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MATURITY MODEL FOR POTENTIAL INTEROPERABILITY

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ABSTRACT

Interoperability potential concerns the preparation level of an enterprise to establish an efficient collaboration with possible partners. In order to improve their interoperability, enterprises need to know witch level of maturity they have achieved. This article proposes a complete maturity model composed by a methodology and a reference set of parameters to measure interoperability potential. In order to clarify the proposal, an example of application in a real case is described.

KEYWORDS

Interoperability Measurement; Potential Interoperability; Measurement Parameters; Maturity Model; Methodology

1. INTRODUCTION

In the current economic context enterprises must collaborate with one another efficiently in order to minimize costs, offer new services, deal with new challenges, and be more competitive both, in times of crisis or economic recession, and in times of

growth. One of the main problems that enterprises face when it comes to establishing efficient collaborative working relationships is the lack of cultural, conceptual, organizational, process and technological compatibility (Doumeingts & Chen, 2003).

The concept of enterprise interoperability thus appears as a solution to such problems. Many definitions of interoperability have been put forward over the years (Ford, Colombi, Graham, & Jacques, 2007). Nevertheless, in this paper enterprise interoperability is defined as the capacity enterprises and organizations have to collaborate in an efficient manner while preserving their own identities and their own ways of doing business through mechanisms that act as facilitators. In this context, *preserving their identity* means that the enterprise does not substantially modify its structure and processes in order to achieve compatibility with other enterprises.

Interoperability is considered to be achieved if the efficient collaboration takes place, at least, in the business, knowledge and information and communication technologies (ICT) layers, and also considering semantics aspects that complement the previous three (Chen, Vallespir, & Daclin, 2008). Also in this context, different types of interoperability measurement have been defined, in this paper we focused on interoperability potentiality measurement that concerns the capability of an enterprise to interoperate with an unknown partner.

To improve enterprise interoperability, different metrics have to be defined in order to assess the aspects that flavor or restrict it (Chen & Daclin, 2007). In addition, these metrics must be organized in a maturity model. A maturity model defines the states or levels at which an enterprise or system can be situated, a set of good practices, goals and quantifiable parameters that make it possible to determine on which of the levels the enterprise currently stands, and also a series of proposals with which to evolve from one level of maturity to a higher one (Ahern, Clouse, & Turner, 2004).

But although in (Chen & Daclin, 2007) the in interoperability potential measurement levels are defined, no specific parameters or solid appropriate methods have been proposed to evaluate which is the level achieved by an enterprise or a process, in a satisfactory way.

To solve this problem, this paper describes a Maturity Model for Potential Interoperability in an enterprise, including a detailed methodology to measure this interoperability. In order to validate and to evaluate the applicability and benefits of this proposal, a description of the use of the model to an enterprise in the textile sector is shown.

This paper is organized as follows: section 2 reviews the approaches and the projects carried out on maturity models that were considered during the development of the proposal; section 3 consists of the maturity model proposed, that includes the measurement parameters, the methodology and its phases; section 4 briefly outlines how the framework was applied to a real enterprise and discusses practical aspects of this application. Finally, in section 5, conclusions and future work are showed.

2. LITERATURE REVIEW IN INTEROPERABILITY AND MATURITY MODELS

In the context of enterprise networks, interoperability refers to the ability to carry out efficient interactions (i.e. exchange information, products and services) between enterprise systems at least three enterprise layers, i.e. data, services and processes, considering the semantics defined in a given context (Doumeingts & Chen, 2003). Interoperability must consider organizational, economic and social aspects, as well as technological changes.

Two integrated enterprises could also be said to interoperate satisfactorily, since the homogeneity of their processes and systems implies a full (and effortless) capacity to collaborate and exchange information (INTEROP, 2008). The problem arises when the enterprises that need to work together do not want to adopt an integrated way of collaborating and employ heterogeneous systems, different tools and procedures, and also different concepts or languages. Moreover, setting up the collaboration must not imply a loss of their independence or of their capacity to continue to work in an autonomous manner or to collaborate with other organizations (Campos, Martí, Grangel, Mascherpa, & Chalmeta, 2008).

