `http://academicearth.org`.

[2] Cabero, J. y Gisbert, M. *La formación en Internet: Guía para el diseño de materiales didácticos*. EduForma, 2005.

[3] de la Serna, M.C. *Los videos didácticos: claves para su producción y evaluación*. PixelBit: Revista de medios y Educación, 1994.

[4] Fuentes Ochoa, J. C. *Video Tutoriales de programación Java*, 2011. [Online]. Disponible: `http://casidiablo.tv/video-tutoriales-java-by-locx24`.

[5] Fonseca Chiu, L.B. *Videos didácticos para enseñar ciencias computacionales, una experiencia universitaria*, 2011. [Online]. Disponible: `http://148.202.105.18/webaprenred/sites/default/files/Memorias/LotzyBeatriz.pdf`.

[6] Khan Academy, 2012. [Online]. Disponible: `http://www.khanacademy.org`.

[7] Moltó, G. Web Personal. 2012. [Online]. Disponible: `http://www.grycap.upv.es/gmolto`.

[8] Polimedia, 2012. [Online]. Disponible: `http://polimedia.blogs.upv.es/?page_id=105`.

[9] Polsani, P. *Use and abuse of reusable learning objects*. Journal of Digital information, 2006.

[10] VideoLectures.net, 2012. [Online]. Disponible: `http://videolectures.net`.

5.3.1.5. Jornadas de Innovación Educativa y Docencia en Red (IN-RED 2014)

G. Moltó, "Gestión Eficiente de Cursos Online: La Experiencia de @CursoCloudAWS en la UPV," in Jornadas de Innovación Educativa y Docencia en Red (IN-RED 2014), 2014, pp. 166–180.

- Participación: Poster
- Título del trabajo presentado: Gestión Eficiente de Cursos Online: La Experiencia de @CursoCloudAWS en la UPV
- Entidad organizadora: Universitat Politècnica de València
- Lugar de celebración: Valencia, España
- Publicación: ISSN/ISBN: 978-84-9048-271-1
- Objetivos: Jornadas de Innovación Educativa y Docencia en Red (IN-RED 2014)
- Perfil de los destinatarios: Congreso docente
- Fecha de inicio: 15/07/2014
- Fecha de fin: 16/07/2014
- Las Jornadas de Innovación Educativa y Docencia en Red (IN-RED), ahora convertidas en el Congreso de Innovación Educativa y Docencia en Red, son un foro de innovación educativa que selecciona las ponencias mediante el método de revisión por pares por miembros del comité científico. Se aporta certificado de participación en la conferencia (al ser primer autor de los tres artículos aportados a la conferencia el candidato realizó la presentación de todos ellos) y la contribución de acuerdo a las indicaciones de la Guía de Ayuda. En el documento adjunto se indica cómo el evento realiza la evaluación de las comunicaciones mediante evaluación por pares

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

CERTIFICAT D' APROFITAMENT
CERTIFICADO DE APROVECHAMIENTO

La Universitat Politècnica de València certifica que

GERMÁN MOLTÓ MARTÍNEZ

amb DNI número 52656437, ha realitzat i superat les proves d'avaluació que estableix la jornada **"JORNADES D'INNOVACIÓ I DOCÈNCIA EN XARXA"**, realitzada del dia 15/07/14 al dia 16/07/14 de 10 hores presencials, corresponents a 0,4 crèdits ECTS. Perquè conste i als efectes oportuns, expedeix aquest certificat.

Jornades organitzades conjuntament pel Vicerectorat de les Tecnologies de la Informació i de les Comunicacions i Vicerectorat d'Estudis, Qualitat i Acreditació

La Universitat Politècnica de València certifica que

GERMÁN MOLTÓ MARTÍNEZ

con DNI número 52656437, ha realizado y superado las pruebas de evaluación establecidas en la jornada **"JORNADAS DE INNOVACIÓN Y DOCENCIA EN RED"**, celebrada del 15/07/14 al 16/07/14 de 10 horas presenciales, correspondientes a 0,4 créditos ECTS. Y para que conste a los efectos oportunos, se expide el presente certificado.

Jornadas organizadas conjuntamente por el Vicerrectorado de las Tecnologías de la Información y de las Comunicaciones y Vicerrectorado de Estudios, Calidad y Acreditación.

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Instituto de Ciencias de la Educación

València, 21 de juliol de 2014 / Valencia, 21 de julio de 2014

Núm. de registre / Nº de registro: 14/25118

Continguts:

Dimarts 15 de Juliol

– Acreditació i recollida de documentació
– Inauguració de les Jornades a càrrec dels Vicerectors D. Vicente Botti Navarro i D. Miguel Ángel Fernández Prada
– Conferencia convidada: D. Ángel Fidalgo Blanco: “La visibilitat de la pràctica de la innovació educativa”
– Cafè i Posters
– Comunicacions moderades per D. Jesús Alba Fernández

Dimecres 16 de Juliol

– Comunicacions moderades per D. José Enrique Simó Tingues
– Cafè i Posters
– Conferència convidada: D. Faraó Llorens Llarg: “Digital Rethinking. Com les tecnologies de la informació ajudaran a transformar la docència universitària”
– Lliurament dels premis Docència en Xarxa i clausura de les Jornades a càrrec del Vicerector D. Vicente Botti Navarro

Contenidos:

Martes 15 de Julio

– Acreditación y recogida de documentación
– Inauguración de las Jornadas a cargo de los Vicerrectores D. Vicente Botti Navarro y D. Miguel Ángel Fernández Prada
– Conferencia invitada: D. Ángel Fidalgo Blanco: “La visibilidad de la práctica de la innovación educativa”
– Café y Posters
– Comunicaciones moderadas por D. Jesús Alba Fernández

Miércoles 16 de Julio

– Comunicaciones moderadas por D. José Enrique Simó Ten
– Café y Posters
– Conferencia invitada: D. Faraón Llorens Largo: “Digital Rethinking. Cómo las tecnologías de la información ayudarán a transformar la docencia universitaria”
– Entrega de los premios Docencia en Red y clausura de las Jornadas a cargo del Vicerrector D. Vicente Botti Navarro

Jornadas de Innovación Educativa y Docencia en Red de la Universitat Politècnica de València

Editores
Vicente Botti Navarro
Miguel Ángel Fernández Prada
José Simó Ten
Fernando Fargueta Cerdá

2014 IN-RED
Jornadas de Innovación Educativa y de Docencia en Red de la Universitat Politècnica de València

Valencia
15 y 16 de julio de 2014

UNIVERSITAT POLITÈCNICA DE VALÈNCIA
EDITORIAL

Jornadas de Innovación Educativa y Docencia en Red de la Universitat Politècnica de València

Editores

Vicente Botti Navarro
Miguel Ángel Fernández Prada
José Simó Ten
Fernando Fargueta Cerdá

2014

EDITORIAL
UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Colección Congresos

Los contenidos de esta publicación han sido evaluados por el Comité Científico que en ella se relaciona y según el procedimiento que se recoge en http://inred2014.blogs.upv.es/comites/

ISBN: 978-84-9048-271-1 (versión cd)

Gestión Eficiente de Cursos Online: La Experiencia de @CursoCloudAWS en la UPV*

Germán Moltó

Instituto de Instrumentación para Imagen Molecular (I3M). Centro mixto CSIC – Universitat Politècnica de València – CIEMAT, camino de Vera s/n, 46022 Valencia, España

Abstract

El creciente interés por la formación online es incuestionable hoy en día, con MOOCs siendo cursados por miles de alumnos. Sin embargo, para que la formación online se popularice es necesario que los profesores perciban que el esfuerzo necesario para preparar y gestionar un curso online es asumible. Este artículo propone una arquitectura basada en herramientas y servicios en la nube para simplificar la gestión de un curso online, desde el uso de laboratorios remotos automáticamente configurados hasta automatizar la comunicación con los estudiantes y recopilar retroalimentación sobre el curso. Esta aproximación ha sido aplicada en la producción, distribución y gestión del Curso Online de Cloud Computing con Amazon Web Services (@CursoCloudAWS[1]). El artículo describe la metodología, herramientas y resultados de la experiencia para destacar que es posible crear cursos online ofreciendo laboratorios remotos, con una mínima carga de gestión para el instructor, al tiempo que se proporciona una experiencia de aprendizaje de alta calidad a una audiencia a escala mundial.

Keywords*: Cloud Computing, MOOC, Technology-enhanced Learning, Remote Laboratories, Online Learning*

Resumen

*Este artículo es una versión traducida, revisada y ampliada del artículo "On Using the Cloud to Support Online Courses" enviado al congreso internacional 2014 Frontiers in Education Conference (FIE 2014), destinada a difundir la experiencia en la UPV.

[1] La abreviatura @CursoCloudAWS se refiere a la cuenta de Twitter del curso, disponible en http://www.twitter.com/CursoCloudAWS

Deterding, Sebastian y col. (mayo de 2011). "Gamification. using game-design elements in non-gaming contexts". En: *Proceedings of the 2011 annual conference extended abstracts on Human factors in computing systems - CHI EA '11*. New York, New York, USA: ACM Press, pág. 2425. ISBN: 9781450302685. DOI: 10.1145/1979742.1979575.

Fang, Ning, Karen Nielson y Stephanie Kawamura (2013). *Using Computer Simulations with a Real-World Engineering Example to Improve Student Learning of High School Physics: A Case Study of K-12 Engineering Education*. eng.

Gaspar, Alessio y col. (mayo de 2008). "March of the (virtual) machines: past, present, and future milestones in the adoption of virtualization in computing education". En: *Journal of Computing Sciences in Colleges* 23.5, págs. 123-132. ISSN: 1937-4771.

Güney, E, Z Ekşi y M Çakıroğlu (2011). "WebECG: A novel ECG simulator based on MATLAB Web Figure". En: *Advances in Engineering Software*.

Kolota, Jakub (2011). *A Remote Laboratory for Learning with Automatic Control Systems and Process Visualization*. eng.

Lieberam-Schmidt, Sönke (2010). "Search Engine Optimization". En: *Analyzing and Influencing Search Engine Results*. Wiesbaden: Gabler, págs. 163-203. ISBN: 978-3-8349-2453-7. DOI: 10.1007/978-3-8349-8915-4.

Moltó, Germán y Miguel Caballer (2013). "Scalable Software Practice Environments Featuring Automatic Provision and Configuration in the Cloud". En: *The 2013 International Conference on Parallel and Distributed Processing Techniques and Applications (PDPTA'13)*.

Moore, MG y G Kearsley (2011). *Distance education: A systems view of online learning*. Wadsworth Publishing. ISBN: 978-0534506889.

Romero-Zaldivar, Vicente-Arturo y col. (mayo de 2012). "Monitoring student progress using virtual appliances: A case study". En: *Computers & Education* 58.4, págs. 1058-1067. ISSN: 03601315. DOI: 10.1016/j.compedu.2011.12.003.

Sun, Pei-Chen y col. (2008). "What drives a successful e-Learning? An empirical investigation of the critical factors influencing learner satisfaction". En: *Computers and Education* 50.4, págs. 1183-1202.

5.3.1.6. Jornadas de Innovación Educativa y Docencia en Red (IN-RED 2014)

G. Moltó, D. Segrelles, M. Caballer, and I. Blanquer, "Gestión de Infraestructuras Virtuales Docentes en Asignaturas con Requisitos Computacionales," in Jornadas de Innovación Educativa y Docencia en Red (IN-RED 2014), 2014, pp. 151–165.

- Participación: Poster
- Título del trabajo presentado: Gestión de Infraestructuras Virtuales Docentes en Asignaturas con Requisitos Computacionales
- Entidad organizadora: Universitat Politècnica de València
- Lugar de celebración: Valencia, España
- Publicación: ISSN/ISBN: 978-84-9048-271-1
- Objetivos: Jornadas de Innovación Educativa y Docencia en Red (IN-RED 2014)
- Perfil de los destinatarios: Congreso docente
- Fecha de inicio: 15/07/2014
- Fecha de fin: 16/07/2014

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

CERTIFICAT D' APROFITAMENT
CERTIFICADO DE APROVECHAMIENTO

La Universitat Politècnica de València certifica que

GERMÁN MOLTÓ MARTÍNEZ

amb DNI número 52656437, ha realitzat i superat les proves d'avaluació que estableix la jornada **"JORNADES D'INNOVACIÓ I DOCÈNCIA EN XARXA"**, realitzada del dia 15/07/14 al dia 16/07/14 de 10 hores presencials, corresponents a 0,4 crèdits ECTS. Perquè conste i als efectes oportuns, expedeix aquest certificat.

Jornades organitzades conjuntament pel Vicerectorat de les Tecnologies de la Informació i de les Comunicacions i Vicerectorat d'Estudis, Qualitat i Acreditació

La Universitat Politècnica de València certifica que

GERMÁN MOLTÓ MARTÍNEZ

con DNI número 52656437, ha realizado y superado las pruebas de evaluación establecidas en la jornada **"JORNADAS DE INNOVACIÓN Y DOCENCIA EN RED"**, celebrada del 15/07/14 al 16/07/14 de 10 horas presenciales, correspondientes a 0,4 créditos ECTS. Y para que conste a los efectos oportunos, se expide el presente certificado.

Jornadas organizadas conjuntamente por el Vicerrectorado de las Tecnologías de la Información y de las Comunicaciones y Vicerrectorado de Estudios, Calidad y Acreditación.

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Instituto de Ciencias de la Educación

València, 21 de juliol de 2014 / Valencia, 21 de julio de 2014

Núm. de registre / Nº de registro: 14/25118

Continguts:

Dimarts 15 de Juliol

– Acreditació i recollida de documentació
– Inauguració de les Jornades a càrrec dels Vicerectors D. Vicente Botti Navarro i D. Miguel Ángel Fernández Prada
– Conferencia convidada: D. Ángel Fidalgo Blanco: “La visibilitat de la pràctica de la innovació educativa”
– Cafè i Posters
– Comunicacions moderades per D. Jesús Alba Fernández

Dimecres 16 de Juliol

– Comunicacions moderades per D. José Enrique Simó Tingues
– Cafè i Posters
– Conferència convidada: D. Faraó Llorens Llarg: “Digital Rethinking. Com les tecnologies de la informació ajudaran a transformar la docència universitària”
– Lliurament dels premis Docència en Xarxa i clausura de les Jornades a càrrec del Vicerector D. Vicente Botti Navarro

Contenidos:

Martes 15 de Julio

– Acreditación y recogida de documentación
– Inauguración de las Jornadas a cargo de los Vicerrectores D. Vicente Botti Navarro y D. Miguel Ángel Fernández Prada
– Conferencia invitada: D. Ángel Fidalgo Blanco: “La visibilidad de la práctica de la innovación educativa”
– Café y Posters
– Comunicaciones moderadas por D. Jesús Alba Fernández

Miércoles 16 de Julio

– Comunicaciones moderadas por D. José Enrique Simó Ten
– Café y Posters
– Conferencia invitada: D. Faraón Llorens Largo: “Digital Rethinking. Cómo las tecnologías de la información ayudarán a transformar la docencia universitaria”
– Entrega de los premios Docencia en Red y clausura de las Jornadas a cargo del Vicerrector D. Vicente Botti Navarro

Jornadas de Innovación Educativa y Docencia en Red de la Universitat Politècnica de València

Editores
Vicente Botti Navarro
Miguel Ángel Fernández Prada
José Simó Ten
Fernando Fargueta Cerdá

2014 IN-RED
Jornadas de Innovación Educativa y de Docencia en Red de la Universitat Politècnica de València

Valencia
15 y 16 de julio de 2014

UNIVERSITAT POLITÈCNICA DE VALÈNCIA
EDITORIAL

Jornadas de Innovación Educativa y Docencia en Red de la Universitat Politècnica de València

Editores

Vicente Botti Navarro
Miguel Ángel Fernández Prada
José Simó Ten
Fernando Fargueta Cerdá

2014

EDITORIAL
UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Colección Congresos

Los contenidos de esta publicación han sido evaluados por el Comité Científico que en ella se relaciona y según el procedimiento que se recoge en http://inred2014.blogs.upv.es/comites/

ISBN: 978-84-9048-271-1 (versión cd)

Gestión de Infraestructuras Virtuales Docentes en Asignaturas con Requisitos Computacionales*

Germán Moltó[1], Damián Segrelles[1], Miguel Caballer[1] y Ignacio Blanquer[2]

[1]Instituto de Instrumentación para Imagen Molecular (I3M). Centro mixto CSIC – Universitat Politècnica de València – CIEMAT, camino de Vera s/n, 46022 Valencia, España

Abstract

This paper summarizes the experiences carried out in different subjects of the Master's Degree in Parallel and Distributed Computing of the Universitat Politècnica de València related to the management of virtualized computational infrastructures in the Cloud to perform lab activities. The diversity of computing infrastructures required to train the students in the different technologies, demanded the usage of automated infrastructure deployment tools using Cloud Computing platforms and techniques. These enabled to create clusters of PCs, Grid infrastructure testbeds and remote labs in a virtualized fashion on on-premise Cloud platforms and Amazon Web Services (AWS). For that, the Infrastructure Manager (IM) tool was employed, developed by the authors and released to the academic community. The results indicate a greater ease of usage for professors, a wide variety of platforms for students and a better usage of computational resources for the educational institution.

Keywords*: Cloud Computing, Virtual Infrastructures, Remote Labs, Technology Enhanced Learning*

Resumen

Este artículo resume las experiencias llevadas a cabo en asignaturas del Máster Universitario en Computación Paralela y Distribuida (MUCPD)

*Este artículo es una versión extendida y revisada del artículo "Gestión de Recursos Computacionales en el Cloud para Actividades Educativas" aceptado en las XX Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2014), destinada a difundir la experiencia en la UPV. Los autores desean agradecer al Vicerrectorado de Estudios, Calidad y Acreditación la financiación recibida en el marco del proyecto PIME/2013/A/016/A.

el uso de la herramienta dentro del LMS utilizado para la gestión de las asignaturas ya que, en realidad, las infraestructuras virtuales deberían ser consideradas parte del material de la asignatura.

Referencias bibliograficas

Caballer, Miguel y col. (feb. de 2014a). "CodeCloud: A platform to enable execution of programming models on the Clouds". En: *Journal of Systems and Software*. ISSN: 01641212. DOI: 10.1016/j.jss.2014.02.005.

Caballer, Miguel y col. (2014b). "Dynamic management of virtual infrastructures". En: *Journal of Grid Computing*. DOI: 10.1007/s10723-014-9296-5.

Carrión, Jose V. y col. (2010). "A Generic Catalog and Repository Service for Virtual Machine Images". En: *2nd International ICST Conference on Cloud Computing (CloudComp 2010)*.

NGI-ES. *Spanish National Grid Initiative*.

5.3.1.7. Jornadas de Innovación Educativa y Docencia en Red (IN-RED 2014)

G. Moltó, J. F. Monserrat, I. C. Fita, and A. M. Fita, "Experiencias Tecnológicas de Soporte al Blended Learning en un Contexto Multidisciplinar," in Jornadas de Innovación Educativa y Docencia en Red (IN-RED 2014), 2014, pp. 54–68.

- Participación: Poster
- Título del trabajo presentado: Experiencias Tecnológicas de Soporte al Blended Learning en un Contexto Multidisciplinar
- Entidad organizadora: Universitat Politècnica de València
- Lugar de celebración: Valencia, España
- Publicación: ISSN/ISBN: 978-84-9048-271-1
- Objetivos: Jornadas de Innovación Educativa y Docencia en Red (IN-RED 2014
- Perfil de los destinatarios: Congreso docente
- Fecha de inicio: 15/07/2014
- Fecha de fin: 16/07/2014

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

CERTIFICAT D' APROFITAMENT
CERTIFICADO DE APROVECHAMIENTO

La Universitat Politècnica de València certifica que

GERMÁN MOLTÓ MARTÍNEZ

amb DNI número 52656437, ha realitzat i superat les proves d'avaluació que estableix la jornada **"JORNADES D'INNOVACIÓ I DOCÈNCIA EN XARXA"**, realitzada del dia 15/07/14 al dia 16/07/14 de 10 hores presencials, corresponents a 0,4 crèdits ECTS. Perquè conste i als efectes oportuns, expedeix aquest certificat.

Jornades organitzades conjuntament pel Vicerectorat de les Tecnologies de la Informació i de les Comunicacions i Vicerectorat d'Estudis, Qualitat i Acreditació

La Universitat Politècnica de València certifica que

GERMÁN MOLTÓ MARTÍNEZ

con DNI número 52656437, ha realizado y superado las pruebas de evaluación establecidas en la jornada **"JORNADAS DE INNOVACIÓN Y DOCENCIA EN RED"**, celebrada del 15/07/14 al 16/07/14 de 10 horas presenciales, correspondientes a 0,4 créditos ECTS. Y para que conste a los efectos oportunos, se expide el presente certificado.

Jornadas organizadas conjuntamente por el Vicerrectorado de las Tecnologías de la Información y de las Comunicaciones y Vicerrectorado de Estudios, Calidad y Acreditación.

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Instituto de Ciencias de la Educación

València, 21 de juliol de 2014 / Valencia, 21 de julio de 2014

Núm. de registre / Nº de registro: 14/25118

Continguts:

Dimarts 15 de Juliol

– Acreditació i recollida de documentació
– Inauguració de les Jornades a càrrec dels Vicerectors D. Vicente Botti Navarro i D. Miguel Ángel Fernández Prada
– Conferencia convidada: D. Ángel Fidalgo Blanco: “La visibilitat de la pràctica de la innovació educativa”
– Cafè i Posters
– Comunicacions moderades per D. Jesús Alba Fernández

Dimecres 16 de Juliol

– Comunicacions moderades per D. José Enrique Simó Tingues
– Cafè i Posters
– Conferència convidada: D. Faraó Llorens Llarg: “Digital Rethinking. Com les tecnologies de la informació ajudaran a transformar la docència universitària”
– Lliurament dels premis Docència en Xarxa i clausura de les Jornades a càrrec del Vicerector D. Vicente Botti Navarro

Contenidos:

Martes 15 de Julio

– Acreditación y recogida de documentación
– Inauguración de las Jornadas a cargo de los Vicerrectores D. Vicente Botti Navarro y D. Miguel Ángel Fernández Prada
– Conferencia invitada: D. Ángel Fidalgo Blanco: “La visibilidad de la práctica de la innovación educativa”
– Café y Posters
– Comunicaciones moderadas por D. Jesús Alba Fernández

Miércoles 16 de Julio

– Comunicaciones moderadas por D. José Enrique Simó Ten
– Café y Posters
– Conferencia invitada: D. Faraón Llorens Largo: “Digital Rethinking. Cómo las tecnologías de la información ayudarán a transformar la docencia universitaria”
– Entrega de los premios Docencia en Red y clausura de las Jornadas a cargo del Vicerrector D. Vicente Botti Navarro

Jornadas de Innovación Educativa y Docencia en Red de la Universitat Politècnica de València

Editores
Vicente Botti Navarro
Miguel Ángel Fernández Prada
José Simó Ten
Fernando Fargueta Cerdá

2014 IN-RED
Jornadas de Innovación Educativa y de Docencia en Red de la Universitat Politècnica de València

Valencia
15 y 16 de julio de 2014

UNIVERSITAT POLITÈCNICA DE VALÈNCIA
EDITORIAL

Jornadas de Innovación Educativa y Docencia en Red de la Universitat Politècnica de València

Editores

Vicente Botti Navarro
Miguel Ángel Fernández Prada
José Simó Ten
Fernando Fargueta Cerdá

2014

EDITORIAL
UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Colección Congresos

Los contenidos de esta publicación han sido evaluados por el Comité Científico que en ella se relaciona y según el procedimiento que se recoge en http://inred2014.blogs.upv.es/comites/

ISBN: 978-84-9048-271-1 (versión cd)

Experiencias Tecnológicas de Soporte al Blended Learning en un Contexto Multidisciplinar

Germán Moltó[a], José F. Monserrat[b], I.C. Fita[c] y Ana M. Fita[d]
[a]Departamento de Sistemas Informáticos y Computación - gmolto@dsic.upv.es, [b]Departamento de Comunicaciones - jomondel@dcom.upv.es, [c]Departamento de Física Aplicada - infifer@fis.upv.es y [d]Departamento de Biotecnología - anfifer@btc.upv.es.

