Towards Interoperability through Inter-enterprise Collaboration Architectures

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Abstract. Most enterprise architectures published so far are capable of generating reasonably good descriptive models for individual enterprises to enable integration, organization and synchronization of enterprise elements: organizational structure, business processes, information systems and technology infrastructure, among others. However, research in this field applied to the extended enterprise or inter-enterprise architectures that takes into account the growing trend towards complex collaborative environments is very scarce. In this sense, this article seeks to analyze, link and synthesize the researches that has addressed the disciplines of enterprise architecture and business collaboration, in order to identify possible future research needs from the conceptualization made.

Keywords: Collaborative networks, enterprise architectures, interoperability.

1 Introduction

In recent years, it has been demonstrated the interest that is taking the enterprise engineering through the use of enterprise architectures, evidenced by the large number of publications found about. However, these methodological proposals are mostly directed and oriented to individual enterprises. Therefore, the focus of these researches are not taking into account the growing and rapidly evolving business collaboration environments where two or more companies involved in one or more supply chains make collaborative supply networks. The operation and organization of these networks should be structured and modeled through collaboration architectures designed with the purpose of supporting collaborative processes and their integration with information systems of partners involved in this collaboration. In this sense, some frameworks have emerged seeking to propose a general framework for collaboration [1], [2], [3] and [4]. However, most of these studies focus their efforts on the proposed framework that in the procedure to ensure effective implementation. Another factor to highlight in these researches is that they propose different modeling

languages, which makes difficult interoperability between different network architectures.

The aim of this paper is to make a detailed analysis of the state of the art of these two disciplines both separately and jointly, in order to build the bases to make a proposal in a future work of an inter-enterprise collaboration architecture to ensure interoperability and synchronization processes belonging to the global domain of a collaborative supply chain.

2 Conceptualization of Enterprise Engineering and Enterprise Architectures

2.1 Enterprise Engineering

Enterprise Engineering is the discipline applied in carrying out any efforts to establish, modify, or reorganize any enterprise [5]. This discipline is responsible for defining, structuring, designing and implementing enterprise operations as communication networks of business processes, which comprise all their related business knowledge, operational information, resources and organization relations [6]. The field of Enterprise Engineering is concerned to understand, define, design and redesign business entities, which includes all knowledge, and organizational relationships, as well as life cycle [7]. Therefore, Enterprise Engineering facilitates the integration of all elements of the enterprise.

2.2 Enterprise Integration

As for the concept of enterprise integration, several authors provide their own definitions: [6; 7; 8; 9; 10; 11; 12]. In order to condense, integrate and collect the most important concepts of these definitions, we propose the following definition:

"Enterprise Integration is an enterprise approach that seeks to relate synergistically the elements of the company such as information, resources, applications and people, thus enabling the company to act as a total joint system which increases cooperation, coordination and communication between its components with the ultimate goal of fulfilling the mission and goals of the organization in a productive and efficient form".

2.3 Enterprise Architecture

Achieving Enterprise Integration through the Enterprise Engineering is possible thanks to the use of Enterprise Architectures. Conceptually, the enterprise architecture can be defined as*:*

"A discipline that provides a set of principles, methods, models and tools used for analysis, design and redesign of a company, thus allowing to represent and document the elements that form the company (such as organizational structure, business processes, systems information and technology infrastructure) and the relations,

organization and joints between these elements, allowing the company to be represented in a holistic and integrated perspective, in order to achieve the business objectives and facilitate decision-making processes"

The above definition brings together the most important elements provided by various authors: [13; 14; 15; 16; 17; 18; 19; 20].

2.3.1 Enterprise Architectures and Elements in Common

In recent years, several researchers have proposed enterprise architectures, among which stand out: CIMOSA [6; 21], GIM-GRAI [22], PERA [12; 23; 24], GERAM [12; 25], IE-GIP [7; 26; 27], TOGAF-ADM [18; 28], ARDIN [2; 10; 29] and ARIS [30].

The common elements that handle these enterprise architectures are: methodology, framework and language modeling. The following describes the use of each of these elements: the definition of a methodology facilitates the implementation of the architecture [15]; the framework allows a graphic and simple structure of the elements that make up the enterprise [16] and how these elements are related [15], according to the standard ISO/CEN 19439 [31], the framework should be composed of views and life cycle phases, and most enterprise architectures follow this approach; furthermore modeling language allows to model, organize and understand the relationship between elements of the enterprise. The enterprise modeling usually is developed in a modular way but at same time these modules must be integrated to ensure a holistic view of the company [6].

3 Conceptualization of Enterprise Collaboration

Nowadays, companies do not compete individually. Supply chains or supply networks compete with each other in the quest to increase profits and create greater added value. Therefore, the degree of integration between the partners that make up these supply chains (customers and suppliers) is growing. This degree of integration can be achieved through collaborative arrangements that ensure the alignment of individual plans in the pursuit of a goal or overall plan. It is here, where the enterprise collaboration becomes as a tool that allows partners of the supply chain a collaborative joint decision-making based, allowing coordinate and synchronize the global activities with the aim of satisfying the customer and increase the profits.