Another important aspect to be taken into account when developing proposals for improvement in interoperability is that, although we usually refer to collaborations with external institutions, it is included (and are even based on) collaborations between different departments or systems that exists within the enterprise itself and which were set up to carry out internal processes. This is defined as intra-interoperability.

In order to establish and define projects for improving interoperability, first it is necessary to evaluate and diagnose the situation in which the enterprise currently finds itself and to suggest improvements that favor evolution in this field. To measure this situation it is necessary to consider a maturity model as far as interoperability is concerned.

The term Maturity Model was made popular by the SEI (Software Engineering Institute) when the Capability Maturity Model© (CMM©) was put forward in 1986 (Dymond, 1995). This maturity model has gradually evolved with each new version and is widely accepted as a guide for evaluating the business processes of an organization (Ahern et al., 2004). Based on this initiative, several maturity models have also been put forward in interoperability research (Ford et al., 2007);(Guedria, Naudet, & Chen, 2008)

In the last decade different maturity models applied to interoperability have been proposed, both in the just the technological field and also taking into account all the different layers of the enterprise (Kasunic & Anderson, 2004).

In most cases the existing maturity models only define the interoperability enterprise levels, there are some maturity models that include a set of good practices advising enterprises about how to become interoperable (Daclin, Chen, & Vallespir, 2006a)(Pardo & Burke, 2008) However, in general, the proposals do not go into great depth regarding which aspects need to be evaluated, how to measure them in order to assign a level of maturity, and how to improve this level if it is considered necessary to do so.

Next sections provide a more detailed description of the interoperability maturity models that, because of their relevance and contents, were taken as the starting point for the proposal in this work.

2.1 Levels of Information Systems Interoperability (LISI)

The first significant initiative carried out to measure interoperability was proposed by the DoD C4ISR Working Group and entitled Levels of Information Systems Interoperability (LISI) (C4ISR, 1988). The aim of LISI was to establish (and, consequently, to improve) the maturity of the information systems used by the US Department of Defense in joint actions implemented between different military units. LISI provides a maturity model including the levels definition, the necessary processes to identify the interoperability needs and how to enable the information systems to support those needs.

LISI proposes five levels of maturity: **Isolated, Connected, Distributed, Domain** and **Enterprise**. To establish these levels of maturity, it defines four areas of interest named

PAID, which stands for Procedures, Applications, Infrastructure and Data. This maturity model establishes a first approach in order to develop a full maturity model, although the proposal is essentially focused on the technological platforms that support information systems and do not cover all the areas of interest that must be taken into account in enterprise interoperability, such as knowledge or semantic.

2.2 Enterprise Interoperability Maturity Model ATHENA (EIMM)

ATHENA (Advanced Technologies for Interoperability of Heterogeneous Enterprise Networks and their Applications, (ATHENA, 2006a) is a project of the European Union that proposes an Enterprise Interoperability Maturity Model called EIMM (ATHENA, 2006b).

EIMM defines five enterprise interoperability levels, i.e. **Performed, Modeled, Integrated, Interoperable** and **Optimizing**. EIMM helps to assess an organization's level of maturity concerning the use of enterprise models as well as, the capability of these models to enable the company to establish collaborations. Based on an EIMM assessment, companies will be guided to choose the right concepts in order to improve their capabilities, by taking into account the environment and enterprise challenges (Berre et al., 2007). Although EIMM state that parameters and methods must be defined to measure interoperability, no complete proposal has been put forward showing the steps to be followed or the methods and tools to be used to carry out this measurement.