Abstract

Blended Learning has been leveraged in the last years due to the widespread usage of ICTs and the increase of distant activities in the new degrees. This paper describes several experiences of introducing Blended Learning in subjects from different fields (Computer Science, Telecommunications, and Biotechnology). The common aspect is the usage of computer tools that enable to perform activities that range from performing practical activities in remote labs provisioned from Cloud environments to the live recording of lessons and its broadcast. This paper summarises the experiences carried out, introducing the required technologies, tools and devices. It is also described the impact for both the students and the involved professors. The goal of this paper is to describe the experiences in a way that encourages other professors from related fields to integrate these techniques and activities in their teaching methodologies.

Keywords: *blended learning, video-lectures, distant learning, virtualised environments,*

Resumen

El Blended Learning (o aprendizaje semipresencial) está siendo impulsado en los últimos años por el auge de las TIC y el aumento de las actividades no presenciales en los nuevos títulos de Grado. En este artículo se describen experiencias de introducción del Blended Learning en asignaturas de diferentes ámbitos (Informática, Telecomunicaciones y Biotecnología). El tronco común es el uso de herramientas y tecnologías informáticas de uso cotidiano que posibilitan y facilitan la realización de actividades que

dominio por parte del profesor es determinante para que los alumnos puedan percibir sus ventajas en la formación semi-presencial.

Referencias

Edmodo. http://www.edmodo.com

EVIR. http://evir.dsic.upv.es

Garrison, D. R., & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. The Internet and Higher Education, 7(2), 95–105. doi:10.1016/j.iheduc.2004.02.001

Hoic-Bozic, N.; Mornar, V.; Boticki, I., 2009. A Blended Learning Approach to Course Design and Implementation. IEEE Transactions on Education,52(1),19-30 doi: 10.1109/TE.2007.914945

Infrastructure Manager (IM). http://www.grycap.upv.es/im

Moltó, Germán, and Oscar Sapena. 2013. "Entorno Virtualizado de Aprendizaje Para Facilitar El Desarrollo de Destrezas de Programación." In XIX Jornadas Sobre La Enseñanza Universitaria de La Informática (JENUI 2013), 327–334. doi:10.6035/e-TIiT.2013.13.

PoliformaT. http://poliformat.upv.es

PoliReunión. https://polireunion2.upv.es

PoliTube. http://politube.upv.es

TodaysMeet. https://todaysmeet.com/

Turró C, Despujol I., Busquets J. 2014. Grabación automatizada de clases magistrales: el proyecto Videoapuntes de la UPV. Revista de Educación a Distancia, 40. http://www.um.es/ead/red/40/

5.3.1.8. XX Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2014)

- Participación: Ponencia
- Título del trabajo presentado: Gestión de recursos computacionales en el Cloud para actividades educativas
- Entidad organizadora: Universidad de Oviedo
- Lugar de celebración: Oviedo, España
- Publicación: ISSN/ISBN: 978-84-697-0774-6
- Objetivos: XX Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2014)
- Perfil de los destinatarios: Docentes universitarios de informática
- Fecha de inicio: 09/07/2014
- Fecha de fin: 11/07/2014

JENUI 2014

XX Jornadas sobre la Enseñanza Universitaria de la Informática

Oviedo, del 9 al 11 de julio

El comité organizador de las XX Jornadas de Enseñanza Universitaria de la Informática certifica que

Germán Moltó Martínez

ha presentado la ponencia

"Gestión de recursos computacionales en el Cloud para actividades educativas"

durante las jornadas celebradas en Oviedo, los días 9, 10 y 11 de julio de 2014.

Miguel Riesco Albizu
Coordinador del Comité Organizador

JENUI 2014

XX Jornadas sobre la Enseñanza Universitaria de la Informática

Oviedo, del 9 al 11 de julio

El comité organizador de las XX Jornadas de Enseñanza Universitaria de la Informática certifica que

Germán Moltó Martínez

ha asistido a las jornadas celebradas en Oviedo, los días 9, 10 y 11 de julio de 2014.

Escuela de Ingeniería Informática · Universidad de Oviedo ·

Miguel Riesco Albizu
Coordinador del Comité Organizador

JENUI 2014

Actas de las XX Jornadas sobre la Enseñanza Universitaria de la Informática

Oviedo, del 9 al 11 de julio de 2014

Organizadas por:

Escuela de Ingeniería Informática.
Universidad de Oviedo

Asociación de Enseñantes
Universitarios de la Informática

Editores
Miguel Riesco Albizu
Marián Díaz Fondón
Benjamín López Pérez

Organizan

Escuela de Ingeniería Informática

AENUI
Asociación de Enseñantes Universitarios de la Informática

Colaboran

novática
Revista de la Asociación de Técnicos de Informática

IEEE
Sociedad Educación
CAPÍTULO ESPAÑOL

ReVisión

Financiado por

OVIEDO.es
AYUNTAMIENTO

Actas de las XX JENUI.
Oviedo, julio de 2014
ISBN: 978-84-697-0774-6

Miguel Riesco, Marián Díaz, Benjamín López (Editores).

Diseño: Vanesa Redondo López

Designed by VanRL 2014

Presentación

En 2014 se ha celebrado la XX edición de las *Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI)*. Gestadas en 1994 durante la celebración de las *II Jornadas sobre innovación docente en las enseñanzas técnicas universitarias*, vivieron su primera edición en 1995. Desde entonces, se han celebrado ininterrumpidamente a lo largo y ancho de toda la geografía española.

Las JENUI pretenden promover el contacto, el intercambio y la discusión de conocimientos y experiencias entre profesorado universitario de informática para debatir sobre los programas docentes y los métodos pedagógicos empleados, así como materializar un foro en el que poder presentar enfoques innovadores orientados a mejorar el aprendizaje de la informática en nuestras universidades.

Las JENUI está promovidas por la *Asociación de Enseñantes Universitarios de la Informática (AENUI)*, cuyo objetivo fundamental es el de promover actividades que incentiven y permitan difundir la investigación y la innovación que se desarrolla en nuestro país en materia de enseñanza universitaria de la informática.

En el año 2014 las Jornadas se celebran en la *Escuela de Ingeniería Informática* de la Universidad de Oviedo. En esta XX edición, las áreas de interés incluidas en la llamada a la participación han sido las siguientes:

- Aplicación de las TIC al proceso de enseñanza-aprendizaje.
- Calidad y evaluación de la docencia.
- Compromiso social y medioambiental.
- Desarrollo de competencias transversales y profesionales.
- Didáctica en los estudios de ingeniería informática.
- Evaluación del aprendizaje.
- Máster en profesorado de secundaria.
- Mejoras pedagógicas en las asignaturas.
- Optimización del tiempo y el trabajo del profesor.
- Organización curricular y planes de estudios.
- Promoción de los estudios de Ingeniería Informática.
- Trabajos fin de carrera, prácticum, proyectos y participación de alumnos en la investigación.

Se ha invitado a presentar trabajos que versen sobre experiencias docentes, recursos informáticos de apoyo a la docencia, investigaciones en educación y reflexiones sobre la docencia universitaria de la informática. Los formatos para la presentación en las JENUI han sido los habituales: ponencia con presentación oral, demostración de recurso docente y póster. En todos los casos se han solicitado trabajos de un máximo de 8 páginas.

En total, se han recibido 77 trabajos: 66 ponencias, 6 recursos docentes y 5 pósteres. Estos trabajos han sido evaluados por un cuerpo de revisores formado por 122 profesores de 36 universidades, y se ha efectuado una media de 4 revisiones por trabajo. Se han aceptado 49 ponencias, 5 recursos docentes y 5 pósteres, lo que supone una tasa de aceptación global del 77

Este volumen recoge los artículos correspondientes a los 59 trabajos aceptados, organizados en las siguientes temáticas:

- Aplicación de las TIC al proceso de enseñanza-aprendizaje.
- Aprendizaje basado en problemas.
- Calidad y evaluación de la docencia
- Demostración de Recurso Docente
- Desarrollo de competencias transversales y profesionales.
- Didáctica en los estudios de ingeniería informática.
- Evaluación del aprendizaje.
- Mejoras pedagógicas en las asignaturas.

- Póster.

Además, hay una sección en la que se han reunido los seis trabajos seleccionados por el Comité Directivo como candidatos a obtener el premio a mejor ponencia.

En el programa de las JENUI se han distribuido los trabajos en quince sesiones de presentaciones orales de ponencias, más una sesión específica para presentar pósteres y recursos docentes, todas ellas organizadas en base a las temáticas anteriores. Por primera vez, todas estas sesiones han sido retransmitidas en directo a través de Internet, permitiendo ser seguidas desde todo el mundo e incluso interactuar con los ponentes enviado preguntas en tiempo real o posteriormente a través de foros creados al efecto.

De las quince sesiones de ponencias, hay catorce que se celebran de forma paralela en siete franjas horarias y una sesión plenaria donde se presentan los seis trabajos seleccionados como candidatos a obtener el premio a la mejor ponencia de las JENUI 2014. Estos seis trabajos han sido seleccionados entre los mejor valorados por el cuerpo de revisores, La selección del mejor trabajo se realizará durante la asamblea de AENUI, que se celebra el penúltimo día de las Jornadas. Podrán votar todos los miembros de AENUI inscritos en JENUI 2014. Los seis trabajos seleccionados como candidatos a mejor ponencia se publicarán en ReVisión[1], la revista electrónica de AENUI de Investigación en Docencia Universitaria de la Informática. Además, se seleccionarán algunas ponencias adicionales que aparecerán en un número especial de la revista. Se anima desde aquí a los autores de todos los artículos aceptados (incluyendo pósteres y recursos docentes) a que envíen una versión más completa a la revista ReVisión.

La mejor ponencia también será publicada en TICAI[2] (TIC Aplicadas para el aprendizaje de la Ingeniería), una iniciativa del CTAE (Comité Técnico, de Acreditación y Evaluación) del Capítulo Español de la Sociedad de Educación del IEEE, que pretende reunir en un libro anual las mejores aportaciones realizadas en los congresos de ámbito iberoamericano en la temática propia de la Sociedad de Educación del IEEE.

Finalmente, se seleccionarán también dos trabajos que serán publicados en la revista Novática[3]. La selección de estos trabajos recaerá sobre el comité editorial de la revista.

Comité Directivo JENUI 2014
Comité Organizador JENUI 2014

[1] ReVisión: http://www.aenui.net/ReVision/
[2] TICAI: http://romulo.det.uvigo.es/ticai/
[3] Novática: http://www.ati.es/novatica/

Índice

Actas de las XX JENUI. Oviedo, 9-11 de julio 2014
ISBN: 978-84-697-0774-6
Páginas: 99-106

Gestión de recursos computacionales en el Cloud para actividades educativas

Germán Moltó, J. Damian Segrelles, Miguel Caballer
Instituto de Instrumentación para Imagen Molecular (I3M).
Centro mixto CSIC - Universitat Politècnica de València - CIEMAT
Camino de Vera s/n, 46022 Valencia, España
{gmolto,dquilis}@dsic.upv.es,micafer1@upv.es

Resumen

En este artículo se describe el uso de la plataforma ODISEA en cuatro asignaturas del Máster Universitario en Computación Paralela y Distribuida (MUCPD) de la Universitat Politècnica de València (UPV). Esta plataforma permite desplegar recursos computacionales sobre proveedores Cloud específicamente configurados para soportar actividades educativas. El instructor declara las necesidades hardware, software y de configuración del entorno de prácticas, que puede ser desplegado automáticamente tanto en un Cloud privado existente en la organización educativa o sobre un Cloud público. Esto permite una flexibilidad sin precedentes en la gestión de recursos de cómputo para actividades educativas. Se resumen las capacidades de ODISEA y el uso en las diferentes asignaturas.

Abstract

This paper describes the usage of the ODISEA platform in four subjects of the Master's Degree in Parallel and Distributed Computing (MUCPD) at the Universitat Politècnica de València (UPV). This platform deploys computational resources on Cloud providers specifically configured to support educational activities. The instructor declares the hardware, software and configuration requirements of the lab resources, which can be automatically deployed both on an on-premise Cloud within the educational center or on a public Cloud. This introduces unprecedented flexibility in the management of computational resources for educational activities. The paper summarizes ODISEA's features and focuses on the usage experience in the subjects.

Palabras clave

Cloud computing, virtualización, laboratorios remotos

1. Introducción

La adquisición de las competencias definidas en numerosas asignaturas en el campo de la informática requiere la realización de prácticas de laboratorio con las herramientas tecnológicas apropiadas, poniendo de manifiesto la importancia de las TIC (Tecnologías de la Información y la Comunicación) en la educación superior [9, 5]. Esto es especialmente necesario en el campo de la Computación Paralela y Distribuida, donde el alumno debe acceder a diferentes infraestructuras de cómputo con sus herramientas y entornos de programación que le permitan desarrollar las actividades necesarias durante las sesiones prácticas.

En este entorno, la diversidad de infraestructuras de cómputo con las que deben interactuar los alumnos (clusters de PCs, infraestructuras Grid, despliegues Cloud, etc.) hace que la gestión de recursos de cómputo sea complicada por múltiples razones: i) es necesario un elevado número de recursos computacionales, en función del número de alumnos; ii) la instalación, configuración y mantenimiento de los despliegues es un procedimiento técnicamente complejo y es conveniente realizarlo para cada curso; iii) en caso de fallo de parte de la infraestructura es imprescindible desplegar una alternativa en el menor tiempo posible.

La solución tradicional para ofrecer al alumno este abanico de infraestructuras pasa por asignar recursos físicos a cada una de ellas. Sin embargo, esto conlleva un desperdicio de recursos, puesto que esas infraestructuras tan solo se utilizan, principalmente, para la realización de las sesiones prácticas. Además, en caso de fallo de los recursos físicos no es posible desplegar una nueva infraestructura de forma inmediata.

En los últimos años, la virtualización ha irrumpido en los laboratorios de prácticas para facilitar la compartición de recursos (ver por ejemplo [4, 10, 8]). Mediante el uso de hipervisores (como KVM o VMware) es posible ejecutar diferentes máquinas virtuales sobre un mismo equipo físico, aislando las diferentes instalaciones y evitando así las posibles incompatibilidades

Ventaja	Laboratorio	Virtualización	VDI	ODISEA
Incremento Súbito de Alumnos	NO	SI	SI (BYOD)	SI (BYOD)
Despliegue de infraestructuras complejas	NO	NO	NO	SI
Repetibilidad del despliegue	NO	SI	SI	SI
Configurable por el Instructor	NO	NO	NO	SI

Cuadro 3: Comparativa de ventajas para instructores y alumnos soportadas por diferentes tecnologías.

la creación de infraestructuras en diferentes proveedores Cloud. Esto ha permitido una flexibilidad sin precedentes para el instructor y el acceso a una gran variedad de infraestructuras por parte del alumno. Todo ello gracias a la utilización de técnicas de Cloud Computing soportadas por proveedores de Cloud Computing on-premise como OpenNebula y proveedores de Cloud público como Amazon Web Services. Parte de los desarrollos de ODISEA, como el Infrastructure Manager se han liberado a la comunidad académica[2]. Además, la plataforma puede ser utilizada directamente desde un navegador web para el despliegue de infraestructuras virtuales adaptadas a los requisitos del docente.

Existen varias líneas de trabajo futuro. En primer lugar se pretende mejorar la interfaz gráfica de la plataforma para facilitar a los instructores fuera del ámbito de la informática el uso de la misma. Por otro lado se explorará la viabilidad de integrar la plataforma desarrollada con las herramientas corporativas de la UPV. Esto permitiría el uso de la herramienta dentro del LMS utilizado para la gestión de las asignaturas ya que, en realidad, las infraestructuras virtuales deberían ser consideradas parte del material de la asignatura.

Agradecimientos

GM y JDS desean agradecer al Vicerrectorado de Estudios, Calidad y Acreditación la financiación recibida en el marco del proyecto PIME/2013/A/016/A. GM también desea agradecer a l'Escola Tècnica Superior d'Enginyeria en Informàtica (ETSINF) el soporte económico para la presentación de este trabajo.

Referencias

[1] Miguel Caballer, Carlos de Alfonso, Germán Moltó, Eloy Romero, Ignacio Blanquer, and Andrés García, *CodeCloud: A platform to enable execution of programming models on the Clouds*, Journal of Systems and Software (2014).

[2] Jose V. Carrión, Germán Moltó, Carlos De Alfonso, Miguel Caballer, and Vicente Hernández, *A Generic Catalog and Repository Service for Virtual Machine Images*, 2nd International ICST Conference on Cloud Computing (CloudComp 2010), 2010.

[3] Carlos de Alfonso, Miguel Caballer, Fernando Alvarruiz, Germán Molto, and Vicente Hernández, *Infrastructure Deployment Over the Cloud*, 2011 IEEE Third International Conference on Cloud Computing Technology and Science, IEEE, November 2011, pp. 517–521.

[4] Dalibor Dobrilovic and Zeljko Stojanov, *Using Virtualization Software in Operating Systems Course*, 2006 International Conference on Information Technology: Research and Education, IEEE, October 2006, pp. 222–226.

[5] Sonsoles Guerra, Natalia González, and Rosa García-Ruiz, *Utilización de las TIC por el profesorado universitario como recurso didáctico.*, Comunicar: Revista científica iberoamericana de comunicación y educación (2010), no. 35, 141–148.

[6] Peter Mell and Tim Grance, *The NIST Definition of Cloud Computing. NIST Special Publication 800-145 (Final)*, Tech. report, 2011.

[7] NGI-ES, *Spanish National Grid Initiative*.

[8] J Ruiz, D Fernández, F Galán, and L Bellido, *Modelo de Laboratorio Docente de Telemática basado en Virtualización Distribuida*, VII Jornadas de Ingeniería Telemática, 2008.

[9] Laura Varela Candamio and María Teresa García-Álvarez, *Analysis of Information and Communication Technologies in Higher Education : A Case Study of Business Degree*, International Journal of Engineering Education **28** (2012), no. 6, 1301–1308.

[10] M Wannous and H Nakano, *NVLab, a Networking Virtual Web-Based Laboratory that Implements Virtualization and Virtual Network Computing Technologies*, IEEE Transactions on Learning Technologies **3** (2010), no. 2, 129–138.

[2] http://www.grycap.upv.es/im

5.3.1.9. 2014 IEEE Frontiers in Education Conference (FIE)

G. Moltó and M. Caballer, "On Using the Cloud to Support Online Courses," in 2014 IEEE Frontiers in Education Conference (FIE)., 2014, pp. 330–338, doi: 10.1109/FIE.2014.7044041.

- Participación: Ponencia
- Título del trabajo presentado: On Using the Cloud to Support Online Courses
- Entidad organizadora: IEEE
- Lugar de celebración: Madrid, España
- Publicación: ISSN/ISBN: 978-1-4799-3921-3
- Objetivos: 2014 IEEE Frontiers in Education Conference (FIE)
- Perfil de los destinatarios: Congreso internacional
- Fecha de inicio: 22/10/2014
- Fecha de fin: 25/10/2014

Frontiers in Education Conference

Opening Doors to Innovation and Internationalization in Engineering Education

Madrid, Spain • October 22-25, 2014

FIE 2014 is sponsored by:
- **American Society for Engineering Education (ASEE)**
  Educational Research Methods (ERM) Division
- **Institute of Electrical and Electronics Engineers (IEEE)**
  IEEE Education Society
  IEEE Computer Society

Co-sponsored by:
Spanish National Distance University and **Universidad Politecnica de Madrid**

FIE 2014 Planning Committee

General Co-Chairs
Manuel Castro
Spanish National Distance University

Edmundo Tovar Caro
Universidad Politecnica de Madrid

Assistant to the General Chairs
Kevin Curry
University of Kansas Continuing Education

ASEE/ERM Program Co-Chair
Monica Cardella
Purdue University

IEEE/Computer Society Program Co-Chair
Arnold Pears
University of Uppsala, Sweden

IEEE/Education Society Program Co-Chair
Russ Meier
Milwaukee School of Engineering

Exhibits Chair
Robert J. Hofinger
Purdue University

International Co-Chair, Africa
Hamadou Saliah Hassane
University of Quebec in Montreal (TELUQ/UQAM)

International Co-Chair, Asia
Ming Zhang
Peking University

International Co-Chair, Australasia
Mark Lee
Charles Sturt University

International Co-Chair, Europe
Edmundo Tovar Caro
Universidad Politecnica de Madrid

International Co-Chair, South America
Melany M. Ciampi
Council of Researches in Education and Sciences

Conference Historian
Ed Jones
Iowa State University

Awards Chair
James Sluss
University of Oklahoma

FIE Steering Committee Chair
Russ Meier
Milwaukee School of Engineering

FROM: Kevin G. Curry
SUBJECT: Attendance and Presentations at FIE
DATE: October 25, 2014
TO: Germán Moltó
Universitat Polit
Camino de Vera S/N
Valencia, Spain

To whom it may concern:

Germán Moltó attended the 44th annual Frontiers in Education Conference in Madrid, Spain. The conference was held from October 22-25, 2014, and the following paper(s), authored by Germán were presented:

ON USING THE CLOUD TO SUPPORT ONLINE COURSES

To see more information about the conference, please visit our web site at http://fie2014.org/.

Sincerely,

Kevin G. Curry
Assistant to the General Chair
Continuing Education
The University of Kansas Edwards Campus
Regents Center 125
12600 Quivira Road
Overland Park, KS, USA 66213
+1 913.897.8761

2014 Frontiers in Education Conference

OCTOBER 22-25, 2014

Opening Innovations and Internationalization in Engineering Education

MADRID - SPAIN

Melia Castilla Hotel & Convention Center

PROCEEDINGS

Table of Contents | Welcome Message | Awards
Workshops | Conference Sponsors | Technical Sessions
Author Index | Plenary Sessions | Search | Help

Technical Support:
Conference Catalysts, LLC
Phone: +1 352 872 5544
cdyer@conferencecatalysts.com

IEEE Catalog Number: CFP14FIE-USB
ISBN: 978-1-4799-3921-3

2014 IEEE Frontiers in Education Conference Proceedings

To obtain copies of the USB version of the proceedings, please contact:

Mail IEEE Customer Service Department
445 Hoes Lane
PO Box 1331
Piscataway, NJ 08855-1331 USA

Phone Toll-free 800-678-IEEE (4333) or 732-981-0060

USB Version of Proceedings IEEE Catalog Number and ISBN

IEEE Catalog Number: CFP14FIE-ART
USB version, IEEE Catalog Number: CFP14FIE-USB
ISBN: 978-1-4799-3921-3

Copyright and Reprint Permission:

TABLE OF CONTENTS

CBL2: Systems and Standards for Computer Based Learning
Chair: Victor F. A. Barros
2:30 PM - 4:00 PM
Room: Patio 3

EEC1: Electrical and Computer Engineering Courses and Laboratories
Chair: Robert Weissbach
2:30 PM - 4:00 PM
Room: Doblon

On Using the Cloud to Support Online Courses

Germán Moltó, Miguel Caballer
Instituto de Instrumentación para Imagen Molecular (I3M)
Centro mixto CSIC – Universitat Politècnica de València – CIEMAT
Camino de Vera s/n, 46022 Valencia, Spain.
Email: gmolto@dsic.upv.es, micafer1@upv.es

***Abstract*—The increasing interest of online learning is unquestionable nowadays, with MOOCs being taken by thousands of students. However, for online learning to go mainstream it is necessary that professors perceive that the effort required to prepare and manage an online course is manageable. Today, a myriad of inexpensive tools and services can be used to produce and manage online courses with unprecedented ease and without distressing the professor. For that, this paper proposes an architecture based on Cloud services that simplifies the process of managing an online course, from delivering on-demand fully customized remote laboratories to communication automation for student engagement and feedback gathering. This approach has been applied to produce, distribute and manage an Online Course on Cloud Computing with Amazon Web Services. The paper describes the methodology, tools and results of this experience to point out that it is possible to deliver online courses with automatically provisioned labs, with minimal management overhead, while still providing a high quality learning experience to a worldwide audience.**

***Index Terms*—Cloud computing, Virtualization, Computing infrastructures**

I. Introduction

Online learning [1] has started to bloom in the last few years with the advances in communication networks, the widespread usage of computers and the ubiquitous access to the Internet. With the advent of online educational platforms such as Coursera [2], edX [3] or Udacity [4], pioneer professors have started to create the so-called MOOCs (Massive Online Open Courses) that are taken by tenths of thousands of students through the Internet. Indeed, online learning materials can now be easily produced and distributed with the help of a myriad of inexpensive software tools and internet or Cloud-based services. Therefore, it is now easier than ever before to produce and manage successful online courses [5] that can be accessed by many students throughout the world.