3.1 Definition of Enterprise Collaboration

From the definitions of [32; 33; 34; 35; 36; 37; 38; 39], we define the enterprise collaboration as:

"A joint process between members of the supply chain, where the decisions are made jointly, based on the information shared and exchanged on a multilateral form, achieving coordinate and synchronize joint activities to meet customer requirements and achieve efficiency joint processes to generate mutual profits".

3.2 Description Collaboration Process

Once the trading partners agree to participate in a collaborative process, this process will start. According to [40], collaboration process consists of six activities: 1) Definition, 2) Local domain planning, 3) Plan exchange, 4) Negotiation and exception handling, 5) Execution and 6) Performance measurement. However, in this generic process is not taken into account a crucial aspect in order to determinate an efficient collaboration, this aspect refers to how to share benefits equitably to ensure the stability of the collaboration [41]. The solution to this is provided by [39], who proposes the definition of a system of compensatory payments, which could be agreed on the definition phase of the negotiation and can be implemented when the results will be evaluated. Another aspect not covered by the process defined by [40], is the need for feedback between the partners once the process of collaboration in the specified horizon has been completed, moreover, the plan must be reviewed and modified if it is necessary.

4 Relationships between the Fields of Enterprise Architecture and Enterprise Collaboration

There are several studies that propose different types of enterprise architecture; however, most are designed to be implemented in an individual company. These architectures do not take into account the new collaborative environments in which companies are obliged to take part to ensure their survival. The architectures that are structured to be implemented in collaborative environments are: ARDIN EVEI (ARDIN Extension for Virtual Enterprise Integration) [2], CFCEBPM (Collaboration Framework for Cross-enterprise Business Process Management) [1], E2AF (Extended Enterprise Architecture Framework) [4] and VECCF (Virtual Enterprise Chain Collaboration Framework) [3]. As mentioned above, the main architectures have in common three elements: framework, methodology and modeling language, therefore we analyzed these three elements to the four above-named collaboration architectures.

4.1 Analysis of Enterprise Architecture Frameworks in the Context of Collaboration

The four architectures analyzed provide a framework; the Table 1 makes a comparative analysis of relevant elements and data of each of these proposals. The four frameworks work with views and some of these views are common among the frameworks; however, the levels posed by each framework are very different from each other.

The levels that define the framework proposed by [2], correspond to the life cycle phases defined by GERAM [25] and the ISO/CEN 19439 [5], in absence of the identification phase. The levels that define the framework proposed by [1], can be

Table 1. Comparative analysis of proposals in the context of collaboration frameworks

ELEMENTS AND DATA RELEVANT FOR THE COLLABORATION FRAMEWORKS		Framework name	Collaboration Framework for Cross-enterprise Business Process Management (CFCEBPM)	ARDIN extension for virtual enterprise integration (ARDIN-EVEI)	Virtual Enterprise Chain Collaboration Framework (VECCF)	Extended Enterprise Architecture Framework (E2AF)
		Year	2005	2003	2008	2006
		Authors	Adam, O.; Hofer, A.; Zang, S. Hammer, C.; Jerrentrup, M. and Leinenbach, S. (1)	Chalmeta, R y Grangel, R (2)	Choi, Y.; Kang, D.; Chae, H. and Kim, K. (3)	Schekkerman, J (4)
		It is based on the principles of	ARIS (Architecture of integrated Information Systems)	ARDIN[1] (Arquitectura de referencia para el desarrollo integrado)	MDA (Model Driven Architecture)	Framework de Zachman
Elements	Views	Global or collaboration	X			
		Function	X	X		
		Processes	X		X	X
		Information	X	X		X
		Resources		X		
		Decision		X		
		Service			X	
		Tecnology			X	X
		Information Systems				X
	Levels	Enterprise definition		X		
		Requirements definition		X		
		Design specification		X		
		Application description		X		
		Operation		X		
		Disolution		X		
		Collaborative business strategy	X			
		Engineering collaborative business processes	X			
		Implementation of collaborative business	X			
		Metamodel			X	
		Reference Model			X	
		Particular model			X	
		Contextual (Why?)				X
		Environmental (Who?)				X
		Conceptual (What?)				X
		Logical (How?)				X
		Physical (Whith What?)				X
		Transformational (When?)				X

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[1] Spanish acronym of Reference Architecture for Integrated Development.

equated with the life cycle phases proposed by ISO/CEN 19439 [5], but in a general form, where the identification and definition of the concept can be matched with the collaborative business strategy; the requirements definition, design specification and description of the application correspond with the engineering collaborative business processes, and the operation corresponds with the implementation of a collaborative business. The levels defined in the framework proposed by [3], may also relate to the life cycle phases, but also are closely related with aspects of enterprise modeling, from a general level to a particular level. The levels that define the framework proposed by [4], match with most abstractions defined by [42], but this framework of collaboration includes the abstraction of "With What?", which seeks to represent solutions for each of the other views defined.