2.3 Barriers Driven Methodology Maturity Model

Another maturity model is proposed as a result of the Barriers Driven Methodology (Daclin, Chen, & Vallespir, 2006b), (Chen & Daclin, 2007). This methodology considers three types of interoperability measurement:

- The **interoperability potentiality measurement,** which is concerned with the ability of an enterprise to interoperate without the need to know its interoperation partner and, consequently, with identifying a set of characteristics that have an impact on interoperability. The aim is to measure the intrinsic capabilities of an enterprise to interoperate with an unknown partner. This measure must evaluate the accessibility and facilities an enterprise has to set up collaborations with others, the use of standards, the organization's flexibility in the use of enterprise modeling, etc.
- The **interoperability compatibility measurement** evaluates a current relationship between known stakeholders. In other words, it is measured while the interoperability project is being carried out in order to establish how well two partners are suited to be able to interoperate.
- **The interoperability performance measurement** has to be set up during the operational phase to evaluate aspects related with the costs involved in implementing interoperability between two enterprises or systems in terms of time or economic investments.

The levels defined to support interoperability potentiality measurement are: **Isolated, Initial, Executable, Connectable and Interoperable**. Table 1 shows the description for each of these levels.

Interoperability potentiality measurement of an enterprise will evaluate how prepared it is to establish, smoothly and efficiently, collaborations with possible partners, relations with current and new customers, business agreements with suppliers, and communication with governmental or financial institutions. Being prepared and having a high level of interoperability potentiality is a critical factor that will enable the

enterprise to adapt to changes and new needs or requirements from the market in a dynamic manner, which will result in better business outcomes.

Although Barriers Driven Methodology highlight the importance of evaluating the interoperability potentiality measurement of enterprises as a critical aspect for carrying out improvement projects, it does not put forward or define a proposal as regards how to measure this interoperability potentiality in a practical way.

3. PROPOSAL OF A MATURITY MODEL FOR POTENTIAL INTEROPERABILITY MEASUREMENT

As a result of the literature review in maturity models and interoperability, there exist maturity models that propose levels for interoperability potentiality measurement, but do not provide a guide and methodology to evaluate which is the level reached and what improvements are needed to increase this level. Potential Interoperability, that identifies the preparation level of an enterprise to establish an efficient collaboration, is considered to be evaluated when interoperability potentiality measurement is applied.

To support this measurement, this paper shows a maturity model for potential interoperability called MM-IRIS including:

- A **set of parameters** considering different **enterprise views**
- A **methodology** that guides to evaluate which maturity level of potential interoperability is achieved for each of the processes the enterprise performs.

These enterprise views, the parameters and the methodology defined are described in the next subsections.

3.1 Enterprise views

The level of maturity in potential interoperability is not homogeneous in all the enterprise and it is therefore necessary to define different views of the enterprise that make it possible to detect the levels attained in each case. In the MM-IRIS the following views are proposed: **Business, Process Management, Knowledge, Human Resources, ICT and Semantics.**

- The **Business** (BS) view considers the strategic aspects related with the interoperability, culture, mission, vision, values, and the economic, social and environmental policies of organizations. In order to interoperate, enterprises must have aspects that favor collaborations defined within their strategy. The use of Enterprise Modeling and business-related barriers must be evaluated as a support to this view.
- The **Business Process Management** (BPM) view includes the work methods (and therefore aspects related to productivity and cutting costs). Interoperability can only be reached when it is based on an efficient interaction with the processes of other enterprises, including processes that generate sustainability. This view takes into account aspects of processes and services, the business layers and data, and values the use (as a support) of Enterprise Modeling and of Architectures and Platforms.
- The **Human Resources** (HR) view, which considers the skills, competencies, roles, culture, collaborative capacity, and so forth, of employees who participate in interoperability processes. Aspects related with the three domains are evaluated, from the point of view of the use and training of the personnel of the enterprise.

- The **Knowledge** (K) view, which includes establishing a knowledge management system with which to identify, extract, represent, process and exploit the knowledge that facilitates efficient cooperation among the different enterprises. Its evaluation takes into consideration aspects related with data, services, support technology and the use of ontologies.
- The **Information and Communication Technologies** (ICT) view, which helps applications, data and communication components to interconnect automatically. This view considers aspects related with data and services from the technological point of view and the supporting platforms and architectures as the domain to be evaluated.
- The **Semantics** (S) view is used to facilitate the understanding of the terminology used by the enterprises that wish to collaborate, that is to say, it considers the aspects needed to ensure that the information is interpreted in the same way. It is related with the data layer and measures aspects related with their own ontologies and barriers.