Traditionally, online courses include video lectures, documentation, online quizzes and collaboration and communication platforms to deliver a remote learning experience. Engineering courses typically require, in addition to the aforementioned materials, the usage of practical laboratories where the students develop the appropriate skills and competencies with the specific tools used in their respective areas of expertise. This has been solved in the past by means of different approaches that include simulators (see for example [6], [7]), virtual laboratories (see for example [8],[9]), software packages (see for example [10]) and downloadable pre-packaged virtual machines (see for example [11], [12]).

This paper proposes using automatically configured Virtual Software Practice Environments (VSPE) deployed on a Cloud, to which students connect via the Internet to perform the practical activities of the course using the required environment and software configuration decided by the instructor. The computing resources are dynamically allocated from a public Cloud provider just for the duration of the educational activity and automatically configured using high level recipes that describe the requirements of the VSPE (in terms of hardware, software and configuration).

According to the NIST (National Institute of Standards and Technology), Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [13]. One of the service models in the Cloud is SaaS (Software as a Service), in which online applications are accessed via web browsers (one example is Google Apps). Another service model is IaaS (Infrastructure as a Service), in which computing and storage resources can be dynamically allocated on a pay-per-use basis from a public Cloud provider. This enables, for example, to deploy Virtual Machines (VMs) that are run on the Cloud provider's hardware and are accessible via the Internet. This paper advocates for embracing the benefits provided by both service models to seamlessly support the delivery and management of high quality online practical courses.

In fact there are related works in this area that have covered the usage of Cloud technologies for e-learning. This is the case of [14], with an analysis on the impact of Cloud technologies for e-learning, or the interest of the Indian government in Cloud technologies to support educational activities with a reduced cost [15]. In [16], the authors introduce Edubase Cloud a platform to perform practical activities related to the analysis of the deployment of virtual machines in an on-premise Cloud. A myriad of different Cloud-related approaches in education are summarized in [17], where the benefits of this technology in terms of economic and versatility benefits are foreseen. In [18], the authors present an evaluation of different types of Cloud technologies in a course on network overlays.

This paper describes the experience in producing and supporting an online course on Cloud Computing using Cloud technologies. It describes an architecture in which online services and Cloud providers are employed to introduce opera-

terio de Economía y Competividad" for the project TIN2013-44390-R. GM would also like to thank the "Escola Tècnica Superior d'Enginyeria Informàtica" (ETSINF) at the Universitat Politècnica de València, for the economic support to present this contribution and the "Vicerrectorado de Estudios y Convergencia Europea" for the project PIME/2013/A/016/A.

REFERENCES

[1] M. Moore and G. Kearsley, *Distance education: A systems view of online learning*. Wadsworth Publishing, 2011.

[2] "Coursera." [Online]. Available: https://www.coursera.org

[3] "edX." [Online]. Available: https://www.edx.org

[4] "Udacity." [Online]. Available: https://www.udacity.com

[5] P.-C. Sun, R. J. Tsai, G. Finger, Y.-Y. Chen, and D. Yeh, "What drives a successful e-Learning? An empirical investigation of the critical factors influencing learner satisfaction," *Computers and Education*, vol. 50, no. 4, pp. 1183–1202, 2008.

[6] E. Güney, Z. Ekşi, and M. Çakıroğlu, "WebECG: A novel ECG simulator based on MATLAB Web Figure," *Advances in Engineering Software*, 2011. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0965997811002444

[7] N. Fang, K. Nielson, and S. Kawamura, "Using Computer Simulations with a Real-World Engineering Example to Improve Student Learning of High School Physics: A Case Study of K-12 Engineering Education," pp. 170–180, 2013. [Online]. Available: http://dialnet.unirioja.es/servlet/articulo?codigo=4152179

[8] J. Kolota, "A Remote Laboratory for Learning with Automatic Control Systems and Process Visualization," pp. 1130–1138, 2011. [Online]. Available: http://dialnet.unirioja.es/servlet/articulo?codigo=3915801

[9] D. S. Alexiadis and N. Mitianoudis, "MASTERS: A Virtual Lab on Multimedia Systems for Telecommunications, Medical, and Remote Sensing Applications," *IEEE Transactions on Education*, vol. 56, no. 2, pp. 227–234, May 2013. [Online]. Available: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=6257505

[10] R. M. F. Bezerra, I. Fraga, and A. A. Dias, "Utilization of integrated Michaelis-Menten equations for enzyme inhibition diagnosis and determination of kinetic constants using Solver supplement of Microsoft Office Excel." *Computer methods and programs in biomedicine*, vol. 109, no. 1, pp. 26–31, Jan. 2013. [Online]. Available: http://dl.acm.org/citation.cfm?id=2400767.2401462

[11] A. Gaspar, S. Langevin, W. D. Armitage, and M. Rideout, "March of the (virtual) machines: past, present, and future milestones in the adoption of virtualization in computing education," *Journal of Computing Sciences in Colleges*, vol. 23, no. 5, pp. 123–132, May 2008. [Online]. Available: http://dl.acm.org/citation.cfm?id=1352627.1352648

[12] V.-A. Romero-Zaldivar, A. Pardo, D. Burgos, and C. Delgado Kloos, "Monitoring student progress using virtual appliances: A case study," *Computers & Education*, vol. 58, no. 4, pp. 1058–1067, May 2012. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0360131511003198

[13] P. Mell and T. Grance, "The NIST Definition of Cloud Computing. NIST Special Publication 800-145 (Final)," Tech. Rep., 2011. [Online]. Available: http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf

[14] D. Al-Jumeily, D. Williams, A. Hussain, and P. Griffiths, "Can We Truly Learn from A Cloud Or Is It Just A Lot of Thunder?" in *2010 Developments in E-systems Engineering*. IEEE, Sep. 2010, pp. 131–139.

[15] D. G. Chandra and M. D. Borah, "Cost benefit analysis of cloud computing in education," in *2012 International Conference on Computing, Communication and Applications*. IEEE, Feb. 2012, pp. 1–6.

[16] S. Yokoyama, N. Yoshioka, and T. Shida, "Edubase Cloud: Cloud platform for cloud education," in *2012 First International Workshop on Software Engineering Education Based on Real-World Experiences (EduRex)*. IEEE, Jun. 2012, pp. 17–20. [Online]. Available: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=6225699

[17] N. Sultan, "Cloud computing for education: A new dawn?" *International Journal of Information Management*, vol. 30, no. 2, pp. 109–116, Apr. 2010. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0268401209001170

[18] L. M. Vaquero, "EduCloud: PaaS versus IaaS Cloud Usage for an Advanced Computer Science Course," *IEEE Transactions on Education*, vol. 54, no. 4, pp. 590–598, Nov. 2011. [Online]. Available: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=\&arnumber=5686886\&contentType=Journals+\&+Magazines\&searchField=Search_All\&queryText=cloud+learning+infrastructure

[19] G. Moltó, "Curso Online de Cloud Computing con Amazon Web Services (AWS)." [Online]. Available: http://www.grycap.upv.es/cursocloudaws

[20] Twitter, "Bootstrap." [Online]. Available: http://getbootstrap.com

[21] M. E. Ally, *Mobile Learning: Transforming the Delivery of Education and Training*. Au Press, 2009.

[22] AddThis, "Smart Layers." [Online]. Available: http://www.addthis.com

[23] S. Lieberam-Schmidt, "Search Engine Optimization," in *Analyzing and Influencing Search Engine Results*. Wiesbaden: Gabler, 2010, pp. 163–203.

[24] "PoliformaT." [Online]. Available: http://poliformat.upv.es

[25] "Sakai Project." [Online]. Available: http://sakaiproject.org

[26] "Polimedia." [Online]. Available: https://polimedia.upv.es/catalogo/

[27] "Politube." [Online]. Available: http://politube.upv.es

[28] "Polireunión." [Online]. Available: https://polireunion2.upv.es

[29] G. Moltó and M. Caballer, "Scalable Software Practice Environments Featuring Automatic Provision and Configuration in the Cloud," in *The 2013 International Conference on Parallel and Distributed Processing Techniques and Applications (PDPTA'13)*, 2013.

[30] M. Caballer, I. Blanquer, G. Moltó, and C. de Alfonso, "Dynamic management of virtual infrastructures," *Journal of Grid Computing*, 2014. [Online]. Available: http://link.springer.com/article/10.1007/s10723-014-9296-5

Frontiers In Education Clearing House

Past Chairs

List of Award Winners and Banquets

Frontiers in Education Mission & Vision

Frontiers in Education (FIE) Vision:
We advance and re-define engineering and computing education to ensure that all students receive the best possible preparation for their future.

Frontiers in Education (FIE) Mission:
ASEE and IEEE unite to create an inclusive venue where excellence in research, teaching, and creative activity are valued. We bring together a multidisciplinary global community committed to improving scholarship and practice in engineering and computing education.

FIE Values:
1) A collaborative, supportive, and inclusive community

- Encouraging mentorship and professional growth
- Promoting global discourse and collaboration
- Appreciating multi-disciplinary approaches

2) Innovation, new approaches, and challenges to established practice

- Recognizing the contributions of other scholars
- Respecting different types of contributions
- Valuing both qualitative and quantitative evidence

3) High quality scholarship

- Improving practice
- Generating new knowledge
- Addressing both successes and failures

4) Ethical conference conduct

- Emphasizing responsible authorship,
- Remaining free from bias and conflict of interest.
- Exhibiting respect for all

Introduction and Historical Sponsorship

The Frontiers in Education conference (FIE) is a well-respected international conference on engineering and computer science education. The IEEE Education Society founded the conference in 1971. The American Society for Engineering Education joined as a co-sponsor in 1973. For more than two decades, these two sponsoring societies held the conference in various locations around the United States and, occasionally, in international venues. In 1995, the IEEE Computer Society became a sponsor and together these three groups have continued to plan high quality events that provide engineering and computer science educators the opportunity to network and showcase peer-reviewed scholarly contributions in educational research and classroom practice. In 2013, the FIE Steering Committee formed formal policy that places FIE within the continental United States with the possibility of an international location at five year intervals.

The educational research and the educational practice literature generated by FIE is regularly cited in scholarly work and helped to inspire a well-regarded textbook in engineering education written by John Heywood and published by Wiley-IEEE Press (ISBN: 978-0-471-74111-4).

Peer Review Process and Paper Statistics

FIE uses a two-stage review process that begins with the issuance of a call-for-papers in June of the year preceding the conference. The first stage requires submission of a short abstract that is then peer-reviewed by the technical program committee for appropriateness to the conference, the yearly theme, new and engaging ideas, and so on. Abstracts that are selected are invited to submit full papers and works-in-progress (short papers) for blind peer-review. A blind peer review means that reviewers can see the names of the authors but the authors are not told the names of the reviewers.

Table 1: Nine Years of FIE Acceptance Rate Data

Year	Accept Rate	Abstracts	Published
2019	56%	648	365
2018	59%	911	539
2017	45%	660	302
2016	48%	854	412
2015	52%	757	396
2014	57%	895	507
2013	70%	609	429
2012	43%	690	300
2011	60%	736	440
2010	45%	833	379
2009	45%	783	355
2008	47%	876	411
2007	55%	734	403

Attendance Statistics

The Frontiers in Education Conference is one of the world's premier conference events covering the areas of engineering, computer engineering, software engineering, and computer science education. It has a loyal author and attendee base. Registrations have remained relatively constant over the past fifteen years. This is remarkable when the worldwide economic recession is considered. The reason is the sense of community that FIE provides to attendees: the high quality technical papers consistently provide state-of-the-art conversation in education, the registration fee has remained relatively affordable, and registration pays for an opening reception, three breakfasts, three lunches, all coffee and refreshment breaks, as well as the conference bag, the proceedings, an exhibit hall, free wireless internet, and other similar amenities. Registrants consistently compliment FIE on the common food functions that foster a sense of camaraderie and provide ample opportunity for participant networking. Table 2 provides the statistical summary of FIE registration in the 21st century. The trend line is nearly horizontal with an average attendance of 576 people.

Table 2: FIE Attendance in the 21st Century

Year	Attendance
2015	513
2014	571
2013	481
2012	505
2011	527
2010	631
2009	513
2008	590
2007	642
2006	659

2005	663
2004	566
2003	693
2002	629
2001	499
2000	464

5.3.1.10. XXII Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2016)

G. Moltó and J.D. Segrelles, ”Panel web de gestión automatizada para actividades educativas no presenciales, ïn XXII Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2016), 2016, pp. 311-318.

- Participación: Ponencia
- Título del trabajo presentado: Panel web de gestión automatizada para actividades educativas no presenciales
- Entidad organizadora: Universidad de Almería
- Lugar de celebración: Almería, España
- Publicación: ISSN/ISBN: 978-84-16642-30-4
- Objetivos: XXII Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2016)
- Fecha de inicio: 06/07/2016
- Fecha de fin: 08/07/2016

CERTIFICADO DE PRESENTACION

GERMÁN MOLTÓ

ha presentado la ponencia titulada PANEL WEB DE GESTIÓN AUTOMATIZADA DE MENSAJES PARA ACTIVIDADES EDUCATIVAS NO PRESENCIALES en las XXII Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2016) organizadas por el Departamento de Informática de la Universidad de Almería y la Asociación de Enseñantes Universitarios de la Informática, celebradas del 6 al 8 de julio de 2016 en Almería.

AENUI
Asociación de Enseñantes Universitarios de la Informática

DEPARTAMENTO DE INFORMÁTICA
UNIVERSIDAD DE ALMERÍA

Manuel Torres Gil
Comité Organizador JENUI 2016
Universidad de Almería

CERTIFICADO DE ASISTENCIA

GERMÁN MOLTÓ MARTÍNEZ

ha asistido a las XXII Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2016) organizadas por el Departamento de Informática de la Universidad de Almería y la Asociación de Enseñantes Universitarios de la Informática, celebradas del 6 al 8 de julio de 2016 en Almería.

AENUI
Asociación de Enseñantes Universitarios de la Informática

DEPARTAMENTO DE INFORMÁTICA
UNIVERSIDAD DE ALMERÍA

Manuel Torres Gil
Comité Organizador JENUI 2016
Universidad de Almería

Jenui 2016

Almería

Actas de las

XXII Jornadas sobre la Enseñanza Universitaria de la Informática

Almería, del 6 al 8 de julio de 2016

Organizadas por:
Departamento de Informática
Universidad de Almería
y
Asociación de Enseñantes Universitarios de la Informática

Manuel Torres Gil
José Joaquín Cañadas Martínez
(editores)

Actas de las XXII Jornadas sobre la Enseñanza Universitaria de la Informática

Editores:
Manuel Torres Gil
José Joaquín Cañadas Martínez

ISBN: 978-84-16642-30-4
Depósito legal: AL 1007-2016

Edita: Editorial Universidad de Almería, 2016
editorial@ual.es
www.ual.es/editorial
Telf/Fax: 950 015459

Presentación

Las *Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI)* pretenden promover el contacto, el intercambio y la discusión de conocimientos y experiencias entre profesorado universitario de Informática para debatir sobre el contenido de los programas docentes y los métodos pedagógicos empleados, así como materializar un foro en el que presentar enfoques innovadores orientados a mejorar el aprendizaje de la Informática en nuestras universidades.

Las JENUI constituyen una de las principales actividades de la *Asociación de Enseñantes Universitarios de la Informática (AENUI)*, cuyo objetivo fundamental es el de promover actividades que incentiven y permitan difundir la investigación y la innovación que se desarrolla en nuestro país en materia de enseñanza universitaria de la informática.

Estas Jornadas se gestaron en 1994 en el seno de las II Jornadas sobre innovación docente en las enseñanzas técnicas universitarias y celebraron su primera edición en 1995. Desde entonces, se han celebrado ininterrumpidamente y con carácter anual a lo largo y ancho de toda la geografía española.

En 2016 las JENUI se celebran en Almería y están organizadas por *Departamento de Informática* de la *Universidad de Almería*. En esta XXII edición, las áreas de interés incluidas en la llamada a la participación han sido las siguientes:

- Aplicación de las TIC al proceso de enseñanza-aprendizaje.
- Calidad y evaluación de la docencia.
- Compromiso social y medioambiental.
- Desarrollo de competencias transversales y profesionales.
- Didáctica en los estudios de Ingeniería Informática.
- Evaluación del aprendizaje.
- Máster en profesorado de secundaria.
- Mejoras pedagógicas en las asignaturas.
- Optimización del tiempo y el trabajo del profesor.
- Organización curricular y planes de estudios.
- Promoción de los estudios de Ingeniería Informática.
- Trabajos fin de carrera, prácticum, proyectos y participación de alumnos en la investigación.

En dicha llamada se ha invitado a presentar trabajos que versen sobre experiencias docentes, recursos informáticos de apoyo a la docencia, investigaciones en educación y reflexiones sobre la docencia universitaria de la Informática. Los formatos para la presentación en las JENUI han sido los habituales: ponencia con presentación oral, demostración de recurso docente y póster. Para las ponencias y los recursos docentes se han solicitado trabajos escritos de hasta ocho páginas, mientras que para los pósteres se han solicitado trabajos de hasta cuatro páginas.

En total, se han recibido 70 trabajos. Estos trabajos han sido evaluados por un cuerpo de revisores formado por 123 profesores de 36 universidades de 7 países, y se ha efectuado una media de casi 6 revisiones por trabajo. Se han aceptado 36 ponencias, 6 recursos docentes y 7 pósteres, lo que supone una tasa de aceptación global del 70 %. Esta tasa refleja, por un lado, el alto nivel de exigencia en las revisiones realizadas y por otro, la gran calidad de los trabajos presentados.

Este volumen recoge los artículos correspondientes a los 49 trabajos aceptados, organizados en las siguientes temáticas:

- Desarrollo de competencias transversales y profesionales.
- Mejoras pedagógicas en las asignaturas.
- Evaluación del aprendizaje.
- Didáctica en los estudios de Ingeniería Informática.

- Aprendizaje basado en problemas.
- Demostración de Recurso Docente.
- Póster.

Además, hay un apartado en el que se han reunido los seis trabajos seleccionados por los revisores y por el Comité Directivo como candidatos a obtener el premio a mejor ponencia. Finalmente, otro apartado recoge tres artículos que se presentarán en las jornadas siguiendo una dinámica innovadora que involucra de forma más activa a los asistentes.

En el programa de las JENUI se han distribuido los trabajos en sesiones de presentaciones orales de ponencias, más una sesión específica para presentar pósteres y recursos docentes, todas ellas organizadas en base a las temáticas anteriores.

Las sesiones de ponencias se distribuyen en franjas horarias de forma paralela, a excepción de dos sesiones plenarias: una para los tres trabajos con presentaciones innovadoras y otra donde se presentan los seis trabajos seleccionados como candidatos a obtener el premio a la mejor ponencia de las JENUI 2016. Estos seis últimos trabajos han sido seleccionados entre los mejor valorados por el cuerpo de revisores. La selección de los dos mejores trabajos se realizará durante la asamblea de AENUI, que se celebra el penúltimo día de las Jornadas. Podrán votar todos los miembros de AENUI inscritos en JENUI 2016. El resultado de la votación se mostrará en la página web de JENUI 2016[1]

Los seis trabajos seleccionados como candidatos a mejor ponencia se publicarán en ReVisión[2], la revista electrónica de AENUI de Investigación en Docencia Universitaria de la Informática. Además, se seleccionarán algunas ponencias adicionales que aparecerán en un número especial de la revista. Se anima desde aquí a los autores de todos los artículos aceptados (incluyendo pósteres y recursos docentes) a que envíen una versión más completa a la revista ReVisión.

Además, las revistas TICAI[3] y Novática[4] publicarán uno o dos trabajos presentados en JENUI. La selección de estos trabajos la realizarán dichas revistas siguiendo sus propios criterios editoriales. Los autores de estos trabajos tendrán la oportunidad de actualizarlos para su publicación en la revista.

Como es habitual, durante las JENUI se entregará el premio AENUI a la calidad e innovación, que reconoce la labor realizada en aras de la calidad e innovación docente en el área de la docencia universitaria de la informática.

Finalmente, por segunda vez en las JENUI, la sociedad SISTEDES[5] otorgará el premio SISTEDES al mejor trabajo de las XXII JENUI en el ámbito de la ingeniería del software y las tecnologías del desarrollo de software.

Comité directivo JENUI 2016
Comité organizador JENUI 2016

[1] JENUI 2016: `http://www2.ual.es/jenui2016/`
[2] ReVisión: `http://www.aenui.net/ReVision/`
[3] TICAI: `http://romulo.det.uvigo.es/ticai/`
[4] Novática: `http://www.ati.es/novatica/`
[5] SISTEDES: `http://www.sistedes.es/`

Índice

Actas de las XXII Jenui. Almería, 6-8 de julio 2016
ISBN: 978-84-16642-30-4
Páginas: 311-318

Panel web de gestión automatizada para actividades educativas no presenciales

Germán Moltó, J. Damian Segrelles
Instituto de Instrumentación para Imagen Molecular (I3M).
Centro mixto CSIC - Universitat Politècnica de València - CIEMAT
Camino de Vera s/n, 46022 Valencia, España
{gmolto,dquilis}@dsic.upv.es

Resumen

Esta contribución presenta un recurso docente para automatizar la gestión de actividades educativas no presenciales, que involucren laboratorios computacionales remotos de prácticas. La interacción profesor-alumno es especialmente necesaria en actividades no presenciales, como es el caso de cursos online asíncronos y asignaturas con dispensa de asistencia. Por ello, el panel web permite: i) el envío periódico de mensajes de correo electrónico personalizados para los alumnos; ii) la gestión centralizada de las credenciales de alumnos para los laboratorios remotos; iii) disponer de una visión actualizada del ciclo de vida de los alumnos (alumnos concurrentes, tiempo restante, etc.). Se describe el uso de la herramienta en el contexto de un curso online asíncrono que opera a escala mundial así como su extensión a asignaturas con dispensa de asistencia. El panel web, creado con Google Spreadsheets y liberado bajo licencia Creative Commons, ha permitido la gestión de más de 350 alumnos, automatizar el envío de más de 1000 mensajes personalizados y facilitar las labores de gestión de credenciales de dichas actividades educativas, pudiendo ser fácilmente adaptado a otras actividades educativas afines.