4.2 Analysis of the Methodologies in Enterprise Architectures in the Context of Collaboration

Only the proposals of [1] and [2] provide a methodology for the implementation of the collaboration architecture. The methodology of [1] includes five phases: Phase 1) Strategy partner analysis, Phase 2) Local TO BE concept, Phase 3) Global TO BE concept, Phase 4) Local implementation and Phase 5) Collaboration execution. Phases 1, 3 and 5 deal with joint collaborative processes, and phases 2 and 4 deal with local domain of each partner in the collaboration.

We miss two phases in this methodology: a preliminary stage of understanding and closeness between partners, in order to identify the strengths of collaboration and envisioning a future state of collaboration and a final phase to assess the results in collaboration and make the necessary reconfiguration if there were differences between partners about the results. According to the above, we propose the following phases: Phase 0) Knowledge and decision to collaborate and Phase 6) Feedback of results and reconfiguration or dissolution.

Regarding to the methodology proposed by [2], its structure is very similar to the previous one, but it also takes into account AS-IS processes, in this way, the current situation is understood by all participants and it is employed to search TO BE processes, in order to avoid the process definition based only on ideals.

These two methodologies (in content and form) are quite similar to the collaborative planning process discussed in Section 3.2, all the activities in this process, are included in the phases of the methodology, so conceptually, the methodology of enterprise architectures in the context of collaboration allows that the collaborative planning process can be conducted through a series of consecutive and related phases.

These methodologies can also be compared with the life cycle phases proposed in the individual enterprise architectures [21; 23; 25; 26], but have been adapted for collaborative environments, defining that activities should be carried out jointly and collaboratively and that activities should be conducted at the individual level in order to adapt processes and individual resources to the definitions and requirements established in the global domain.

4.3 Analysis of Modeling Languages in Enterprise Architectures in the Context of Collaboration

Researches by [1], [2] and [3], provide modeling language quite different from each other. By [1], is necessary to use tools that allow the visualization of the collaborative process and ensure a common understanding of collaborative processes between all companies and individuals involved in the process of joint business, so they propose to use a specific software (INTERACTIVE Process Modeler[VR]), this tool provides an intuitive platform for Internet-based communication to register the business processes in an interactive and decentralized form. The employees are functionally responsible in the description of the business processes and establish an agreement between them through a virtual environment. The modeling language used in this software is BPML (Business Process Modeling Language), which they consider an appropriate exchange language. According to [3], they propose to use a platform-independent modeling architecture based on models (Model Driven Architecture - MDA), an initiative from OMG (Object Management Group), this platform is based on UML (Unified Modeling Language). Finally [2], propose the use of IDEF0 and GRAI nets to represent a general level of the different activities and decisions within the different business, they also propose using UML to describe the business process of the virtual enterprise and related information systems with a more specific detail level.

The existence of such different modeling languages makes it much more complicated to implement the interoperability of the various enterprise networks. However, interoperability between the companies that establish collaborative agreements is possible through the use of enterprise architectures that allow standardization and synchronization of joint processes and the integration of the key elements of global business.

5 Conclusions

At the present time, it is evident the interest that is taking the enterprise engineering through the use of enterprise architectures, both in the academic field as well as enterprise field. In recent years, interest is taking the enterprise engineering through the use of enterprise architectures is demonstrated by the large number of publications found in this respect, however, these methodological proposals are mostly directed and oriented to individual companies, which is not taking into account the growing and rapidly changing environments to inter-enterprise collaboration. The operation and organization of these collaborative networks should be structured and modeled through collaboration architectures designed with the purpose of supporting collaborative processes and their integration with information systems of partners involved in the collaboration. In this sense, some frameworks have emerged that seek to propose a general framework of collaboration, but these proposals fall short in the field of enterprise architecture, these do not meet all the elements identified as necessary for its correct implementation (framework, methodology and language modeling).

The analysis of elements of enterprise architecture in the context of collaboration had allowed us to identify: 1) All research proposes a framework, under the approach

of views and levels. Although some views are common, the levels of each framework are very different, indicating different degrees of abstraction. 2) Only two research make a proposed methodology, these are closely related both to the collaborative planning process and the life cycle phases of the proposed enterprise architectures of individual enterprise, adapted to collaborative context. 3) Three investigations make different proposals of language modeling. The existence of such different modeling languages makes it difficult interoperability of various enterprise networks, but interoperability in the enterprise that establish collaborative agreements are facilitated by the use of enterprise architectures in the collaboration context.

We miss researches combining the disciplines of enterprise architecture and enterprise collaboration in a balanced way. Therefore, one possible research line that takes strength, following the analysis of the state of the art is to propose a collaboration architecture that meets all the necessary elements defined as in the field of enterprise architecture and also consider the methodological component of the business collaboration process, in order to facilitate the definition and conceptualization of collaboration architecture through collaboration architecture framework, the implementation of the collaborative process through an appropriate methodology understood by all partners in the collaboration and modeling language that facilitate understanding of the architecture of collaboration and allow interoperability of the collaborative processes.

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