The parameters defined in the ICT view will concern, above all, general technological issues in the enterprise. In each of the other views, use of the ICT as a support will be valued.

3.2 Measurement parameters of each view

Interoperability is accomplished if it is achieved in all areas or views of the enterprise. Hence, carrying out a separate evaluation of each of them will make it possible to detect where there is a greater need for improvement and to define projects that are suitable for each case.

In defining the measurement parameters of each of the views, all the relevant aspects identified in the literature that have to be considered to reach interoperability were taken into account. For example, the three interoperability domains to provide enterprise interoperability solutions defined by (IDEAS, 2006) and (INTEROP, 2008): Enterprise modeling (EM), which deals with the representation of the inter-networked organization and considers how to ensure interoperability between different models; Architecture and Platforms (A&P), which considers the necessary technology to implement interoperable applications; and ontologies (ONTO), which ensure that the semantics used are understandable by the two systems. Other works that have been considered to define these parameters are: works developed in order to improve interoperability in different sectors, as e-government (Alvarez Sabucedo & Aido Rifon, 2010), performance measurement applied to business processes (Alfaro, Rodriguez-Rodriguez, Verdecho, & Ortiz, 2009) and interoperability (Blanc, Ducq, & Vallespir, 2007), previous works carried out in the fields of methodologies and interoperability (Campos et al., 2008), of knowledge modeling (Grangel, Chalmeta, & Campos, 2007) and performance measurement systems (Chalmeta & Grangel, 2005).

Next, the parameters for each view are defined and justified. For each set of parameters the relationships between each potential interoperability level and the measurement results of the parameters are shown in tables 2, 3, 4, 5, 6, and 7.

Parameters for the business view

The first step to measure the enterprise potential interoperability maturity is to establish the enterprise's vision and strategy when faced with the challenges of reaching a suitable level of interoperability. In order to define the parameters of this view, it is deemed necessary to measure those aspects related with the strategic plans of the enterprise that have repercussions on its capacity to establish collaborations. Having certifications

endorsed by official, especially international organizations, such as the International Standards for Business, Government and Society (ISO), (http//www.iso.org/iso/iso_catalogue.htm), will allow collaborations to be established more clearly and quickly. Processes in enterprises will be organized and will comply with standards that other firms can rate positively when it comes to establishing new businesses or maintaining existing ones. Next parameters are detailed and Table 2 shows each potential interoperability level and the measurement results.

- **Sustainability and quality policies**, certified by official bodies: an enterprise that already has, or is implementing, these standards will be able to establish collaborations more efficiently.
- Any **certifications** in the area of quality and sustainability that the enterprise already has will be evaluated, as will those that are pending but are currently being assessed. A study will be conducted to compare the minimum standards that the enterprise must have by law and those that exist at state, autonomic and international level.
- The **capacity/willingness** to adapt to organizational, technological and social **changes**. Flexibility and adaptation to change can be evaluated by the number of training schemes that exist in the enterprise related to the incorporation of new business models or new technologies. Projects that have been carried out, or are due to be carried out soon, that take into account social aspects such as sustainability or gender equality will be valued. The new business approach towards aspects with social repercussions is an added value that can be decisive when it comes to establishing relations with public bodies that value such issues.
- **Strategy** as regards the use of **technologies** as a support to aid in collaborations with other enterprises. Projects carried out in recent years on improvements in

the technological field that may result in better interactions with other firms and the proposals included in the strategic plans will be evaluated.

- **Policies** with respect to the use of **technological** and information standards. Whether or not this type of policy exists and the willingness to adopt them will be key factors that must be evaluated in order to know the extent to which the enterprise is ready to interoperate.
- Policies of (social, technological, etc.) **evaluation of possible partners** prior to establishing relations. The existence of procedures that allow the capacities and characteristics of a possible collaborator to be ascertained and evaluated, taking into account not only technological aspects but also organizational and social responsibility, will make it possible to know whether the company is prepared to be more efficient when selecting future collaborations.
- **Contractual policies** regarding collaborations with other bodies. Evaluating the existence of conditions beyond those contemplated by the law will make it possible to know whether the enterprise controls and establishes its own criteria when it comes to interoperating with another enterprise.