Abstract

This contributions introduces a teaching resource to automate online educational activities that involve remote computational labs. Student-professor interaction is specially necessary in such activities, as is the case of asynchronous online courses and subjects with non-mandatory attendance. The web panel allows: i) to periodically send personalised e-mail messages; ii) the centralised management of student credentials for the remote labs; iii) a dashboard with the lifecycle of students (concurrent students, time left, etc.). The tool has been employed on a worldwide asynchronous online course together with a non-mandatory attendance subject. The web panel, created with Google Spreadsheets and released under a Creative Commons License has enabled to manage more than 350 students, automate more than 1000 personalised messages and ease the credential management. It can be adapted to other educational similar activities.

Palabras clave

Mensajería, Automatización, Educación, Cloud Computing

1. Introducción

El ámbito de la enseñanza de la informática se ha visto revolucionado en los últimos años con el auge de la docencia online. La no presencialidad ha ganado terreno en la educación dada las ventajas que ofrece este tipo de formación, como por ejemplo la ubicuidad, flexibilidad y acceso bajo demanda [3]. Este hecho ha popularizado la creación de numerosos cursos online a través de experiencias como Flip Teaching [2], cursos MOOCs (Massively Online Open Courses) [3] o cursos SPOCs (Small Private Online Course) [1] que consisten en versiones de MOOCs específicamente utilizadas con estudiantes dentro del propio campus.

El diseño de actividades educativas en el ámbito de la informática requiere a menudo que los alumnos tengan que utilizar herramientas informáticas específicas para desarrollar las habilidades necesarias, ya sean compiladores, editores, simuladores, laboratorios remotos, etc. Por ello, en el contexto de la formación online, es muy habitual el uso de Entornos Virtuales Computacionales (EVC) [7] que proporcionen acceso a dichas herramientas. Concretamente, en este artículo definimos EVC como máquinas virtuales desplegadas en la nube que tienen instaladas todas las herramientas informáticas necesarias para la realización de actividades y a las que los alumnos se conectan vía SSH, en el

sentado en este artículo. El principal problema ha radicado en los alumnos con dispensa que, al no haberse sentido acompañados, han realizado las entregas a última hora en detrimento de la calidad de los mismos. Por ello, pensamos que el uso del recurso presentado en este artículo, permitirá mejorar este aspecto y activar el alumno en la realización de las tareas programadas.

A continuación se resume el proceso para implantar el panel de cara al próximo año. La primera interacción se realizará vía mail por parte del alumno a través de un mensaje con sus datos personales y asunto "Alta CVE-IME", lo que permitirá su procesado de forma automática y notificar al profesor su intención de iniciar los seminarios y prácticas. Procesado el mail, se lanza el EVC asignado al alumno través de ODISEA. El panel, envía un mensaje de bienvenida al alumno, indicándole la dirección del CVE asignado junto las credenciales que requiere para su acceso. En ese momento, el alumno ya puede realizar las actividades programadas. Conforme progrese el tiempo, el panel mandará una serie de mensajes con el objetivo de que el alumno se sienta acompañado durante el proceso de aprendizaje, indicándole cuales son las actividades que están en marcha y las fechas de entregas de las mismas.

5. Conclusión y Trabajos Futuros

Este trabajo ha descrito un recurso docente que aporta un panel centralizado para la gestión de actividades educativas online y asignaturas con dispensa, que involucran laboratorios remotos. La herramienta, disponible en la nube y accesible mediante un navegador web ha sido liberada mediante licencia abierta para que otros docentes pueden incorporarla, con las adaptaciones necesarias, a sus propias actividades educativas.

La herramienta se está utilizando desde 2014 y ha supuesto un pilar importante en la automatización de la gestión del Curso Online de Cloud Computing con AWS, facilitando la gestión de credenciales y mensajería personalizada, evitando el envío manual de más de mil mensajes de correo electrónico. Esta funcionalidad no está cubierta actualmente por los LMS más populares por lo que se trata de una aportación relevante al estado del arte. Además, se ha diseñado su uso para el curso 2016 en la asignatura de Máster IME, especialmente para los alumnos con dispensa de asistencia.

Como trabajos futuros se espera mejorar la herramienta para que los mensajes se envíen no solo periódicamente o a petición del instructor sino directamente cuando un alumno se inscriba en la actividad educativa. La conexión con otras herramientas de automatización como IFTTT o Zapier puede automatizar todavía más el proceso de alta de un nuevo alumno.

6. Agradecimientos

Los autores quieren agradecer al Vicerrectorado de Estudios, Calidad y Acreditación de la UPV por la financiación del proyecto PIME "Análisis y Evaluación de Impacto del Cloud Computing en la Gestión de entornos Virtuales Computacionales en la Enseñanza", con referencia (A014). GM quiere agradecer a l'Escola Tècnica Superior d'Enginyeria Informàtica de la Universitat Politècnica de València el soporte económico para la presentación de este trabajo.

Referencias

[1] Armando Fox, *From MOOCs to SPOCs*, Communications of the ACM **56** (2013), no. 12, 38–40.

[2] Clyde Freeman Herreid and Nancy A. Schiller, *Case Study: Case Studies and the Flipped Classroom.*, Journal of College Science Teaching **42** (2013), no. 5, 62–67 (en).

[3] Judy Kay, Peter Reimann, Elliot Diebold, and Bob Kummerfeld, *MOOCs: So Many Learners, So Much Potential ...*, IEEE Intelligent Systems **28** (2013), no. 3, 70–77.

[4] Yair Levy, *Comparing dropouts and persistence in e-learning courses*, Computers & Education **48** (2007), no. 2, 185–204.

[5] Germán Moltó, *Gestión Eficiente de Cursos Online: La Experiencia de @CursoCloudAWS en la UPV*, Jornadas de Innovación Educativa y Docencia en Red (IN-RED 2014) (Editorial Universitat Politècnica de València, ed.), 2014, pp. 166–180.

[6] Germán Moltó and Miguel Caballer, *On Using the Cloud to Support Online Courses*, 2014 Frontiers in Education Conference (FIE)., 2014, pp. 330–338.

[7] Germán Moltó, J Damian Segrelles, and Miguel Caballer, *Gestión de recursos computacionales en el Cloud para actividades educativas*, XX Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2014). ISBN:, 2014, pp. 99–106.

[8] J. Damià Segrelles and Germán Moltó, *Recopilación Automatizada de Evidencias de la Realización de Actividades Educativas en el Cloud*, XXI Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2015), 2015, pp. 97–104.

[9] J. Damian Segrelles, Germán Moltó, and Miguel Caballer, *Remote Computational Labs for Educational Activities via a Cloud Computing Platform*, 2015 Proceedings of the Information Systems Education Conference (ISECON), 2015, pp. 309–321.

5.3.1.11. XV Congreso Internacional de la Sociedad Española de Didáctica de la Lengua y la Literatura (SEDLL)

C. López and G. Moltó, "Herramienta de análisis para el estudio de la ortografía preventiva," in XV Congreso Internacional de la Sociedad Española de Didáctica de la Lengua y la Literatura, 2014, p. 94.

- Participación: Ponencia
- Título del trabajo presentado: Herramienta de análisis para el estudio de la ortografía preventiva
- Entidad organizadora: Universitat Politècnica de València
- Lugar de celebración: Valencia, España
- Publicación: ISSN/ISBN:
- Objetivos: XV Congreso Internacional de la Sociedad Española de Didáctica de la Lengua y la Literatura (SEDLL) Perfil de los destinatarios: Docentes.
- Fecha de inicio: 19/11/2014
- Fecha de fin: 21/11/2014
- Contribución al XV Congreso Internacional de la Sociedad Española de Didáctica de la Lengua y la Literatura (SEDLL). SEDLL es una conferencia que se celebra anualmente, auspiciada por la sociedad homónima y que dispone de un proceso de evaluación por pares para la selección de las contribuciones. Se aporta certificado de presentación de comunicación y la contribución de acuerdo a las indicaciones de la Guía de Ayuda. Este artículo fue seleccionado para contribuir una versión extendida del mismo como un capítulo de libro al libro "INVESTIGACIÓN EN LA ENSEÑANZA DE LAS LENGUAS Y LAS LITERATURAS", aportado como una contribución adicional.

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

GERMÁN MOLTÓ MARTÍNEZ

Con Nº de DNI/Pasaporte 52656437 ha asistido al **XV CONGRESO INTERNACIONAL DE LA SOCIEDAD ESPAÑOLA DE DIDÁCTICA DE LA LENGUA Y LA LITERATURA,** organizado por la Universitat Politècnica de València y la Universitat de València del 19 al 21 de noviembre de 2014 y para que conste a los efectos oportunos, se expide el presente certificado.

UNIVERSIDAD POLITÉCNICA VALENCIA CENTRO DE FORMACIÓN PERMANENTE

María Luisa Carrió
Coordinadora
Universitat Politècnica de València

Josep Ballester
Coordinador
Universitat de València

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

El Comité Científico del XV Congreso de la Sociedad Española de Didáctica de la Lengua y la Literatura organizado por la Universitat Politècnica de València y la Universitat de València y celebrado en Valencia del 19 al 21 de noviembre de 2014, hace constar que se ha presentado la comunicación titulada: "**Herramienta de Análisis para el Estudio de la Ortografía Preventiva**".

Autores:

López, Clara; Moltó, Germán

UNIVERSIDAD POLITECNICA VALENCIA CENTRO DE FORMACION PERMANENTE

María Luisa Carrió
Coordinadora
Universitat Politècnica de València

Josep Ballester
Coordinador
Universitat de València

LIBRO DE RESÚMENES

XV Congreso Internacional de SEDLL

FACULTAT DE MAGISTERI
UNIVERSITAT DE VALÈNCIA

DEPARTAMENTO DE LINGÜÍSTICA APLICADA
UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Reptes en l'adquisició de les literatures i de les llengües en l'era digital

Retos en la adquisición de las literaturas y las lenguas en la era digital

López, Clara & Moltó, Germán
Panel: 6. Tecnologías e innovación educativa
HERRAMIENTA DE ANÁLISIS PARA EL ESTUDIO DE LA ORTOGRAFÍA PREVENTIVA
Este trabajo propone una metodología para el análisis de los errores ortográficos cometidos por cada uno de los alumnos de los diferentes grupos de un curso. Para ello, se ha desarrollado una herramienta de recopilación de errores que facilita la anotación de los errores individuales y que permite obtener información agregada del comportamiento de la clase a nivel ortográfico. Se trata, por tanto, de una herramienta de recopilación de errores ortográficos así como su posterior análisis mediante técnicas informáticas que permiten al profesor estudiar la evolución de sus alumnos tanto de forma cualitativa (mediante la creación de gráficas automáticas de evolución del número de errores cometidos por alumno y por grupos) como cuantitativa (mediante la creación de tablas de números de errores cometidos tanto por alumnos concretos como agrupados por aulas). Previamente, se ha determinado una clasificación de los errores ortográficos, permitiendo así conocer qué categoría de errores predomina más en los diferentes dictados. La herramienta permite la visualización de la evolución de los errores cometidos por cada alumno a lo largo de las diferentes sesiones de dictados. Esto facilita al profesor, el seguimiento de la evolución de cada alumno y también del grupo en su conjunto. Permite saber en qué aspectos de la ortografía se cometen mayor o menor número de errores. También permite la comparación del desempeño de un grupo frente a los demás, en cuestiones ortográficas (ver figuras). Lo que se pretende con la investigación es poder detectar qué tipo de errores ortográficos se cometen en los dictados de primero de primaria, y en base a los mismos, abrir una reflexión sobre los tipos de errores cometidos, y por qué han ocurrido. Esto nos lleva a la siguiente reflexión; ¿Qué podemos hacer para subsanarlos y así mejorar el rendimiento académico de los alumnos?, que sería el paso siguiente a la presente investigación. La creación de esta herramienta permite a los profesores comprender mejor el comportamiento ortográfico de los alumnos y también analizar las tendencias en el número de faltas de ortografía cometidas por diferentes grupos. Esto permite determinar objetivamente posibles mejoras en los procedimientos de presentación de dictados llevados a cabo en el centro. La herramienta descrita en este artículo es genérica y puede ser perfectamente implantada en otros centros. La herramienta desarrollada ha sido aplicada en 1º de Primaria del Complejo Educativo Mas Camarena desde Febrero a Mayo de 2012, sobre una población de 177 alumnos repartidos en 8 clases. Esta experiencia piloto ha permitido poner de manifiesto las ventajas de la herramienta desarrollada, siendo la misma adoptada por el Departamento de Innovación Pedagógica para los cursos futuros. La herramienta se ha aplicado también en el Centro Privado de Enseñanza Hermes desde Enero a Mayo de 2014, en una clase 3º de Educación Infantil, sobre una población de 30 alumnos. Se pretende liberar esta herramienta a la comunidad académica mediante licencia de código abierto durante la realización de esta comunicación.

Luque Arrufat, Vita Vera
Panel: 6. Tecnologías e innovación educativa
L'AVALUACIÓ ENTRE COMPANYS COM A RECURS PER A MILLORAR L'APRENENTATGE DE L'ALEMANY A TRAVÉS DE L'EINA "TALLER" DE MOODLE
En aquest treball presentem una experiència duta a terme dins d'un projecte d'innovació educativa de la Universitat Jaume I (UJI) de Castelló amb el qual pretenem fomentar la visió crítica de l'alumnat davant del treball dels companys i aconseguir així que després siga capaços de reflexionar sobre els seus propis treballs de redacció en llengua estrangera. L'objectiu principal d'aquest projecte és millorar l'expressió escrita en llengua alemanya de l'alumnat del Grau de Turisme, que acaba d'iniciar-se en l'aprenentatge d'aquest idioma. És important que l'alumnat aprenga a revisar els seus escrits abans de lliurar-los i siga capaç d'autocorregir-se, per això hem proposat un sistema d'avaluació entre companys que permet a l'alumnat prendre consciència del procés d'aprenentatge a través dels errors dels companys i elaborar una llista pròpia d'elements a revisar abans de lliurar una tasca escrita. El projecte s'ha dut a terme al llarg d'un semestre i mitjançant l'eina "taller" de la plataforma Moodle que allotja l'Aula Virtual de l'UJI. Presentarem les diferents fases en què s'ha organitzat, des de l'explicació als alumnes del sistema de correcció amb una rúbrica i les propostes de redacció, fins a l'anàlisi dels resultats obtesos. Aquests resultats han estat, en general, positius. Hem comprovat que la participació de l'alumnat ha estat bastant elevada, ja que dels 50 alumnes matriculats, dels quals assistien regularment a classe poc més de la meitat, en cada taller han participat una mitjana de prop del 70% de la totalitat dels alumnes. Això ens dóna a entendre que l'alumnat s'ha sentit motivat i ha treballat de manera activa en l'assignatura, cosa que ha potenciat la seua capacitat crítica i d'avaluació i ha millorat el seu procés d'aprenentatge. Aquest projecte d'innovació educativa ens ha permés millorar el procés d'aprenentatge de la llengua alemanya del nostre alumnat i augmentar el seu nivell de motivació.

SEDLL 2014

COL·LABORADORS

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

VNIVERSITAT DE VALÈNCIA Facultat de Magisteri

Departamento de Lingüística Aplicada
Departament de Lingüística Aplicada

VNIVERSITAT DE VALÈNCIA
Servei de Política Lingüística

VNIVERSITAT DE VALÈNCIA Centre de Formació i Qualitat "Manuel Sanchis Guarner"

VNIVERSITAT DE VALÈNCIA Vicerectorat de Polítiques de Formació i Qualitat Educativa

VNIVERSITAT DE VALÈNCIA
Vicerectorat de Cultura i Igualtat

ACADÈMIA VALENCIANA DE LA LLENGUA

CAMBRIDGE UNIVERSITY PRESS

OXFORD UNIVERSITY PRESS

SGEL

ele
Español Lengua Extranjera

Florida UNIVERSITÀRIA

edicions bromera

5.3.1.12. XXIII Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2017)

J. González, J.D. Segrelles, and G. Moltó, ”Grid as a Service: Herramiento para el despliegue y gestión de un Grid en la nube para actividades educativasïn Actas de las XXIII Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2017), 2017, pp. 191-197.

- Participación: Ponencia
- Título del trabajo presentado: Grid as a Service: Herramienta para el despliegue y gestión de un Grid en la nube para actividades educativas
- Entidad organizadora: Universidad de Cáceres
- Lugar de celebración: Cáceres, España
- Publicación: ISSN/ISBN: 978-84-697-477-4
- Objetivos: XXIII Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2017)
- Perfil de los destinatarios: Docentes universitarios de la informática.
- Fecha de inicio: 05/07/2017
- Fecha de fin: 07/07/2017

JENUI 2017

XXIII Jornadas sobre la Enseñanza Universitaria de la Informática
Cáceres, del 5 al 7 de julio

Escuela Politécnica

UNIVERSIDAD DE EXTREMADURA

CERTIFICADO DE ASISTENCIA

Germán Moltó Martínez

ha asistido a las **XXIII Jornadas sobre la Enseñanza Universitaria de la Informática** (JENUI 2017), organizadas por la Escuela Politécnica de la Universidad de Extremadura y la Asociación de Enseñantes Universitarios de la Informática, celebradas en Cáceres del 5 al 7 de julio de 2017.

Cáceres, 7 de julio de 2017

AENUI
Asociación de Enseñantes Universitarios de la Informática

Alberto Gómez Mancha
Coordinador del Comité Organizador de JENUI 2017

JENUI 2017

XXIII Jornadas sobre la Enseñanza Universitaria de la Informática
Cáceres, del 5 al 7 de julio

Escuela Politécnica

UNIVERSIDAD DE EXTREMADURA

CERTIFICADO DE PARTICIPACIÓN

Germán Moltó Martínez

ha presentado la ponencia titulada ***"Grid as a Service: Herramienta de despliegue y gestión de un Grid en la nube para ámbitos docentes"*** en las **XXIII Jornadas sobre la Enseñanza Universitaria de la Informática** (JENUI 2017), organizadas por la Escuela Politécnica de la Universidad de Extremadura y la Asociación de Enseñantes Universitarios de la Informática, celebradas en Cáceres del 5 al 7 de julio de 2017.

Cáceres, 7 de julio de 2017

AENUI
Asociación de Enseñantes Universitarios de la Informática

UNIVERSIDAD DE EXTREMADURA
CÁCERES

Alberto Gómez Mancha
Coordinador del Comité Organizador de JENUI 2017

ACTAS
XXIII Jornadas sobre la Enseñanza Universitaria de la Informática

Cáceres, del 5 al 7 de julio de 2017

Organizadas por:

Asociación de Enseñantes Universitarios de la Informática
Escuela Politécnica
Universidad de Extremadura

Editores:

Alberto Gómez Mancha
Roberto Rodríguez-Echeverría

jenui2017.unex.es

Actas de las XXIII Jornadas sobre la Enseñanza Universitaria de la Informática

Editores:
Alberto Gómez Mancha
Roberto Rodríguez Echeverría

ISBN: 978-84-697-4077-4

Presentación

Las *Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI)* pretenden promover el contacto, el intercambio y la discusión de conocimientos y experiencias entre profesorado universitario de Informática para debatir sobre el contenido de los programas docentes y los métodos pedagógicos empleados, así como materializar un foro en el que presentar enfoques innovadores orientados a mejorar el aprendizaje de la Informática en nuestras universidades.

Las JENUI constituyen una de las principales actividades de la *Asociación de Enseñantes Universitarios de la Informática (AENUI)*, cuyo objetivo fundamental es promover actividades que incentiven y permitan difundir la investigación y la innovación que se desarrolla en nuestro país en materia de enseñanza universitaria de la Informática.

Estas Jornadas se gestaron en 1994 en el seno de las *II Jornadas sobre innovación docente en las enseñanzas técnicas universitarias* y celebraron su primera edición en 1995. Desde entonces, se han celebrado ininterrumpidamente y con carácter anual a lo largo y ancho de toda la geografía española.

En 2017 las JENUI vuelven a celebrarse en Cáceres (tras la edición de 2002), organizadas por la Escuela Politécnica de la Universidad de Extremadura.

En esta XXIII edición, las áreas de interés incluidas en la llamada a la participación han sido las siguientes:

- Didáctica en los estudios de Ingeniería Informática
- Calidad y evaluación de la docencia
- Evaluación del aprendizaje
- Promoción de los estudios de Ingeniería Informática
- Desarrollo de competencias transversales y profesionales
- Organización curricular y planes de estudio
- Compromiso social y medioambiental
- Trabajos fin de carrera, prácticum, proyectos y participación de alumnos en la investigación
- Aplicación de las TIC al proceso de enseñanza-aprendizaje
- Optimización del tiempo y el trabajo del profesor
- Mejoras pedagógicas en las asignaturas
- Máster en profesorado de secundaria
- Estrategias institucionales en los estudios de Ingeniería Informática

En dicha llamada se ha invitado a presentar trabajos que versen sobre experiencias docentes, recursos informáticos de apoyo a la docencia, investigaciones en educación y reflexiones sobre la docencia universitaria de la Informática. Los formatos para la presentación en las JENUI han sido los habituales: ponencia con presentación oral, demostración de recurso docente y póster. Para las ponencias y los recursos docentes se han solicitado trabajos escritos de hasta ocho páginas, mientras que para los pósteres se han solicitado trabajos de hasta cuatro páginas.

En total, se han recibido 61 trabajos. Estos trabajos han sido evaluados por un cuerpo de revisores formado por 125 profesores de 36 universidades de 8 países, y se ha efectuado una media de 5 revisiones por trabajo. Se han aceptado 33 ponencias, 4 recursos docentes y 5 pósteres, lo que supone una tasa de aceptación global del 68 %. Esta tasa refleja, por un lado, el alto nivel de exigencia en las revisiones realizadas y por otro, la gran calidad de los trabajos presentados.

Este volumen recoge los artículos correspondientes a los 42 trabajos aceptados. En el programa de las JENUI se han distribuido los trabajos en 14 sesiones de presentaciones orales de ponencias y recursos docentes, con una sesión específica para presentar los pósteres.

Las sesiones de ponencias se distribuyen en franjas horarias de forma paralela, a excepción de tres sesiones plenarias. La primera sesión plenaria recoge 3 trabajos sobre sostenibilidad en la ingeniería informática que se

presentarán siguiendo una dinámica innovadora que involucra de forma más activa a los asistentes. La segunda sesión plenaria incluye 4 trabajos sobre estrategias institucionales en los estudios de Ingeniería Informática. Por último, se presentarán en una sesión plenaria los 6 trabajos seleccionados como candidatos a obtener el premio a la mejor ponencia de las JENUI 2017. Estos seis trabajos han sido seleccionados por el Comité Directivo entre los mejor valorados por el cuerpo de revisores. La selección de los dos mejores trabajos se realizará durante la asamblea de AENUI, que se celebra el penúltimo día de las Jornadas. Podrán votar todos los miembros de la asociación. El resultado de la votación se mostrará en la página web de JENUI 2017[1] .

Todos los trabajos presentados en las JENUI y en el simposio-taller previo se publican en sendas revistas de AENUI[2].

Los seis trabajos seleccionados como candidatos a mejor ponencia se publicarán en ReVisión, la revista electrónica de AENUI de Investigación en Docencia Universitaria de la Informática[3]. Se anima desde aquí a los autores de todos los artículos aceptados (incluyendo pósteres y recursos docentes) a que envíen una versión más completa a la revista ReVisión.

Además, las revistas TICAI[4] y Novática[5] publicarán uno o dos trabajos presentados en las JENUI. La selección de estos trabajos la realizarán dichas revistas siguiendo sus propios criterios editoriales. Los autores de estos trabajos tendrán la oportunidad de actualizarlos para su publicación en la revista.

Como es habitual, durante las JENUI se entregará el premio AENUI a la calidad e innovación, que reconoce la labor realizada en aras de la calidad e innovación docente en el área de la docencia universitaria de la Informática.

Finalmente, por tercera vez en las JENUI, la sociedad SISTEDES[6] otorgará el premio SISTEDES al mejor trabajo de las XXIII JENUI en el ámbito de la ingeniería del software y las tecnologías del desarrollo de software.

Comité directivo JENUI 2017
Comité organizador JENUI 2017

[1]JENUI 2017: `http://jenui2017.unex.es`
[2]Revista Actas de las JENUI: `http://actasjenui.aenui.net`, Taller: `http://actastaller.aenui.net`
[3]ReVisión: `http://www.aenui.net/ReVision/`
[4]TICAI: `http://romulo.det.uvigo.es/ticai/`
[5]Novática: `http://www.ati.es/novatica/`
[6]SISTEDES: `http://www.sistedes.es/`

Índice

Actas de las XXIII JENUI. Cáceres, 5 al 7 de julio de 2017
ISBN: 978-84-697-4077-4
Páginas: 191-197

Grid as a Service: Herramienta para el despliegue y gestión de un Grid en la nube para actividades educativas

Jesus González, J. Damian Segrelles, Germán Moltó
Instituto de Instrumentación para Imagen Molecular (I3M).
Centro mixto CSIC - Universitat Politècnica de València - CIEMAT
Camino de Vera s/n, 46022 Valencia, España
jegonnie@inf.upv.es;{gmolto,dquilis}@dsic.upv.es

Resumen

Un Grid se compone de un conjunto de recursos de cómputo y datos ubicados en dominios administrativos diferentes que se gestionan bajo el marco de una Organización Virtual (OV) con el objeto de resolver problemas científicos.

Existen OV específicas tanto a nivel nacional (e.g. tut.vo.ibergrid.eu) como a nivel internacional (Testbed Gilda) que proporcionan infraestructuras Grid específicas para uso docente. Sin embargo, estas OVs tienen un uso limitado para la realización de actividades educativas, debido a que estas solo se pueden utilizar desde un punto de vista de un usuario Grid y no como administradores de recursos, dado que son recursos prefijados, imposibilitando agregar o borrar nuevos de forma elástica y dinámica.

En este trabajo se presenta un recurso docente que despliega dinámica y elásticamente un Grid as a Service (GaaS) en la nube, utilizando tanto proveedores públicos (Amazon Web Services) como privados (OpenNebula), en la que se virtualizan los dominios administrativos del Grid y se integran en una OV. Estos GaaS se crean con fines educativos y se pueden emplear tanto para usuarios del Grid como para administradores.

Abstract

A Grid is composed by a set of computational and data resources located in different administrative domain that are managed under the framework of a Virtual Organisation (VO) and aim to resolve scientific problems.

There are specific VOs both national (VO tut.vo.ibergrid.eu) and international (Gilda testbed that provide specific Grid infrastructures for educational purposes. However, these VOs have limited interest for educational activities since they can only be used from the Grid user point of view and not as administrators of the resources and services. This is because they use preallocated resources and it is impossible add or remove resources in the existing infrastructure in a dynamic and elastic way.

In this work we present an educational resource that dynamically deploys a Grid as a Service (GaaS) on the Cloud, using both public providers (Amazon Web Services) and on-premises (OpenNebula), virtualising the administrative domains of the Grid that are integrated in a VO. These GaaS are used for educational purposes and can be employed both by Grid users and system administrators.

Palabras clave

Grid, Cloud, Virtualización, Aprendizaje Basado en Proyectos

1. Introducción

Un Grid [8], en el área de la computación distribuida, se define como un conjunto de recursos (cómputo, redes, sofware y datos) heterogéneos y servicios distribuidos compartidos entre diferentes dominios administrativos (e.g. universidades, institutos de investigación, etc.) que se integran y gestionan bajo el marco de una Organización Virtual [8] (OV). El fin de un Grid es principalmente proporcionar una infraestructura de cómputo y datos para la ejecución de proyectos científicos que requieran de una elevada carga computacional y de almacenamiento de datos en diferentes áreas de la ciencia, tales como la radiología [1], astronomía [7] o la física de altas energías [5], entre otras.

A través de las OV, los investigadores disponen de un gran número de recursos [5] y pueden lanzar sus experimentos a través de los servicios que proporciona el Grid mediante los interfaces que ofrecen los Middlewares [11] (APIs o interfaces de líneas de comandos) o Gateways [15] construidos sobre estos, consiguiendo tiempos de computación más reducidos respecto a los que obtendría utilizando sus propios recursos de forma local.

tructuras virtuales de uso docente supone un paso adelante para facilitar la gestión de este tipo de plataformas por parte de los profesores involucrados.

Agradecimientos

Los autores agradecen este trabajo por la financiación recibida por el Vicerrectorado de Estudios, Calidad y Acreditación de la Universitat Politècnica de València (UPV) para desarrollar el Proyecto de Innovación y Mejora Educativa (PIME) "Entornos Virtuales Computacionales para la Evaluación de Competencias Transversales en la Nube", con referencia A04. GM quiere agradecer a l'Escola Tècnica Superior d'Enginyeria Informàtica de la Universitat Politècnica de València el soporte económico para la presentación de este trabajo.

Referencias

[1] Salvator Roberto Amendolia, Florida Estrella, Waseem Hassan, Tamas Hauer, David Manset, Richard McClatchey, Dmitry Rogulin, and Tony Solomonides. MammoGrid: A Service Oriented Architecture Based Medical Grid Application. pages 939–942. Springer Berlin Heidelberg, 2004.

[2] G. Andronico, V. Ardizzone, R. Barbera, R. Catania, A. Carrieri, A. Falzone, E. Giorgio, G. La Rocca, S. Monforte, M. Pappalardo, G. Passaro, and G. Platania. GILDA: The Grid INFN Virtual Laboratory for Dissemination Activities. In *First International Conference on Testbeds and Research Infrastructures for the DEvelopment of NeTworks and COMmunities*, pages 304–305. IEEE, 2005.

[3] Adam L. Bazinet, Daniel S. Myers, John Fuetsch, and Michael P. Cummings. Grid Services Base Library: A high-level, procedural application programming interface for writing Globus-based Grid services. *Future Generation Computer Systems*, 23(3):517–522, 2007.

[4] Miguel Caballer, Ignacio Blanquer, Germán Moltó, and Carlos de Alfonso. Dynamic management of virtual infrastructures. *Journal of Grid Computing*, 13(1):53–70, 2015.

[5] Ann Chervenak, Ian Foster, Carl Kesselman, Charles Salisbury, and Steven Tuecke. The data grid: Towards an architecture for the distributed management and analysis of large scientific datasets. *Journal of Network and Computer Applications*, 23(3):187–200, 2000.

[6] Dietmar W. Erwin. UNICORE: A Grid computing environment. *Concurrency and Computation: Practice and Experience*, 14(13-15):1395–1410, nov 2002.

[7] A. Forti, S.R. Bavikadi, C. Bigongiari, G. Cabras, A. de Angelis, B. de Lotto, M. Frailis, M. Hardt, H. Kornmayer, M. Kunze, and M. Piraccini. Grid Services For the MAGIC Experiment. In *Frontiers of Fundamental Physics*, pages 333–337. Springer Netherlands, Dordrecht, 2006.

[8] I. Foster, Carl Kesselman, and Steven Tuecke. The Anatomy of the Grid: Enabling Scalable Virtual Organizations. *International Journal of High Performance Computing Applications*, 15(3):200–222, aug 2001.

[9] José A. González-Martínez, Miguel L. Bote-Lorenzo, Eduardo Gómez-Sánchez, and Rafael Cano-Parra. Cloud computing and education: A state-of-the-art survey. *Computers & Education*, 80:132–151, 2015.

[10] M. Caballer J.D. Segrelles, G. Moltó. Remote Computational Labs for Educational Activities via a Cloud Computing Platform. In *2015 Proceedings of the Information Systems Education Conference (ISECON).*, pages 309–321, 2015.

[11] Attila Kertész and Péter Kacsuk. *A Taxonomy of Grid Resource Brokers*, pages 201–210. Springer US, Boston, MA, 2007.

[12] D. Kranzlmüller, J. Marco de Lucas, and P. Öster. The European Grid Initiative (EGI). In *Remote Instrumentation and Virtual Laboratories*, pages 61–66. Springer US, Boston, MA, 2010.

[13] Johan Montagnat, Ákos Frohner, Daniel Jouvenot, Christophe Pera, Peter Kunszt, Birger Koblitz, Nuno Santos, Charles Loomis, Romain Texier, Diane Lingrand, Patrick Guio, Ricardo Brito Da Rocha, Antonio Sobreira de Almeida, and Zoltán Farkas. A Secure Grid Medical Data Manager Interfaced to the gLite Middleware. *Journal of Grid Computing*, 6(1):45–59, mar 2008.

[14] J. Damian Segrelles and Germán Moltó. Assessment of cloud-based Computational Environments for higher education. In *2016 IEEE Frontiers in Education Conference (FIE)*, pages 1–9. IEEE, oct 2016.

[15] Nancy Wilkins-Diehr. Special Issue: Science Gateways—Common Community Interfaces to Grid Resources. *Concurrency and Computation: Practice and Experience*, 19(6):743–749, apr 2007.

5.3.1.13. XXV Jornadas sobre Enseñanza Universitaria de la Informática

G. Moltó, D. M. Naranjo, and J. R. Prieto, ”Herramienta web para el seguimiento automatizado de actividades educativas prácticas en la nube,ïn XXV Jornadas sobre Enseñanza Universitaria de la Informática, 2019, pp. 175-182.

- Participación: Ponencia
- Título del trabajo presentado: Herramienta web para el seguimiento automatizado de actividades educativas prácticas en la nube
- Entidad organizadora: Universidad de Murcia
- Lugar de celebración: Murcia, España
- Publicación: ISSN/ISBN: 2531-0607
- Objetivos: XXV Jornadas sobre Enseñanza Universitaria de la Informática
- Perfil de los destinatarios: Docentes universitarios de informática
- Fecha de inicio: 03/07/2019
- Fecha de fin: 05/07/2019

UNIVERSIDAD DE MURCIA

Facultad de Informática

JENUI [25] Murcia2019

XXV JORNADAS SOBRE LA ENSEÑANZA UNIVERSITARIA DE LA INFORMÁTICA

Germán Moltó Martínez

Ha presentado la **ponencia** Herramienta web para el seguimiento automatizado de actividades educativas prácticas en la nube, en las JENUI 2019 organizadas por la Facultad de Informática de la Universidad de Murcia y celebradas en el Campus de la Merced del 3 al 5 de julio de 2019.

Murcia, 5 de julio de 2019.

Fdo.: Jesús García Molina
Coordinador del Comité Organizador, Universidad de Murcia

AENUI
Asociación de Enseñantes Universitarios de la Informática

UNIVERSIDAD DE MURCIA

Facultad de Informática

JENUI [25] Murcia2019

XXV JORNADAS SOBRE LA ENSEÑANZA UNIVERSITARIA DE LA INFORMÁTICA

Germán Moltó Martínez

Ha asistido a las XXV Jornadas sobre la Enseñanza Universitaria de la Informática, organizadas por la Facultad de Informática de la Universidad de Murcia y celebradas en el Campus de la Merced del 3 al 5 de julio de 2019.

Murcia, 5 de julio de 2019.

Fdo.: Jesús García Molina
Coordinador del Comité Organizador, Universidad de Murcia

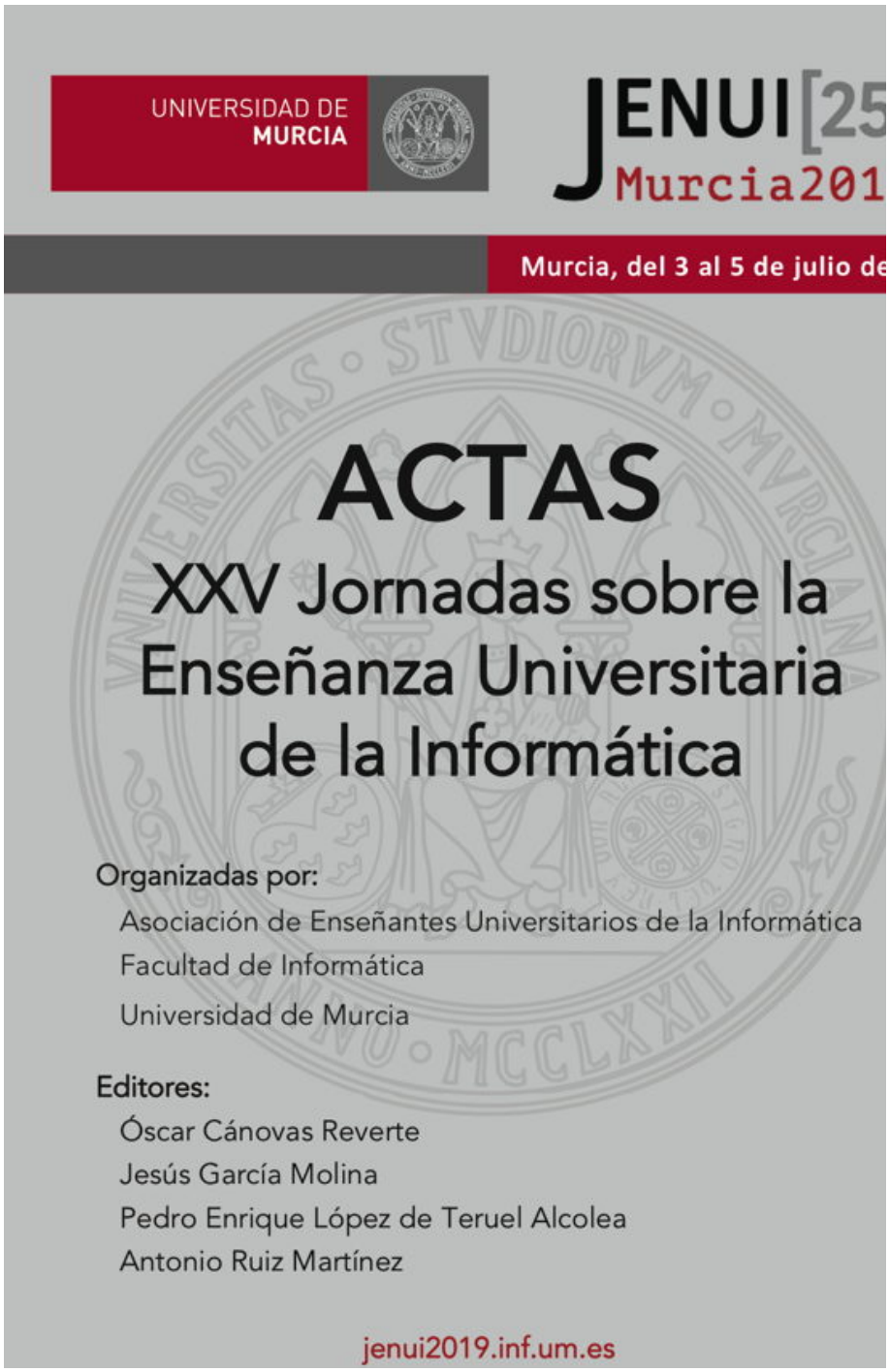
AENUI
Asociación de Enseñantes Universitarios de la Informática

Actas de las JENUI
Jornadas sobre la Enseñanza Universitaria de la Informática
AENUI Asociación de Enseñantes Universitarios de la Informát

Vol 4 (2019)

Actas de las XXV Jornadas sobre Enseñanza Universitaria de la Informática

TABLA DE CONTENIDOS



OPEN JOURNAL SYSTEMS

Ayuda de la revista

USUARIO/A

Nombre usuario/a
Contraseña
Recordar mis datos
Login

CONTENIDO DE LA REVISTA

Buscar
Todos
Buscar

Navegar
- Por número
- Por autor
- Por título

TAMAÑO DE FUENTE

INFORMACIÓN
- Para lectoras/es
- Para autoras/es
- Para bibliotecarias/os

ISSN: 2531-0607

Presentación

A lo largo de más de dos décadas, las *Jornadas de Enseñanza Universitaria de la Informática* (JENUI) se han convertido en el foro dónde los profesores universitarios de informática de España, y en menor medida de países latinoamericanos, han podido discutir sobre cómo mejorar los procesos de enseñanza/aprendizaje que atañen a la disciplina. Tras nacer en 1994 como un track de Informática dentro de las *II Jornadas sobre Innovación Docente en las Enseñanzas Técnicas Universitarias* celebradas en Valencia, las primeras JENUI tuvieron lugar al siguiente año en Sitges (Barcelona), y de forma ininterrumpida se han celebrado desde 1996 hasta ahora. Las JENUI propiciaron la creación de la *Asociación de Enseñantes Universitarios de la Informática* (AENUI) en el año 2000, y desde entonces esta asociación es la responsable de las Jornadas, entre otras actividades que realiza cada año.

Repasando las actas de JENUI se puede observar como las JENUI han servido para debatir sobre las inquietudes de los enseñantes de informática en cada período, bien marcado por un acontecimiento político, normalmente directrices de elaboración de planes de estudio, como el denominado "Proceso de Bolonia", o por innovaciones tecnológicas como la aparición de la Web o de las redes sociales, o por nuevas metodologías de aprendizaje como la clase invertida, entre otras coyunturas. A través de ponencias, pósteres, conferencias invitadas y mesas redondas, las JENUI han permitido presentar experiencias del profesorado, debatir sobre temas de actualidad y acoger a prestigiosos conferenciantes de todo el mundo.

Como fácilmente se puede deducir de las fechas indicadas arriba sobre el nacimiento de JENUI, esta edición tiene un carácter especial por tratarse de la vigesimoquinta. En cualquier institución, alcanzar esa antigüedad suele significar haber conseguido madurez y estabilidad, y una perspectiva de persistir en el largo plazo. Por ello, en esta edición se dedicará especial atención a conmemorar este aniversario con diversos actos, entre los que cabe destacar que las jornadas arrancarán con una mesa redonda para tratar sobre la influencia de las JENUI en la docencia universitaria de la Informática durante sus 25 años de existencia. Esta mesa contará con la presencia de profesores muy vinculados a la comunidad JENUI como son Alberto Gómez, Inés Jacob, Merche Marqués y Miguel Valero. La Universidad de Murcia, con sus más de 100 años de historia, acogerá la XXV edición de JENUI cuyo Comité Organizador está formado por un grupo de profesores de su Facultad de Informática coordinado por Óscar Cánovas Reverte y Jesús García Molina.

En la parte académica de las Jornadas, un Comité Directivo coordinado por José Manuel Badía se ha encargado de seguir con ese compromiso de conjugar la calidad de las contribuciones presentadas y servir como punto de encuentro anual de docentes interesados en intercambiar ideas y experiencias con sus colegas. Para ello, se lanzó una llamada a presentar contribuciones que (i) expongan experiencias docentes, (ii) presenten recursos informáticos de apoyo a la docencia, (iii) describan investigaciones en educación, o (iv) realicen reflexiones sobre la docencia universitaria de la Informática. En particular, se identificaron las siguientes áreas de interés para centrar las contribuciones:

- 25 años de JENUI
- Aplicación de las TIC al proceso de enseñanza-aprendizaje
- Calidad y evaluación de la docencia
- Compromiso social y medioambiental
- Didáctica en los estudios de Ingeniería Informática
- Didáctica de la informática en secundaria: programación, pensamiento computacional y máster de profesorado
- Desarrollo de competencias transversales y profesionales
- Estrategias institucionales en los estudios de Ingeniería Informática
- Evaluación del aprendizaje
- Mejoras pedagógicas en las asignaturas
- Organización curricular y planes de estudio

- Optimización del tiempo y el trabajo del profesor
- Promoción de los estudios de Ingeniería Informática
- Trabajos fin de carrera, prácticum, proyectos y participación de alumnos en la investigación

Los formatos de las presentaciones han sido los habituales: ponencia con presentación oral, demostración de recurso docente y póster. Para las ponencias y los recursos docentes se han solicitado trabajos escritos de hasta 8 páginas, mientras que para los pósteres se han solicitado trabajos de hasta 4 páginas.

Se han recibido 72 contribuciones, las cuales han sido evaluadas por un Comité de Programa formado por 135 profesores de 40 universidades de 9 países, y se han efectuado 5 revisiones por contribución. Se han aceptado 33 ponencias, 11 recursos docentes y 8 pósteres, lo que supone una tasa de aceptación global del 72 %. Esta tasa refleja una gran calidad de los trabajos presentados dado que se ha mantenido el alto nivel de exigencia. Todos los trabajos aceptados se incluyen en estas actas organizadas por las sesiones en las que han sido presentados: 9 sesiones de presentaciones orales de ponencias y recursos docentes, y una sesión específica para presentar los pósteres. Las 9 sesiones de ponencias y recursos docentes se han organizado en 4 franjas horarias (2 sesiones por franja) y una sesión plenaria dedicada a presentar los 6 trabajos elegidos como candidatos a obtener el premio a las dos mejores ponencias de las JENUI 2019. Estos 6 trabajos han sido seleccionados por el Comité Directivo entre los mejor valorados por los revisores del Comité de Programa.

En cuanto a las sesiones plenarias, además de la mesa redonda comentada anteriormente, se han incluido 3 conferencias. En la primera de ellas, el Dr. Ernesto Cuadros (UTEC, Perú, miembro del equipo CC2020 de ACM/IEEE) expondrá las novedades del nuevo Computing Curricula de ACM/IEEE que será presentado el próximo año. La segunda será impartida por el galardonado con el Premio AENUI de 2018, el profesor Alberto Gómez (Universidad de Extremadura). Por último, la tercera consistirá en una conferencia de Matti Tedre (Stockholm University, Sweden) que abordará cómo ha evolucionado la enseñanza de la informática desde los primeros años y sobre el interés actual por el paradigma del pensamiento computacional.

Como es habitual, las Jornadas acogerán la asamblea anual de AENUI, y en ella se realizará la selección de los dos mejores trabajos pudiendo votar todos los miembros de la asociación. El resultado de la votación se mostrará en la página web de JENUI 2019[1]. Todos los trabajos presentados en las JENUI se publican en la revista de AENUI[2].

Algunos artículos serán invitados a ser publicados en la revista IEEE-RITA (Revista iberoamericana de tecnologías del aprendizaje [3], que está indexada en SJR, SCImago y Emerging Sources en la Web of Science. También, las revistas TICAI[4] y Novática[5] publicarán uno o dos trabajos presentados en las JENUI. La selección de estos trabajos la realizarán dichas revistas siguiendo sus propios criterios editoriales. Los autores de estos trabajos tendrán la oportunidad de actualizarlos para su publicación en las revistas.

Como es habitual, durante las JENUI se entregará el *Premio AENUI a la Calidad e Innovación Docente*, que reconoce la labor realizada en aras de la calidad e innovación docente en el área de la docencia universitaria de la Informática. También se entregará el premio SISTEDES al mejor trabajo presentado en el ámbito de la Ingeniería del Software y de las tecnologías del desarrollo de software, el cual es otorgado por la sociedad SISTEDES[6].

Finalmente, nuestro agradecimiento a los verdaderos protagonistas de JENUI en cada edición, los cuales han hecho posible llegar a este 25 aniversario: los autores y revisores. A los primeros por enviar contribuciones y acudir a Murcia para su presentación, y a los segundos por su esfuerzo en conseguir mantener el nivel de calidad de JENUI en esta edición.

Comité directivo JENUI 2019
Comité organizador JENUI 2019

[1] JENUI 2019: `http://jenui2019.inf.um.es`
[2] Revista Actas de las JENUI: `http://actasjenui.aenui.net`
[3] Revista IEEE RITA: `http://rita.det.uvigo.es/IEEERITA2018`
[4] TICAI:`http://romulo.det.uvigo.es/ticai/`
[5] Novática: `http://www.ati.es/novatica/`
[6] SISTEDES: `http://www.sistedes.es/`

Actas de las JENUI
Jornadas sobre la Enseñanza Universitaria de la Informática
AENUI Asociación de Enseñantes Universitarios de la Informática

Vol 4 (2019)

Actas de las XXV Jornadas sobre Enseñanza Universitaria de la Informática

Tabla de contenidos

Presentación

Candidatos a Mejor Ponencia

Ponencias

Pósteres

ISSN: 2531-0607

Actas de las Jenui, vol. 4. 2019.
Páginas: 175-182

Herramienta web para el seguimiento automatizado de actividades educativas prácticas en la nube

Germán Moltó, Diana M. Naranjo, José Ramón Prieto
Instituto de Instrumentación para Imagen Molecular (I3M).
Centro mixto CSIC - Universitat Politècnica de València
Camino de Vera s/n, 46022 Valencia, España
gmolto@dsic.upv.es

Resumen

Esta contribución presenta un recurso docente destinado a la recopilación y análisis automatizado de evidencias generadas en actividades educativas prácticas en la nube, ejemplificado para Amazon Web Services (AWS). Incluye una arquitectura que posibilita la captura de datos y procesado utilizando servicios en la nube, así como un panel web de control educativo donde profesor y alumnos pueden consultar información relativa al uso de los diferentes servicios de AWS. Además, permite la autorregulación de los estudiantes proporcionándoles información sobre el porcentaje de progreso de cada sesión de laboratorio y las acciones que faltan para culminar cada práctica. La herramienta permite extraer automáticamente analíticas de aprendizaje en base a dichos datos, que permiten evidenciar el grado de desarrollo de una práctica para un alumno concreto. También obtiene información agregada sobre el uso de recursos en AWS de diferentes alumnos a lo largo de un curso académico. La herramienta, que se ha liberado a la comunidad como código abierto, se está utilizando en producción en tres másteres y un curso online de formación en AWS, y puede ser aplicada en entornos educativos que involucren el uso de este proveedor Cloud.

Abstract

This contribution presents a teaching resource aimed at the collection and automated analysis of data generated in practical educational activities in the cloud, exemplified for Amazon Web Services (AWS). It includes an architecture that enables data capture and processing using cloud services, as well as an educational web panel where the teacher can access information related to the use of the different AWS services. In addition, it allows self-regulation of students by providing information on the percentage of progress of each laboratory session and the actions that are missing to complete each practice session. The tool allows automatic extracting of learning analytics based on these data that allows to demonstrate the degree of development of a practice session for a specific student. Teachers can also get aggregated information about the use of AWS resources from different students throughout an academic year. The tool, which has been released to the community as open source, is being used in production in three master's degrees and an online training course in AWS, and can be applied in educational environments that involve the use of this Cloud provider.

Palabras clave

Cloud Computing, Analíticas de Aprendizaje, Evaluación, Autorregulación

1. Introducción

La computación en la nube (Cloud Computing) es un paradigma de computación distribuida que permite el acceso a recursos virtualizados de cómputo, almacenamiento, redes, servicios y aplicaciones, tal y como define el NIST [10].

En el ámbito de la educación superior, principalmente en las ingenierías, cada vez es más común el uso de esta tecnología, por lo que se utiliza tanto en actividades educativas de carácter presencial, semi-presencial y completamente on-line. Esto es debido a las numerosas ventajas que proporciona a los principales actores involucrados en los procesos de enseñanza aprendizaje (instituciones educativas, profesores y alumnos) [8]. Por ello, en la literatura, podemos encontrar experiencias docentes en ingenierías que utilizan el Cloud, entre otras cosas, para: a) externalizar servicios, tales como el correo electrónico o herramientas colaborativas que pasan a ser utilizadas por parte de los alumnos a través de un navegador web [1]; b) aplicar metodologías de aprendizaje como el Aprendizaje Basado en Proyectos (ABP) [2]; c) dar soporte a asignaturas que

Pregunta	# en [5,6]	# en [7,8]	# en [9,10]
La herramienta siempre ha estado accesible cuando la he necesitado	0	1	31
He sabido utilizar la herramienta sin requerir la ayuda del instructor	1	9	22
He sido capaz de interpretar la información obtenida por la herramienta	2	8	22
La información mostrada me ha ayudado a conocer el progreso en cada una de mis prácticas	2	4	26
El uso de CloudTrail-Tracker es apropiado como herramienta de apoyo para la formación práctica en AWS	1	5	26

Cuadro 1: Resultados de la encuesta de evaluación de CloudTrail-Tracker.

Agradecimientos

Los autores desean agradecer al Ministerio de Economía, Industria y Competitividad" por el proyecto "BigCLOE" con número de referencia TIN2016-79951-R. Los autores agradecen la financiación recibida por el VECE de la UPV para desarrollar el PIME con referencia B29. GM quiere agradecer a l'Escola Tècnica Superior d'Enginyeria Informàtica de la Universitat Politècnica de València el soporte económico para la presentación de este trabajo.

Referencias

[1] Enric Brescó Baiges y Noemí Verdú Surroca. Valoración del uso de las herramientas colaborativas wikispaces y google drive, en la educación superior. *Edutec. Revista Electrónica de Tecnología Educativa*, (49), 2015.

[2] Agustin C. Caminero, Salvador Ros, Roberto Hernandez, Antonio Robles-Gomez y Rafael Pastor. Cloud-based e-learning infrastructures with load forecasting mechanism based on Exponential Smoothing: A use case. In *2011 Frontiers in Education Conference (FIE)*, pages S3C–1–S3C–6. IEEE, oct 2011.

[3] Karim Chine. Learning math and statistics on the cloud, towards an EC2-based google docs-like portal for teaching/learning collaboratively with R and scilab. In *Proceedings - 10th IEEE International Conference on Advanced Learning Technologies, ICALT 2010*, pages 752–753. IEEE, jul 2010.

[4] Adam Eivy. Be Wary of the Economics of Serverless Cloud Computing. *IEEE Cloud Computing*, 4(2):6–12, mar 2017.

[5] Alberto Fernández, Daniel Peralta, José Manuel Benítez y Francisco Herrera. E-learning and educational data mining in cloud computing: an overview. *International Journal of Learning Technology*, 9(1):25, 2014.

[6] Maite García. La autorregulación académica como variable explicativa de los procesos de aprendizaje universitario. *Profesorado. Revista de Currículum y Formación de Profesorado*, 16:203–221, 2012.

[7] José A. González-Martínez, Miguel L. Bote-Lorenzo, Eduardo Gómez-Sánchez y Rafael Cano-Parra. Cloud computing and education: A state-of-the-art survey. *Computers and Education*, 80:132–151, jan 2015.

[8] Anwar Hossain Masud, Jianming Yong y Xiaodi Huang. Cloud Computing for Higher Education: A roadmap. In *Proceedings of the 2012 IEEE 16th International Conference on Computer Supported Cooperative Work in Design, CSCWD 2012*, pages 552–557. IEEE, may 2012.

[9] Peter Mell and Tim Grance. The NIST Definition of Cloud Computing. NIST Special Publication 800-145 (Final). Technical report, 2011.

[10] J. Damià Segrelles y Germán Moltó. Recopilación Automatizada de Evidencias de la Realización de Actividades Educativas en el Cloud. In *XXI Jornadas sobre la Enseñanza Universitaria de la Informática (JENUI 2015)*, pages 97–104, 2015.

[11] J. Damian Segrelles y Germán Moltó. Assessment of Cloud-based Computational Environments for Higher Education. In IEEE, editor, *2016 IEEE Frontiers in Education Conference Proceedings*, 2016.

[12] J. Damian Segrelles, Germán Moltó y Miguel Caballer. Remote Computational Labs for Educational Activities via a Cloud Computing Platform. In *2015 Proceedings of the Information Systems Education Conference (ISECON)*, pages 309–321, 2015.

[13] J Damian Segrelles, Alicia Martinez, Nuria Castilla y Germán Moltó. Virtualized computational environments on the cloud to foster group skills through pbl: A case study in architecture. *Computers & Education*, 108:131–144, 2017.

[14] Luis M. Vaquero. EduCloud: PaaS versus IaaS cloud usage for an advanced computer science course. *IEEE Transactions on Education*, 54(4):590–598, nov 2011.

5.3.1.14. 2016 IEEE Frontiers in Education Conference

J. D. Segrelles and G. Molto, "Assessment of cloud-based Computational Environments for higher education," in 2016 IEEE Frontiers in Education Conference (FIE), 2016, pp. 1-9, doi: 10.1109/FIE.2016.7757604.

- Participación: Ponencia
- Título del trabajo presentado: Assessment of Cloud-based Computational Environments for Higher Education
- Entidad organizadora: IEEE
- Lugar de celebración: Eire, PA, USA
- Publicación: ISSN/ISBN: 2531-0607
- Objetivos: 2016 IEEE Frontiers in Education Conference
- Perfil de los destinatarios: Docentes internacionales
- Fecha de inicio: 12/10/2016
- Fecha de fin: 15/10/2016

2016 Frontiers in Education Conference

The Crossroads of Engineering and Business
Erie, PA • October 12-15, 2016

FIE 2016 is sponsored by:
- **American Society for Engineering Education (ASEE)**
  Educational Research Methods (ERM) Division
- **Institute of Electrical and Electronics Engineers (IEEE)**
  IEEE Education Society
  IEEE Computer Society

Co-sponsored by:
Gannon University and
Penn State University, Behrend

FROM: Kevin G. Curry
SUBJECT: Attendance and Presentations at FIE
DATE: October 15,2016
TO: Germán Moltó
Universitat Politecnica de Valencia
Valencia
Spain

To whom it may concern:

Germán Moltó attended the 46th annual Frontiers in Education Conference in Erie, Pennsylvania. The conference was held from October 12-15, 2016. The following paper(s), authored by Germán were presented:

Assessment of Cloud-based Computational Environments for Higher Education

To see more information about the conference, please visit our web site at http://fie-conference.org/.

Sincerely,

Kevin G. Curry
Assistant to the General Chairs
The University of Kansas
Overland Park, KS
+1 913.897.8761
Kevin.Curry@ku.edu

Frontiers in Education 2016

The Crossroads of Engineering and Business

October 12-15, 2016 | Bayfront Convention Center | Erie, PA

Table of Contents | Welcome Message | Awards | Workshops
Conference Sponsors | Technical Sessions | Author Index | Plenary Sessions
Search | Help

IEEE

IEEE computer society

IEEE Catalog Number: CFP16FIE-USB
ISBN: 978-1-5090-1789-8

Technical Support:
Conference Catalysts, LLC
Phone: +1 352 872 5544
cdyer@conferencecatalysts.com

2016 IEEE Frontiers in Education Conference Proceedings

To obtain copies of the USB version of the proceedings, please contact:

Mail IEEE Customer Service Department
445 Hoes Lane
PO Box 1331
Piscataway, NJ 08855-1331 USA

Phone Toll-free 800-678-IEEE (4333) or 732-981-0060

USB Version of Proceedings IEEE Catalog Number and ISBN

IEEE Catalog Number: CFP16FIE-ART
USB version, IEEE Catalog Number: CFP16FIE-USB
ISBN: 978-1-5090-1790-4

Copyright and Reprint Permission:

TARGETED FLIPPED CLASSROOM TECHNIQUE APPLIED TO A CHALLENGING TOPIC
Joseph Ranalli (Penn State Hazleton, USA)
Jacob Moore (Penn State Mont Alto, USA)

ASSESSMENT OF CLOUD-BASED COMPUTATIONAL ENVIRONMENTS FOR HIGHER EDUCATION
J. Damian Segrelles (Universitat Politècnica de València, Spain)
Germán Moltó (Universitat Politècnica de València, Spain)

DESIGN OF OPEN SOURCE PLATFORM FOR AUTOMATIC CONTROL SYSTEMS EDUCATION BASED ON COOPERATIVE LEARNING
Jonathan Alvarez Ariza (Uniminuto, Colombia)

USING DESIGN JOURNALS TO UNCOVER INFORMATION LITERACY HABITS OF FIRST-YEAR STUDENTS
Michael Fosmire (Purdue University, USA)
Nastasha Johnson (Purdue University, USA)
Nathan Mentzer (Purdue University, USA)

S1D: Inclusivity and Diversity Initiatives
Chair: Rebekah Michael (University of Cincinnati, USA)
8:30 AM - 10:00 AM
Room: 130C

METHODOLOGY FOR INNOVATION IN THE EDUCATION OF FUTURE ENGINEERS WITH TECHNOLOGICAL AND SOCIAL AWARENESS
D. Arias (Pontificia Universidad Catolica del Peru, Peru)
D. Quiroz (Pontificia Universidad Catolica del Peru, Peru)
D. Elias (Pontificia Universidad Catolica del Peru, Peru)

MOTIVATING ATTENDEE'S PARTICIPATION IN DISTANCE LEARNING VIA AN AUTOMATIC MESSAGING PLUGIN FOR THE MOODLE PLATFORM
Luciano R. de Almeida (University of Brasília, Brazil)
Joao Paulo C. L. da Costa (University of Brasília, Brazil)
Rafael T. de Sousa Junior (University of Brasília, Brazil)
Edison P. de Freitas (Federal University of Rio Grande do Sul, Brazil)
Edna D. Canedo (University of Brasília, Brazil)
Juliano Prettz (Universidade de Brasília, Brazil)
Eliakim Zacarias (Universidade de Brasília, Brazil)
Giovanni Del Galdo (Ilmenau University of Technology, Germany)

INTERDISCIPLINARY SYSTEMS ENGINEERING AND AERONAUTICS SCIENCE EFFORT TO ENHANCE SUAS TRAINING PROGRAM FOR UNDERGRADUATE STUDENTS
Luis Daniel Otero (Florida Institute of Technology, USA)
Nicholas Gagliardo (Florida Institute of Technology, USA)
Dennis Dalli (Florida Institute of Technology, USA)
Julie Moore (Florida Institute of Technology, USA)

INSTRUCTIONAL DESIGN PRINCIPLES OF DIVERSITY-FOCUSED PROFESSIONAL DEVELOPMENT MOOC FOR COMMUNITY COLLEGE COMPUTING FACULTY: LIGHTHOUSE CC
Yunjeong Chang (University of Virginia, USA)
Leslie Cintron (University of Virginia, USA)
Joanne Cohoon (University of Virginia, USA)
James Cohoon (University of Virginia, USA)
Luther Tychonievich (University of Virginia, USA)

Assessment of Cloud-based Computational Environments for Higher Education

J. Damian Segrelles and Germán Moltó
Instituto de Instrumentación para Imagen Molecular (I3M)
Centro mixto CSIC - Universitat Politècnica de València - CIEMAT,
Valencia, España.
Email: dquilis@dsic.upv.es; gmolto@dsic.upv.es

***Abstract*—Education in Engineering requires bringing the students to scenarios as close to reality as possible. Indeed, the new technologies have fostered the development of a wide spectrum of Computational Environments (CE), such as simulators, virtual laboratories or specific software tools. These environments typically share the same Physical Hardware Resources (PHRs) (e.g. laboratories of PCs) for different subjects on which the CEs are deployed. It is especially important to properly and efficiently manage the rationalization of these PHRs so that the level of service, scalability and versatility is maintained without requiring additional investments in new hardware. The innovation in this work consists on introducing Virtualized CEs (VCEs) based on Cloud Computing by means of the open-source ODISEA platform. The benefits have been assesed and evaluated through 12 educational activities carried out in 8 subjects across 4 degrees at the Universitat Politècnica de València (UPV), in Spain. The results assessed in the paper demonstrate that ODISEA provides economical benefits for the educational institutions. Also, the platform provides the students with ubiquitous and highly available access to VCEs. In addition, this approach fosters BYOD (Bring Your Own Device) where students use their own computers to access the remote labs provided by the VCEs.**

I. Introduction

The European Higher Education Area (EHEA)[1] requires the students to gain experience with specific tools to solve real problems. For this aim, the advances in Information and Communication Technologies (ICTs) have fostered the development of a wide spectrum of Computational Environments (CEs) that are executed on underlying Physical Hardware Resources (PHRs) to support Educational Activities (EAs). These CEs are presented as simulators[1][2][3] virtual laboratories [4][5] and specific software tools [6][7].

This contribution focuses on EAs that require CEs composed by a set machines involving certain hardware, software and complex configuration requirements. For example, a subject on an advanced Computer Science topic such as distributed systems may require that students access a set of machines configured as a Hadoop cluster with support for the Java programming language and some pre-staged datasets.

In general, CEs provide significant benefits for educational centres and students, though their deployment is not free from difficulties and challenges, which are summarised below.

From the point of view of the educational institutions, there are two basic aims: to improve the learning outcome of students and to cut down the budget allocated to the acquisition and maintenance of their resources while maintaining an appropriate quality of service. In this sense, the acquisition and use of CEs improves the teaching-learning process as demonstrated in different studies in Higher Education [8]. However, their acquisition and maintenance is economically convenient only under certain circumstances because there are challenges that remain unsolved:

(a) **Complex maintenance of the CEs**. Problems might arise due to the wide spectrum of CEs and software tools that may require both complex PHRs configurations and potentially incompatible specific software requirements. Typically, the educational institutions are multi-disciplinary environments with different academic subjects that share the same PHRs (e.g. laboratories of PCs).
(b) **Rationalization of PHRs associated to CEs**. It is specially important to properly and efficiently manage the PHRs of an education center so that the level of service and versatility is maintained without requiring additional investments in hardware, specially in the context of an economic crisis, and to reduce the carbon footprint [9].
(c) **Bring Your Own Device (BYOD) to access the CEs**. When students are allowed to bring their own devices to school, the educational institution is not required to purchase as many laptops. Economics also play an important role to leverage BYOD for interacting with the CEs [10].

From the point of view of students, CEs enable them to interact with real or simulated tools used in their professional environments. However, there are fundamental challenges that need to be addressed:

(a) **Ubiquitious Availability of the CEs**. Students should be provided with ubiquitous and 24/7 access to CEs, which has many pedagogical advantages [11] such as more efficient time-management and the ability to work collaboratively [12] regardless of space and time.
(b) **Bring Your Own Devices (BYOD)**. Students should be allowed to access the CEs using their own devices because there are important advantages such as promoting a greater participation in the classroom [13] and a positive attitude and motivation from students [14] [15].
(c) **Variety of CEs**. Introducing different CEs within an EA enables students to access a wide range of platforms or

[1]Bologna Process - European Higher Education Area: http://www.ehea.info

978-1-5090-1790-4/16/$31.00 ©2016 IEEE

tools, enriching the variety of the activity.

Our hypothesis is that Cloud Computing is an appropriate technology to overcome the challenges and difficulties described above. Cloud computing [17][18][19] arises as a paradigm to rapidly provision and release configurable resources, mainly computing and storage. A Virtualized CE (VCE) consists of a set of customized Virtual Machines (VMs) running on a Cloud provider, either on-premises or public. These VMs can be customized and configured to deploy VCEs that satisfy the hardware, software and configuration requirements for an educational activity. This enables to dynamically deploy virtual infrastructures on top of a fleet of Virtual Machines (VMs) running on top of PHRs, when using the Infrastructure as a Service (IaaS) Cloud service model. The usage of virtualization [20] enables to increase the usage of hardware and thus reducing the investments on additional hardware. In the case of a public Cloud provider, such as Amazon Web Services (AWS), Microsoft Azure or Google Cloud Platform, a pay-per-use model is employed so that users are charged for the resources consumed in terms of hours or minutes of computing, network traffic, etc. In the case of private or on-premises Clouds, tools such as OpenStack[2] or OpenNebula [21] allow system administrators to deploy Cloud infrastructures on top of the the educational institution PHRs.

In our previous work [23], the ODISEA platform was introduced, validated and assessed by means of 6 EAs carried out through 6 subjects involved in 2 different degrees at the Universitat Politècnica de València (UPV) during the academic course 2013/2014. In this previous work, the validation was addressed only from the point of view of the lecturers, demonstrating: a) The capability to provide elasticity and scalability of the VCEs; b) The capability to reproduce a precise clone of a VCE at a later point in time; c) The capability to share and reuse the VCEs among different EAs; d) The user-friendly interface of the platform to manage the VCEs.

The innovation in this work consists on introducing VCEs based on Cloud Computing in multiple EAs across on-premises and public Clouds by means of the ODISEA open-source platform with the goal of assessing its benefits from the point of view of the educational institution and for the students. This contribution goes far beyond the current trend of using virtualization to ease the configuration and update of the physical labs, which basically represents a benefit for the system administrators. Virtualization itself is not enough to provide the automated deployment and configuration of complex VCEs (involving multiple machines with inter-dependent configuration among them) and that have to be dynamically deployed in minutes and easily disposed of after the educational activity via a high-level Graphical User Interface (GUI) that can be operated by the professors themselves. Therefore, this contribution complements our previous work [23] and, together, represent a practical approach on using Cloud Computing to support educational activities that require CEs.

[2]OpenStack: http://www.openstack.org/

After the introduction, the remainder of the paper is structured as follows. First, section II briefly describes the ODISEA Platform and the phases required to use it. Section III presents the objectives of this paper. Then, section IV describes the platform validation carried out through 12 EAs across 8 subjects. Next, section V presents the assessment and introduces a discussion of the benefits and drawbacks of the proposed platform. Finally, section VI summarises the paper and points to future work.

II. ODISEA Platform

ODISEA, an acronym for *On-demand Deployment of Infrastructures to Support Educational Activities*, is an open-source platform to deploy VCEs both on public and on-premise Clouds, with the precise hardware, software and configuration requirements to perform specific EAs.

A. Architecture

The technical details of ODISEA platform architecture were presented in [23]. Basically, the architecture is composed of three layers (see Figure 1). The Level 1 is a repository of Virtual Machine Images (VMIs) with a pre-installed Operating System. Software requirements can be deployed at runtime via the Ansible tool. However, complex or time-consuming software can be pre-packaged into specific VMIs to speed up the deployment process of the VCE. Level 2 consists of a repository of recipes, which are described with a high level language supported by ODISEA named RADL [24]. Each recipe describes the rules to create a VCE, specifying the VMIs (from Level 1) and the hardware resources required for the VCE, in terms of vCPUs (virtual CPUs), Hard Disk size, network connectivity, etc.) and software resources. The third layer, is composed by a set of Cloud providers, where the VCEs can be provisioned and configured considering the recipes from Level 2. These providers can be on-premise (such as OpenNebula or OpenStack, and even virtualization platforms such as Xen or KVM) or public providers (such as Microsoft Azure, Amazon Web Services, etc.).

B. Using ODISEA

ODISEA is typically used following these three phases:

1) (Phase 1). Firstly, the lecturer analyzes the subjects to identify the CEs (simulators, virtual laboratories or specific software tools) required in the EAs in her course or subject. Information such as the number of students by CEs together with their period of use must be determined. Also, the hardware and software requirements have to be identified.
2) (Phase 2). Secondly, the lecturer creates the descriptions of the VCEs in ODISEA depending on the list of CEs detected at, reusing existing VMIs (Level 1), recipes of VCEs (Level 2) and choosing the cloud provider (Level 3) accessible by the lecturer. Depending on the computer skills of the lecturer, this may require further support from a system administrator. ODISEA uses the GUI provided by the Infrastructure Manager (IM) [25].

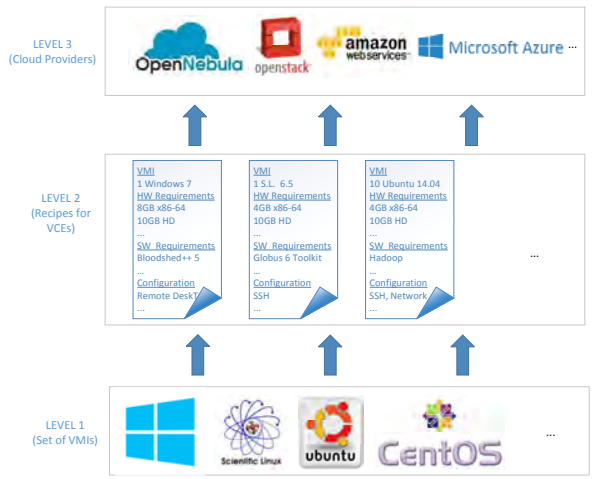


Fig. 1. Levels of the ODISEA Architecture.

Access is currently provided as a web tool [26] where no registration is required to use it. Readers are encouraged to use it and submit feedback.

3) (Phase 3). Finally, the lecturer uses ODISEA to manage the lifecycle of the VCEs by deploying them before the EA start and to terminate them once the EA has finished.

Note that the usage of ODISEA by the lecturers is not restricted to institutions that support a Cloud platform. AWS offer the AWS Educate[3] program where institutions, educators and students can join to obtain credits to access AWS technology. In particular the Amazon EC2 service allows educators to deploy Virtual Machines for free (until consuming the amount of credits obtained). Therefore, we believe that platforms such as ODISEA pave the way for educators to dynamically deploy complex remote labs, accessible anywhere and anytime, to support their educational activities with an unprecedented degree of flexibility when compared to traditional physical laboratories.

III. Objectives

In this work, we extend the assessment of the ODISEA platform initiated in [23], and the main objective is to validate and assess ODISEA from the point of view of the educational institution and students in order to resolve the challenges exposed in section I. This validation has been performed through 12 EAs carried out in 8 subjects involved in 4 different degrees at the Universitat Politècnica de València (UPV) during the academic course 2015/2016.

These are the parameters to evaluate concerning the educational institution:

- The ability to **improve the teaching-learning process**, easing the use of VCEs in the EAs.
- The reduction of the budget of **acquisition** and **maintenance** of PHRs associated to VCEs, simplifying their configuration and update.
- The promotion of **BYOD** in the students, avoiding investments in devices that can be provided by the student (such as laptops).
- The capability of providing an efficient **rationalization** of PHRs, avoiding the upfront investments in additional PHRs.

These are the parameters to evaluate concerning the students:

- The capability to provide **high availability and ubiquitous access** for the VCEs.
- The ability for students to use their own devices in the learning activities, thus **promoting BYOD**.
- The capability to access different VCEs, enabling the students to work with a wide range of platforms and or tools, thus enriching the **variety** of EAs.

IV. Validation

This section describes the validation process to asses the ODISEA platform with respect to the parameters identified in the previous section. First, a brief description of the Cloud platforms used for the validation is provided. Second, the usage of ODISEA within the different EAs is described, following the phases described in section II-B.

A. Cloud Providers

We have used different Cloud platforms from which the hardware resources that support the VCEs are provisioned:

- An on-premises IaaS Cloud platform with a total of 128 cores and 352 GB of RAM managed by OpenNebula 4.2 to provision a large number of VMs.
- The AWS public Cloud, to provision computing, storage and network capacity on a pay-as-you-go basis. Our institution joined the AWS Educate program and, therefore, credits are available to cover the costs of the main AWS services.

B. Analyzing EAs and Identifying CEs (Phase 1).

The ODISEA Platform has been extensively employed in four academic degrees such as the Bachelor's Degree in Industrial Electronics and Automation Engineering (BIEA), the Master's Degree in Parallel and Distributed Computing (MPDC)[4], the Master's Degree in Informatics Engineering (MIE)[5], and an Online Postgraduate Course (OPC) at the Universitat Politècnica de València (UPV). In this phase each subject is analyzed together with the CEs required to carry out the EAs. Table I includes a summary of them though a brief description is provided here:

[3] AWS Educate: https://aws.amazon.com/es/education/awseducate

[4] http://www.upv.es/titulaciones/MUCPD

[5] http://muiinf.webs.upv.es

TABLE I
LIST OF SUBJECTS, EDUCATIONAL ACTIVITIES (EAS) SCHEDULED, CES INVOLVED AND THE NUMBER OF STUDENTS PER SUBJECT.

DEGREE	SUBJECT	EAs	ACTIVE	CEs	Nº
BIEA	Computer Science (INF)	E.A.1	16 weeks	-Bloodshed Dev-C++5 (IDE + Compiler)	36
MIE	Medical Informatics (IME)	E.A.2	8 weeks	-DCM4CHEE PACS Server -TUDOR DICOM toolkit + NetBeans IDE	6
	Grid and Cloud Computing Concepts (CCGC)	E.A.3	6 weeks	-Globus Toolkit 6 -Public Key Infrastructure (PKI) based on OpenCA	14
		E.A.4	4 hours		
		E.A.5	4 weeks		
MCPD	Grid Advanced Infrastructures (IAG)	E.A.6	7 weeks	-CLIs of gLiteUI package -OpenLDAP service and Berkeley Database -Public Key Infrastructure (PKI) based on OpenCA	6
		E.A.7	2 weeks		
		E.A.8	4 weeks		
MCPD	Grid Programming Models (MPG)	E.A.6	1 week	-CLIs of gLiteUI package -OpenMP compiler	12
MCPD	Cloud Programming Models (MPC)	E.A.9	7 weeks	-Python user interface to AWS (Boto) and AWS CLI - Hadoop Cluster	15
		E.A.10	4 hours		
MCPD	Cloud Advanced Infrastructures (IAC)	E.A.9	7 weeks	-Python user interface to AWS (Boto) and AWS CLI -Ansible -OpenNebula Testbed	15
		E.A.11	4 hours		
		E.A.12	4 hours		
OPC	Online Course on AWS (CloudAWS)	E.A.9	70 days	-Python user interface to AWS (Boto) and AWS CLI -Ansible	380
		E.A.11	4 hours		

E.A.1. Developing C Programs. The students learn programming skills developing C programs in class using Dev-C++[6] or autonomous tasks using their own computers (Dev-C++ for Windows or Xcode for OS X) as homework.

E.A.2. Developing DICOM applications. The students learn the DICOM protocol for managing medical images and they develop DICOM programs in the classroom and autonomous tasks to transfer and encapsulate medical images using TUDOR DICOM[7] toolkit with the NetBeans IDE[8], and interacting with a DCM4CHEE PACS Server[9].

E.A.3. Developing Grid Applications. The students learn Grid programming skills and develop Grid applications using the Globus Toolkit 6 (GT6)[10] in the classroom or via autonomous tasks.

E.A.4. Developing Grid Secure Applications. The students learns basic concepts about Grid security issues and they create X.509 certificates (just-in-time for the practice lesson) to secure connections during just one practice lesson. A Public Key Infrastructure (PKI) based on OpenCA[11] is used.

E.A.5. Developing a Grid Project. Students are evaluated by developing a grid project. Each student configures and uses a secure grid infrastructure based on GT6 , and develop a complex grid application that use the created infrastructure. For the project a PKI (managed by the lecturer) is required for all students. Also, each student requires a grid infrastructure composed of three machines with GT6.

E.A.6. Developing an Advanced Grid Application. The students learn Grid programming skills. Each student develops advanced grid applications using gLite Command Line Interfaces (CLIs)[12] interacting with the European Grid Infrastructure (EGI)[13] through classroom or homework tasks.

E.A.7. Developing LDAP Services. The students learn basic and advanced concepts about LDAP Services. Each student should configure secure grid information services based on OpenLDAP[14] using the Oracle Berkeley Database as backend emulating replicated models via classroom tasks. For this, each student need two resources (PCs) with OpenLDAP, a Berkeley DB and a PKI infrastructure to generate certificates.

E.A.8. Developing an Advanced Grid Project. The students are evaluated by developing a Grid project. Each student uses the EGI infrastructure and develops a complex grid application using the gLite CLI.

E.A.9. Architecting with AWS Cloud Services. The students use different services provided by AWS to create architectural designs of applications and deploy them on the AWS Cloud using Boto[15] and the AWS CLI[16]. The activity is performed via classroom and autonomous tasks.

E.A.10. Analysing Big Data with Apache Hadoop. The students create programs based on the MapReduce programming model to extract information from large datasets available in an Apache Hadoop[17] cluster, deployed with 10 nodes, and shared by all the students.

E.A.11. Automatic Configuration of Infrastructures. Each student deploys two VMs via a shell-script, just-in-time for the practice lesson, and use the Ansible tool to practice with the automated configuration of VMs. The activity is performed through classroom tasks.

E.A.12. Provision of VMs from an on-premises Cloud. The students use the functionality of OpenNebula to deploy

[6]Dev-C++.http://www.bloodshed.net/devcpp.html
[7]TUDOR DICOM tools. http://www.santec.lu/project/dicom
[8]NetBeans IDE. https://netbeans.org/
[9]DCM4CHEE PACS Server. http://www.dcm4che.org/
[10]Globus Toolkit 6. http://toolkit.globus.org/toolkit/docs/latest-stable/
[11]Open CA. http://www.openca.org/
[12]gLite. http://grid-deployment.web.cern.ch/grid-deployment/glite-web/
[13]EGI. http://www.egi.eu/
[14]OpenLDAP project. http://http://www.openldap.org
[15]http://boto.readthedocs.org/en/latest/
[16]http://aws.amazon.com/es/cli/
[17]http://hadoop.apache.org

```
network public (inbound = 'yes')
system iac (
  cpu.arch='x86_64' and
  cpu.count>=1 and
  memory.size>=1024m and
  net_interfaces.count = 1 and
  net_interface.0.connection = 'public' and
  disk.0.os.name='linux' and
  disk.0.os.flavour='ubuntu' and
  disk.0.os.version>='14.04'
)
configure iac (
@begin
- vars:
 - pw_00: M3Je2TpgZ3n
 tasks:
 - user: name=alucloud00 password=$pw_00
 - get_url: url=<sdr_url>/${item} dest=/tmp/${item}
   with_items:
    - iaccourse_1.0_all.deb
 - command: dpkg -i /tmp/${item}
   with_items:
    - iaccourse_1.0_all.deb
 - apt: pkg=mysql-client-5.5 state=installed
@end
)
deploy iac 1
```

Fig. 2. Part of the RADL document to deploy the remote lab for the IAC subject.

VMs and dynamically allocate storage capacity from an OpenNebula deployment during the classroom.

C. Implementing the VCEs in ODISEA (Phase 2).

The second phase consists of implementing the VCEs to support the different EAs based on the CEs identified at phase 1. For each CE (identified in Table I) a VCE is implemented and we provide details about the first two levels of ODISEA (see Table II), which addresses the VMIs and the recipes. All the hardware, software and configuration requirements are expressed by means of a recipe for each VCE created. As an example, Figure 2 includes an excerpt of the recipe to deploy the remote lab (VCE) for the IAC subject, where the hardware, software and configuration requirements (user accounts, download educational material, install applications, etc.) are expressed in RADL.

D. Integration and use of the VCEs in the EAs (Phase 3).

In the third phase the VCEs were integrated in the EAs. The results of this phase are shown in Table III which shows the EAs where the VCEs have been used and the features provided by the Level 3 of the ODISEA platform.

To perform **E.A.1** seven PRG VCEs (one per student) where deployed, accessed by a user account and used for implementing the C programs. The students connect via Remote Desktop and, therefore, use the same framework (Dev-C++) regardless of their client device platform (OS X, GNU/Linux, etc).

To perform **E.A.2** one PACS VCEs was created and shared by all students together with six DICOM VCEs (one per student) using a personal user account for implementing the DICOM applications. The students connect to the VCE DICOM via Remote Desktop or a web browser to interact with the VCE PACS for testing the results of the DICOM applications created.

To perform **E.A.3** and **E.A.4** 14 GT6 VCE (one per student) were deployed for implementing the Grid applications. Also, one PKI VCE was created for four hours to create X.509 certificates.

To perform **E.A.5** three GT6 VCE per student (42 in total) were created for developing the Grid project using their own resources. Also, it was created one VCE PKI shared by all students.

To perform **E.A.6** in IAG and MPG a single gLiteUI VCE was created and shared by all students by means of different user accounts. It was employed to create advanced Grid applications which allow access to EGI.

To perform **E.A.7** two LDAP VCEs per student (12 in total) were created for implementing the secure LDAP services with different replication models. Also, one PKI VCE was created to generate the X.509 certificates required to implement secure services.

To perform **E.A.8** one gLiteUI VCE was deployed, shared by all students by means of user accounts creating advanced complex Grid application which allow to access to EGI. This activity shares VCE with E.A.6.

To perform **E.A.9** in MPC, IAC and CursoCloudAWS a single AWS VCE was created shared by all the students with different user accounts. They use the VCE to create architectural designs of applications and deploy them on the AWS Cloud.

To perform **E.A.10** a shared Hadoop Cluster VCE with multiple user accounts is used to create programs based on the MapReduce programming model. The VCE is deployed on the on-premises Cloud and on the AWS public Cloud to carry out different performance analysis.

To perform **E.A.11** in IAC and CursoCloudAWS two Ansible VCEs per student (30 and 760) are created on-demand by each student using pre-configured scripts. The use it to learn the fundamentals of the Ansible tool.

To perform **E.A.12** only one OpenNebula (ONE) VCE was created shared by the students via multiple user accounts. They use it to deploy VMs on an existing Cloud deployment.

In all EAs when an activity finished the VCEs involved were terminated and the resources associated to VMs were released.

V. Assessment and Discussion

This section evaluates the parameters and capabilities of ODISEA that have been described as objectives in section III. The assessment has been done through the different EAs that have been validated at section IV.

A. The capability of improving teaching-learning.

ODISEA is a platform to ease the deployment of VCEs in EAs. In this sense, the capability of improving the teaching-learning process due to the use of VCEs is demonstrated in different studies, for example in fields such as mechanics [27] or electrical engineering [28] and other more generic studies in Higher Education such as [8].

TABLE II
VCEs IMPLEMENTED AT ODISEA. IT IS SHOWN THE FEATURES OF LEVEL 1 AND LEVEL 2 OF THE PLATFORM.

VCE	LEVEL1	LEVEL 2			
	O.S	VMs	Hardware	Software	Configuration
PRG	Windows 7 Professional	1	8GB,x86-64 70GB HD	-Dev-C++5	-User accounts and privileges to develop C programs. -User accounts to access via Microsoft Remote Desktop.
PACS	Windows 7 Professional	1	8GB,x86-64 50GB HD	-DCM4CHEE Server	-Accessible via web browser with user and password.
DICOM	Windows 7 Professional	1	8GB,x86-64 50GB HD	-TUDOR toolkit -NetBeans 8.1	-Users enabled to access via Microsoft Remote DeskTop.
GT6	Scientific Linux 6.7	1	4GB,x86-64 20GB HD	-Globus Toolkit 6	-User accounts with privileges to develop grid applications. -User accounts to access via SSH with a password.
GLite	Scientific Linux 6.7	1	2GB,x86-64 10GB HD	-gLite User Interface -OpenMP compiler	-gLite CLIs and X.509 cert. to connect to EGI infrastructure. -User accounts to access via SSH with a password.
PKI	Ubuntu 13	2	1GB,x86-64 10GB HD	-OpenCA 1.4	-Two VMs configure a RA and a CA. -Accessible via Web browser with a user and password.
LDAP	Scientific Linux 6.7	2	4GB,x86-64 10GB HD	-Berkeley DB 6 -OpenLDAP 2.4	-An OpenLDAP (VM) and BerkeleyDB (VM) admin user. -User accounts to access via SSH with a password.
AWS	Ubuntu 14.04	1	1GB,x86-64 10GB HD	-Python and Boto -AWS CLI	-Multiple users to access the services. -User accounts to access via SSH with a password.
HADOOP	Ubuntu 14.04	10	2GB,x86-64 10GB HD	-Hadoop	-Multiple users and different pre-staged large datasets. -Accessible via web browser with a user and password. -User accounts to access via SSH with a password.
Ansible	Ubuntu 14.04	2	1GB,x86-64 10GB HD	-Ansible	-Set of VMs to be accesses to via SSH without password.
ONE	Ubuntu 14.04	2	1GB,x86-64 10GB HD	-OpenNebula	-Multiple users to access the OpenNebula testbed. -User acccounts to access via SSH with a password.

TABLE III
VCEs EMPLOYED IN THE DIFFERENT EAs.

SUBJECT	E.A.	VCE	# of VCEs	ACCESS	# of VMs	AVAILABILITY	CLOUD PROVIDER (LEVEL 3)
INF	E.A.1	PRG	7	Remote Desktop	7	16 weeks 24x7	On-premises
IME	E.A.2	PACS DICOM	1 6	Web browser Remote Desktop	1 6	8 weeks 24x7	On-premises
CCGC	E.A.3	GT6	14	SSH client	14	6 Weeks 24x7	On-premises
	E.A.4	PKI	1	Web browser	2	4 Hours	
	E.A.5	GT6 PKI	42 1	SSH client Web browser	42 2	4 Weeks 24x7 4 Weeks 24x7	
IAG	E.A.6	gLiteUI	1	SSH client	1	7 weeks 24x7	On-premises
	E.A.7	LDAP PKI	12 1	SSH client Web browser	24 2	2 weeks 24x7	
	E.A.8	gLiteUI	1	SSH client	1	4 weeks 24x7	
MPG	E.A.6	gLiteUI	1	SSH client	1	1 weeks 24x7	On-premises
MPC	E.A.9	AWS	1	SSH client	1	7 weeks 24x7	AWS Cloud Provider
	E.A.10	HADOOP	1	SSH client	10	4 hours 24x7	AWS Cloud Provider / On-premises
IAC	E.A.9	AWS	1	SSH client	1	7 weeks 24x7	AWS Cloud Provider
	E.A.11	Ansible	30	SSH client	30	4 hours	
CloudAWS	E.A.9	AWS	1	SSH client	1	7 weeks 24x7	AWS Cloud Provider
	E.A.11	Ansible	760	SSH client	760	4 hours 24x7	
	E.A.12	ONE	1	SSH client / Ansible	2	4 hours 24x7	

B. Reduce of the budget of acquisition of PHRs associated to VCEs

ODISEA is able to deploy the VMs that support the VCEs on on-premises cloud and public clouds. This allows reducing the budget of acquisition of PHRs associated to VCEs. The E.A.11 is a clear example of this issue. E.A.11. required many simultaneous Ansible VCEs both for the IAC subject and the online course. In this situation, the educational centers may not have available all the required PHRs to execute the VCEs and the on-premises cloud resources could be insufficient. That is the main reason to use a public cloud, where additional resources can be provisioned on a pay-by-the-hour model. This way, it is not necessary to invest in new PHRs to support the activity, reducing the budget of acquisition of PHRs associated to VCEs as we can see at table IV. This table compares the cost of acquisition of a certain number of machines so that students can perform the practical lessons. These will be noted as on-premises physical machines and their price has been obtained from dell.com choosing the average price of the set of computers for the desktop category, which results in 426

€ (including the monitor, 4 GB of RAM, 1 TB of disk). For the virtual machines on AWS we selected the $m1.small$ instance type (1.7 GB of RAM, 160 GB of disk), which is powerful enough to perform the practice lessons. Considering the pay-per-use model of AWS, we estimate that 4 hours are required to perform the practice lesson that involves Ansible. Costs for AWS have been estimated using the AWS Simple Monthly Calculator[18]. Dollar-euro ratio was 1 $ = 0.79815 € at the time the study was performed.

You can derive from the table that it would take more than 16 months of 24/7 running instances to match the cost of the on-premises physical machines. Notice that the table does not include the cost of maintenance of hardware, electricity and housing of the equipment. If we restrict the comparison to the specific duration of the practical lesson (4 hours) you can estimate from the table that the activity could be performed more than 3.040 times before matching the cost of the on-premises physical machines. Therefore there is a clear cost reduction when outsourcing the computational resources for the E.As to the Cloud.

C. Reduce the maintenance budget of PHRs for VCEs.

All implemented VCEs in ODISEA require complex PHRs configurations and the specific software requirements can be potentially incompatible (see Table II) between them. In the validation process, 11 VCEs have been implemented and used in multi-disciplinary environments with different academic subjects, sharing the same PHRs available in the on-premises cloud. ODISEA has allowed provisioning and configuring PHRs in an affordable and practical way, avoiding the technical overhead of switching among configurations and the intricacies of the configuration and customisation of the infrastructures, reducing the budget of maintenance of the resources associated to VCEs.

D. The ability for students to use their own devices in the learning activities, thus promoting BYOD.

All implemented VCEs in the ODISEA platform allow SSH connections, Remote Desktop or web access to be accessed by the students. This leverages BYOD among them because they can use their own devices (laptops or personal computers) using different platforms (OS X, Windows, GNU/Linux) for performing the EAs since the PHRs capabilities (hardware and software requirements) are provided by the cloud. This feature has allowed students to perform the EAs related with online course using their own devices (laptops or personal computers). In addition, in the E.A.1 the students have connected to the VCEs using a Remote Desktop and only seven VMs have been deployed on the on-premises cloud. In this EA, there are 36 students and 97% have used their own devices (laptops) for connecting to the VCES. In previous scenarios, it was necessary one computer per student, using physical laboratories to perform the activities. Nowadays, using ODISEA, only seven VCEs (7 VM with 5-6 users per VM) have been necessary.

[18] Available at http://calculator.s3.amazonaws.com/index.html

E. Capability to ease the configuration and update process of the VCEs.

The ODISEA architecture (see section II) allows defining three implementation levels for each VCE. The lowest level (Level 1) corresponds to the basic Virtual Machine Images (VMIs). On top of these VMIs, the second level describes the hardware (HW), software (SW) requirements and configuration for each VM throuht a high-level language. The third level define the clud provider. The three levels enable ODISEA to ease the configuration and update process of the VCEs. For example, the group composed of PRG, PACS and DICOM VCEs or the group of GT6, gLiteUI and LDAP VCEs or the group of VCEs composed of AWS, HADOOP, Ansible and ONE are used in different EAs activities (see Table III)) and all VCEs of each group use the same Operating System (OS). The first group uses Windows 7 Professional, the second group Scientific Linux 6.7 and the third group uses Ubuntu 14.04. Within ODISEA, just one VMI (first level) with the basic OS has been created. In this way, when a VM is instantiated to support a given VCE, ODISEA deploys the HW requirements and configures the SW requirements. That is why the configuration and update process is simplified, if a new OS package versions appear it is just necessary to update the VMI. New versions of software are updated in the base VMI and applied to VCEs when new instances are deployed.

F. Provide an efficient rationalization of PHRs.

ODISEA has been used to dynamically deploy the VCEs required for the EAs. Once finished the EAs, the VCEs are terminated because there is no need to maintain the VCEs up and running and the underlying PHRs can be employed to support other EAs for other VCEs. In the validation process, eight VCEs were implemented, which shared the same PHRs belonging to the on-premises cloud. Note that in-campus software licenses can still be valid for VCEs deployed on on-premises Clouds within the educational institution.

G. Provide high availability for the VCEs and ubiquitous access for the students.

In the INF subject a questionnaire was employed with regard to this issue. The first item of the questionnaire questioned the students whether they had connected to the VCEs from other places different to the specific laboratories of the subject (at home, library, etc.) and if the resources had always been available. 100% of the students had also worked outside of the university (for example at home) and claim to have had always available the VCEs.

In the case of CursoCloudAWS, the VCEs deployed are configured with special monitoring alarms via the Amazon CloudWatch service that enables to deliver instant notifications to the instructor in case the remote laboratory is either overloaded (CPU $>$ 70% for more than 10 minutes) or inaccessible. This enables to introduce corrective measures so that high availability for students is guaranteed. Also, multiple instances (clones) can be deployed to ensure availability.

TABLE IV
COST COMPARISON OF A CERTAIN NUMBER OF PHYSICAL MACHINES VS THE USAGE OF VIRTUAL MACHINES ON AWS FOR A SPECIFIC ACTIVITY LESSON THAT LASTS 4 HOURS.

#Machines	Cost of On-premises Physical Machines (€)	Cost of Virtual Machines on AWS (just 4 hours) (€)	Monthly Cost of Virtual Machines on AWS (24 hours / day) (€)
10	4.260	1.4	257
20	8.520	2.9	514
50	21.300	7.2	1.284
100	42.600	14.4	2.570

H. The capability to introduce different VCEs, enabling to the students to access a wide range of platforms or tools.

Three EAs (E.A.2, E.A.5 and E.A.7) have used different VCEs (see Table III) that have also been used in other EAs. Also, all subjects (see Table III) except INF and MPG use more than one VCE during the course. In particular the subjects IME, CCGC, IAC and MPC use two different VCEs in their EAs and the subjects IAG and CursoCloudAWS uses three. This variety of VCEs in the subjects and their EAs is because ODISEA allows to reuse the recipes of the VCEs in a easy way and deploy them in a user-friendly manner.

VI. CONCLUSION AND FUTURE WORK

The ODISEA platform has been validated and evaluated thought of different EAs belonging to 8 subjects of four different knowledge areas which are Bachelor's Degree in Industrial Electronics and Automation Engineering (BIEA), the Master's Degree in Parallel and Distributed Computing (MPDC), the Master's Degree in Informatics Engineering (MIE), and an Online Postgraduate Course (OPC). Furthermore, the total number of VCEs identified and implemented in the ODISEA platform for supporting the EAs has been 11, in which each VCE has different features (hardware and software requirements, availability, number of VMs, connection type, different clouds where the VMs are deployed, etc.). For this, we can conclude that the ODISEA platform is flexible to support the common VCEs needed in a wide variety of EAs, and the methods and procedures described in this paper can definitely be applied to other similar scenarios.

It is important to highlight the reuse of VCEs among different EAs and also among subjects. Notice that sharing can occur at two levels: First, sharing the VCE description (its recipe) where different virtual infrastructures are really deployed. Second, the very same virtual infrastructure can be shared across subjects, where different user accounts are employed for the students of different subjects. Third, the same VCE can be deployed in public or on-premises cloud depending on the scalability required.

Being able to use both on-premises and public Clouds, ODISEA enables educational enters to introduce cost saving strategies by outsourcing computational resources on Cloud platforms and fostering BYOD. In addition, this platform is ideal for online courses and MOOCs, where the ability to scale (increase) the virtual infrastructures enables to seamlessly adapt to a dynamic number of students.

Future works include using the platform in more EAs within new fields. We also plan to better customise the virtual infrastructures to leverage work group and, this way, to focus on these transversal competencies so required for our students.

ACKNOWLEDGMENT

The authors wish to thank the financial support received from Vicerrectorado de Estudios, Calidad y Acreditación of the Universitat Politècnica de València (UPV) to develop the PIME project "Análisis y Evaluación de Impacto del Cloud Computing en la Gestión de Entornos Virtuales Computacionales en la Enseñanza", with reference A014. GM would like to thank Amazon for the AWS Educate program and the "Escola Tècnica Superior d'Enginyeria Informàtica (ETSINF) de la Universitat Politècnica de València" for the financial support to present this contribution. The authors would also like to thank the Spanish "Ministerio de Economía y Competitividad" for the project TIN2013-44390-R.

REFERENCES

[1] E. Güney, Z. Eki, and M. Çakrolu, "WebECG: A novel ECG simulator based on MATLAB Web Figure," *Advances in Engineering Software*, vol. 45, no. 1, pp. 167–174, Mar. 2012. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0965997811002444

[2] A. Barella, S. Valero, and C. Carrascosa, "JGOMAS: New Approach to AI Teaching," *IEEE Transactions on Education*, vol. 52, no. 2, pp. 228–235, May 2009. [Online]. Available: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=4696064

[3] N. Fang, K. Nielson, and S. Kawamura, "Using Computer Simulations with a Real-World Engineering Example to Improve Student Learning of High School Physics: A Case Study of K-12 Engineering Education," pp. 170–180, 2013. [Online]. Available: http://dialnet.unirioja.es/servlet/articulo?codigo=4152179

[4] J. Kolota, "A Remote Laboratory for Learning with Automatic Control Systems and Process Visualization," pp. 1130–1138, 2011. [Online]. Available: http://dialnet.unirioja.es/servlet/articulo?codigo=3915801

[5] D. S. Alexiadis and N. Mitianoudis, "MASTERS: A Virtual Lab on Multimedia Systems for Telecommunications, Medical, and Remote Sensing Applications," *IEEE Transactions on Education*, vol. 56, no. 2, pp. 227–234, May 2013. [Online]. Available: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=6257505

[6] R. M. F. Bezerra, I. Fraga, and A. A. Dias, "Utilization of integrated Michaelis-Menten equations for enzyme inhibition diagnosis and determination of kinetic constants using Solver supplement of Microsoft Office Excel." *Computer methods and programs in biomedicine*, vol. 109, no. 1, pp. 26–31, Jan. 2013. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0169260712002143

[7] L. R. Marr-Lyon, G. V. Gupchup, and J. R. Anderson, "An evaluation of the psychometric properties of the Purdue Pharmacist Directive Guidance Scale using SPSS and R software packages." *Research in social & administrative pharmacy : RSAP*, vol. 8, no. 2, pp. 166–71, Jan. 2012. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S1551741111000039

[8] L. Varela Candamio and M. T. García-Álvarez, "Analysis of Information and Communication Technologies in Higher Education: A Case Study of Business Degree," pp. 1301–1308, 2012. [Online]. Available: http://dialnet.unirioja.es/servlet/articulo?codigo=4146267

[9] A. Molla, "IT and eco-sustainability: Developing and validating a green IT readiness model," in *ICIS 2009 Proceedings*, 2009, p. Paper 141. [Online]. Available: http://researchbank.rmit.edu.au/view/rmit:11290

[10] A. S. Ackerman and M. L. Krupp, "Five Components to Consider for BYOT/BYOD." *International Association for Development of the Information Society*, Sep. 2012. [Online]. Available: http://eric.ed.gov/?id=ED542652

[11] S. M. Sotillo, "Pedagogical advantages of ubiquitous computing in a wireless environment," *The Technology Source*, 2003.

[12] W. Appelt and P. Mambrey, "Experiences with the BSCW Shared Workspace System as the Backbone of a Virtual Learning Environment for Students." Nov. 1998. [Online]. Available: http://eric.ed.gov/?id=ED446729

[13] M. L. Wu and K. Richards, "Facilitating Communication through Interactive Polls and Reminders. 2013. p. 3818-3818." in *Society for Information Technology & Teacher Education International Conference.*, 2013, p. 3818.

[14] Y. Song, "Bring Your Own Device (BYOD) for seamless science inquiry in a primary school," *Computers & Education*, vol. 74, pp. 50–60, may 2014. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0360131514000153

[15] P. C. Blumenfeld, E. Soloway, R. W. Marx, J. S. Krajcik, M. Guzdial, and A. Palincsar, "Motivating Project-Based Learning: Sustaining the Doing, Supporting the Learning," *Educational Psychologist*, vol. 26, no. 3-4, pp. 369–398, Jun. 1991. [Online]. Available: http://dx.doi.org/10.1080/00461520.1991.9653139

[16] K. W. Miller, J. Voas, and G. F. Hurlburt, "BYOD: Security and Privacy Considerations," *IT Professional*, vol. 14, no. 5, pp. 53–55, Sep. 2012. [Online]. Available: http://www.computer.org/csdl/mags/it/2012/05/mit2012050053.html

[17] P. Mell and T. Grance, "The NIST Definition of Cloud Computing," 2011. [Online]. Available: http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf

[18] R. Buyya, J. Broberg, and A. M. Goscinski, *Cloud computing: Principles and Paradigms*. Wiley, 2011. [Online]. Available: http://onlinelibrary.wiley.com/doi/10.1002/9780470940105.fmatter/pdf

[19] K. Hwang, J. Dongarra, and G. C. Fox, *Distributed and Cloud Computing: From Parallel Processing to the Internet of Things [Paperback]*. Morgan Kaufmann; 1 edition, 2011. [Online]. Available: http://www.amazon.com/Distributed-Cloud-Computing-Parallel-Processing/dp/0123858801

[20] J. Sahoo, S. Mohapatra, and R. Lath, "Virtualization: A Survey on Concepts, Taxonomy and Associated Security Issues," in *2010 Second International Conference on Computer and Network Technology*. IEEE, 2010, pp. 222–226. [Online]. Available: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=5474503

[21] I. F. Borja Sotomayor, Rubén Santiago Montero, Ignacio Martín Llorente, "Capacity leasing in cloud systems using the opennebula engine," 2008. [Online]. Available: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.357.2591

[22] D. Nurmi, R. Wolski, C. Grzegorczyk, G. Obertelli, S. Soman, L. Youseff, and D. Zagorodnov, "The Eucalyptus Open-Source Cloud-Computing System," in *2009 9th IEEE/ACM International Symposium on Cluster Computing and the Grid*. IEEE, 2009, pp. 124–131. [Online]. Available: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=5071863

[23] J. D. Segrelles, G. Molt, and M. Caballer, "Remote Computational Labs for Educational Activities via a Cloud Computing Platform," in *2015 Proceedings of the Information Systems Education Conference (ISECON)*, Nov. 2015, pp. 309–321.

[24] RADL, "Resource and Application Description Language (RADL)," 2016. [Online]. Available: http://imdocs.readthedocs.org/en/devel/radl.html

[25] M. Caballer, I. Blanquer, G. Moltó, and C. de Alfonso, "Dynamic management of virtual infrastructures," *Journal of Grid Computing*, 2014. [Online]. Available: http://link.springer.com/article/10.1007/s10723-014-9296-5

[26] IM, "Infrastructure Manager (IM)," 2016. [Online]. Available: http://www.grycap.upv.es/im

[27] D. M. Fraser, R. Pillay, L. Tjatindi, and J. M. Case, "Enhancing the Learning of Fluid Mechanics Using Computer Simulations," *Journal of Engineering Education*, vol. 96, no. 4, pp. 381–388, Oct. 2007. [Online]. Available: http://doi.wiley.com/10.1002/j.2168-9830.2007.tb00946.x

[28] J. O. Campbell, J. R. Bourne, P. J. Mosterman, and A. J. Brodersen, "The Effectiveness of Learning Simulations for Electronic Laboratories," *Journal of Engineering Education*, vol. 91, no. 1, pp. 81–87, Jan. 2002. [Online]. Available: http://doi.wiley.com/10.1002/j.2168-9830.2002.tb00675.x

5.3.1.15. International Conference on Innovation, Documentation and Education (INNODOCT 2017)

G. Moltó, J. F. Monserrat, I. Fita, A. Fita, and E. M. Mestre, "A Flipped Learning Approach to Develop Soft Skills in Multidisciplinary Higher Education," in INNODOCT 2017, 2017, pp. 295-305.

- Participación: Ponencia
- Título del trabajo presentado: A Flipped Learning Approach to Develop Soft Skills in Multidisciplinary Higher Education
- Entidad organizadora: Universitat Politècnica de València
- Lugar de celebración: Valencia, España
- Publicación: ISSN/ISBN: 978-84-9048-612-2
- Objetivos: INNODOCT 2017 - International Conference on Innovation, Documentation and Education
- Perfil de los destinatarios: Docentes internacionales
- Fecha de inicio: 25/10/2017
- Fecha de fin: 27/10/2017

This is to certify that the paper entitled:

"A Flipped Learning Approach to Develop Soft Skills in Multidisciplinary Higher Education"

By: Germán Moltó, Jose F. Montserrat, Inmaculada Fita, Ana Fita and Eva Mestre

has has been presented at the

5th International Conference on Innovation

Held in Valencia (Spain), 25th-27th October, 2017

Sofía Estellés Miguel
Chair of INNODOCT 2017

Fernando J. Garrigós Simón
Chair of INNODOCT 2017

INNODOCT/17

"!INTERNATIONAL CONFERENCE ON INNOVATION, DOCUMENTATION AND EDUCATION"

Editores
Fernando Garrigós Simón
Sofía Estellés Miguel
Ismael Lengua Lengua
José Onofre Montesa
Carlos M. Dema Pérez
Juan Vicente Oltra Gutiérrez
Yeamduan Narangajavana
María José Verdecho Sáez

EDITORIAL
UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Editores
Fernando J. Garrigós Simón
Sofía Estellés Miguel
Ismael Lengua Lengua
José Onofre Montesa
Carlos M. Dema Pérez
Juan Vicente Oltra Gutiérrez
Yeamduan Narangajavana
María José Verdecho Sáez

INNODOCT/17

"INTERNATIONAL CONFERENCE ON INNOVATION, DOCUMENTATION AND EDUCATION"

EDITORIAL
UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Colección Congresos

Los contenidos de esta publicación han sido evaluados por el Comité Científico que en ella se relaciona y según el procedimiento que se recoge en http://www.innodoct.com

Diseño portada: Ismael Lengua Lengua

www.lalibreria.upv.es / Ref: 6396_01_01_01

ISBN: 978-84-9048-612-2

INNODOCT 2017
Valencia, 25th-27th October 2017

A Flipped Learning Approach to Develop Soft Skills in Multidisciplinary Higher Education

Moltó, Germán[a]; Monserrat, Jose F.[b]; Fita, Inmaculada[c]; Fita, Ana[d], Mestre, Eva M.[e]
[a]Departamento de Sistemas Informáticos y Computación - gmolto@dsic.upv.es, [b]Departamento de comunicaciones - jomondel@dcom.upv.es, [c]Departamento de Física Aplicada - infifer@fis.upv.es, [d]Departamento de Biotecnología - anfifer@btc.upv.es y [d]Departamento de Lingüística Aplicada - evmesim@idm.upv.es, Universitat Politècnica de València, Spain

Abstract

Soft skills play an important role in higher education degrees since they have to be developed and assessed along the different academic years. The advent of online instruction and the ability of our students to use multimedia material for self-instruction have paved the way for flipped learning to rise. This work focuses on the development of Soft Skills by means of Flipped Learning in different higher education degrees. This involves diverse subjects in Computer Science, Telecommunications, Linguistics, Agricultural Science and Physics, providing use cases on which flipped learning techniques can be applied to develop Soft Skills such as: Comprehension and Integration, Specific Instrumentation or Long-life Learning. The paper centers the discussion in the Soft Skills that need to be evaluated by the aforementioned subjects addressing their requirements, the Flipped Learning methodology used, the technological material underpinning the experiences, together with the results obtained. Results hint that students have more difficulties developing soft skills without personal interactions, and consequently new online approaches applied to class groups are needed to address this challenge.

Keywords: *Soft Skills, methodology, assessment, Flipped Learning*

EDITORIAL UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Moltó, G., Monserrat, J. F., Fita, I. C., & Fita, A. M. (2014). Experiencias Tecnológicas de Soporte al Blended Learning en un Contexto Multidisciplinar. In Jornadas de Innovación Educativa y Docencia en Red (IN-RED 2014) (pp. 54–68). Retrieved from http://riunet.upv.es/handle/10251/40404.

Murray, K. (2011). Microsoft Office 365: Connect and collaborate virtually anywhere, anytime. Microsoft Press.

Segrelles, J. D., Moltó, G., & Caballer, M. (2015). Remote Computational Labs for Educational Activities via a Cloud Computing Platform. In 2015 Proceedings of the Information Systems Education Conference (ISECON) (pp. 309–321). Retrieved from http://proceedings.isecon.org/download/ki9hcpvocepkcwky5te9.

Segrelles Quilis, J. D., Antón, A. M., Castilla Cabanes, N., & Martínez, G. M. (2017). Virtualized Computational Environments on the cloud to foster group skills through PBL: A case study in architecture. Computers & Education, 108, 131–144. http://doi.org/10.1016/j.compedu.2017.02.001.

EDITORIAL UNIVERSITAT POLITÈCNICA DE VALÈNCIA

5.3.2. Participación como asistente, en cursos orientados a la formación docente universitaria

5.3.2.1. FIPPU: Programa de Formación para la Docencia Universitaria

Título: Programa de Formación para la Docencia Universitaria Entidad organizadora: Instituto de Ciencias de la Educación de la Universitat Politècnica de València Lugar de celebración: Universidad Politécnica de Valencia (Seminario Intensivo de 5 días en Morella) Objetivos del curso: El objetivo general del título se orienta a iniciar y desarrollar el proceso de profesionalización del docente universitario en el siglo xxi. Competencias pedagógicas: construir una visión del proceso de aprendizaje y enseñanza en el contexto universitario, con el fin de lograr una actividad docente lo más eficaz posible. Gestionar el proceso de aprendizaje- enseñanza, de manera sistemática y coherente. Competencias institucionales: educar de manera integral a cada uno de sus alumnos. Trabajar en equipos pluri/interdisciplinares para la realización de proyectos de innovación educativa. Competencias socio-profesionales: desarrollar un pensamiento reflexivo en el desarrollo de su práctica docente. Afrontar los deberes y dilemas éticos de la profesión docente universitaria. Perfil de los destinatarios: Profesores de universidad noveles Duración: Fecha de inicio: 10/09/2007 Fecha de fin: 31/07/2008

UNIVERSIDAD POLITECNICA DE VALENCIA

VICERRECTORADO DE ESTUDIOS Y CONVERGENCIA EUROPEA

Instituto de Ciencias de la Educación

PROGRAMA DE FORMACIÓN PARA LA DOCENCIA UNIVERSITARIA

Don Fernando Fargueta Cerdá,
Director del Título de Especialista Universitario en Pedagogía Universitaria
de la Universidad Politécnica de Valencia,

CERTIFICA QUE:

GERMÁN MOLTÓ MARTÍNEZ

N.I.F. 52656437F

ha realizado con aprovechamiento el curso de Especialista Universitario en Pedagogía Universitaria, organizado conjuntamente por el Vicerrectorado de Estudios y Convergencia Europea y el Instituto de Ciencias de la Educación, durante el curso académico 2007-08 con una duración de 320 horas.

Y para que así conste, firma el presente a petición de la persona interesada, en Valencia, a 18 de julio de 2008.

ha realitzat amb aprofitament el curs d'Especialista Universitari en Pedagogia Universitaria, organitzat conjuntament pel Vicerectorat d'Estudis i Convergència Europea i l'Institut de Ciències de l'Educació, durant el curs acadèmic 2007-08 amb una duració de 320 hores.

I perquè així conste, signa aquest a petició de la persona interessada, València, 18 de juliol de 2008.

D. Fernando Fargueta Cerdá

5.3.2.2. EUFOL: Experto Universitario en Formación Online

Entidad organizadora: Instituto de Ciencias de la Educación de la Universitat Politècnica de València Lugar de celebración: Universitat Politècnica de València Objetivos del curso: Aplicar métodos y técnicas pedagógicas de cara a programar, implementar y evaluar acciones formativas on line. Desarrollar la programación didáctica y la tutorización de las acciones formativas on line diseñadas previamente.

Perfil de los destinatarios: Profesores interesados en la formación online Duración: Fecha de inicio: 10/09/2014 Fecha de fin: 31/07/2015

UNIVERSITAT
POLITÈCNICA
DE VALÈNCIA

LA UNIVERSITAT POLITÈCNICA DE VALÈNCIA

y en su nombre D. Francisco José Mora Mas, Rector de la misma,
expide el presente título de

EXPERTO UNIVERSITARIO EN FORMACIÓN ONLINE
por la Universitat Politècnica de València

a favor de

GERMÁN MOLTÓ MARTÍNEZ

por cuanto que ha cursado las 150 horas correspondientes al programa que figura al dorso de esta titulación, y ha superado todas las pruebas de evaluación correspondientes, en fecha 15 de julio de 2015.

Valencia, a 24 de noviembre de 2015

El Rector

Director

Francisco Javier Oliver Villarroya

REGISTRO UNIVERSITARIO DE TÍTULOS

El Jefe del Servicio	/ Código de Referencia	/ Número de Registro
	E 1617 001 2015	**17787**

Este título se otorga con el carácter de propio de la Universitat Politècnica de València, al amparo de lo establecido en el artículo 34.1 de la Ley Orgánica 6/2001, de Universidades, modificada por la Ley Orgánica 4/2007, sin perjuicio de los títulos que, con carácter oficial y validez en todo el territorio nacional, se expiden por el Rector en nombre del Rey.

1-R-0413

PROGRAMA CURSADO	CRÉDITOS
PEDAGOGIA UNIVERSITARIA Y E-LEARNING	1
PROGRAMACION DE ASIGNATURAS SEMIPRESENCIALES Y ON LINE	1
PLATAFORMAS EDUCATIVAS COMO APOYO A LA ENSEÑANZA	1
BUSQUEDA Y GESTION DE INFORMACION ON LINE	1,5
LA TUTORIA Y EL SEGUIMIENTO DEL TRABAJO DEL ALUMNO	1
PLATAFORMAS DE TRABAJO COLABORATIVO	1
LOS BLOGS AL SERVICIO DE LA DOCENCIA	0,5
AULA 2.0. LAS TIC COMO ELEMENTO DINAMIZADOR DE LA INTERACTIVIDAD	0,5
INNOVACIONES Y PROPUESTAS PARA LA E-EVALUACION DE COMPETENCIAS EN LA UNIVERSIDAD	1
ESTRUCTURA PEDAGOGICA DE LOS MATERIALES ONLINE: CREACION Y ORGANIZACION DE CONTENIDOS CON EL EDITOR DE POLIFORMAT	1
ELABORACION DE RECURSOS MULTIMEDIA PARA LA DOCENCIA: POLIMEDIAS	0,5
ELABORACION DE RECURSOS MULTIMEDIA PARA LA DOCENCIA: VIDEOS SCREENCAST CON CAMSTUDIO PARA WINDOWS	0,5
ELABORACION DE RECURSOS MULTIMEDIA PARA LA DOCENCIA: PUBLICACIONES DOCENTES CON LA PLANTILLA LATEX DE LA UPV	1
RECURSOS TECNOLOGICOS DE APOYO AL APRENDIZAJE: TABLETAS Y TINTA DIGITAL	0,5
RECURSOS TECNOLOGICOS DE APOYO AL APRENDIZAJE OFERTADOS POR LA UPV	1
REALIZACION DE EXAMENES A TRAVES DE PLATAFORMAS EDUCATIVAS: POLIFORMAT	1
REALIZACION DE TAREAS A TRAVES DE PLATAFORMAS EDUCATIVAS: POLIFORMAT	1
CREDITOS ECTS	**15**

5.3.2.3. INED: Programa de Iniciación a la Investigación Educativa

Título: Programa de Iniciación a la Investigación Educativa Entidad organizadora: Instituto de Ciencias de la Educación de la Universitat Politècnica de València Lugar de celebración: Universitat Politècnica de València Objetivos del curso: Aprender el diseño de proyectos de investigación educativa. Utilizar herramientas estadísticas para el análisis de datos. Conocer estrategias de difusión de resultados de investigación educativa.

Perfil de los destinatarios: Profesores interesados en la investigación educativa Duración: Fecha de inicio: 01/01/2018 Fecha de fin: 31/12/2019

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Instituto de Ciencias de la Educación

GERMÁN MOLTÓ MARTÍNEZ

52656437

Ha participat en / *Ha participado en*

PROGRAMA D'INICIACIÓ A L'INVESTIGACIÓ EDUCATIVA

organitzat per

l'Institut de Ciències de l'Educació,

celebrat entre gener de 2018 i

desembre de 2019,

amb una duració de 125 hores.

PROGRAMA DE INICIACIÓN A LA INVESTIGACIÓN EDUCATIVA

organizado por

el Instituto de Ciencias de la Educación,

celebrado entre enero de 2018 y

diciembre de 2019,

con una duración de 125 horas.

UNIVERSITAT POLITÈCNICA VALÈNCIA INSTITUTO CIENCIAS de la EDUCACIÓN

D. Antonio Molina Marco
Director de l'Institut de Ciències de l'Educació
Director del Instituto de Ciencias de la Educación

València, 23 de gener de 2020
Valencia, 23 de enero de 2020

INvestigación EDucativa