Parameters for the Process Management view

The processes view will evaluate the level of formalization that exists, the documents and use of enterprise modeling languages, the capacity to exchange and make public the parts of the processes in which collaborations with other firms may take place. The parameters considered are:

- **Identification of processes** in which there is some collaboration with external institutions: it is necessary to find out whether the processes are identified, whether they are documented and within the collaborators reach, and whether they are represented in some enterprise modeling standard.

- **Formalization of processes**: tacit, documented, modeled procedures. Evaluations will be conducted to determine whether procedures have been defined or whether activities are simply carried out as they are learnt from experience. If the processes have been formally defined, they will be evaluated to determine whether they are documented, together with the modeling languages and tools used to represent them.
- **Process planning:** studies will be conducted to examine whether processes are planned and, if so, the deadlines that are set and the level of detail to which they are planned.
- **Quality measurement and control**: in processes that involve collaboration with external institutions, in which cases methods and indicators have been developed to measure the quality and to control processes

Table 3 shows each potential interoperability level and the measurement results for these parameters.

Parameters for the Human Resources view

One aspect that is fundamental in order to have a good level of potential interoperability is how prepared the workers are, the plans for training that exist in the company, and how easily human resources adapt to changes. The parameters to be measured in this view are:

- **Organizational structure**: there is a well-defined and documented structure with a clear hierarchy and allocated functions.
- Assigned **roles**, flexibility to exchange jobs.
- **Training** the enterprise has a training plan that takes into account different levels and contents depending on the tasks and human resources.

- **Evaluation and control**: assigning resources to follow up, supervise and make processes known.

Table 4 shows each potential interoperability level and the measurement results for these parameters.

Parameters for the Knowledge view

The knowledge view covers aspects concerned with how knowledge is managed and transmitted, not only internally, but also how it is identified and transmitted to possible collaborators that need to use it. The potential interoperability of an enterprise will, in turn, be marked by the level of maturity that exists in the management of its knowledge, since greater specification of enterprise knowledge makes the company better prepared to establish efficient collaborations with possible stakeholders that seek to interoperate with it.

Furthermore, companies have a greater level of maturity in this field if they have the capacity to apply the ICT to enterprise knowledge management by a Knowledge Management System (KMS). The first aim would be to identify the knowledge that is going to be managed by the system, that is to say, the target knowledge.

The parameters are:

- **Knowledge** that is exchanged and **points of interaction**, which will make it possible to detect the existence of at least tacit knowledge in the processes of the enterprise.
- **Channels of knowledge** to evaluate the use of suitable methods and technologies for the exchange of information.
- Existence of a **Knowledge Management System**.
- **Identification** of the conceptual blocks of knowledge and the target knowledge that the enterprise wishes to manage; thus, evaluations are carried out to

determine whether possible stakeholders and points for exchanging or sharing knowledge have been identified.

- **Type of conceptual blocks** on which the target knowledge has been defined.
- **Identification of** the explicit and tacit **sources** of knowledge.
- **Knowledge modeling** that has been identified, so that the enterprise's target knowledge concerning its processes, products, resources, suppliers, customers, etc. is made explicit.
- **Exploitation** of knowledge by means of a KMS.

Table 5 shows each potential interoperability level and the measurement results for these parameters.

Parameters for the ICT view

Information technologies play a fundamental role in achieving a high level of maturity. The use of standard platforms and technologies is essential to be able to interoperate and to be able to open up new collaborations efficiently; companies not prepared to cooperate with each others using ICT and inter-enterprise applications will fall through their business (Hoving, 2007). In this section the use of ICT and projects that have been planned to improve them will be evaluated. The parameters are:

- **ICT resources** for communication: which ones exist, which ones are standard.
- **Systems** for the integrated management of information: whether they exist, are used and training is carried out in this respect.
- **Planning** of technology needs in order to support collaborations.
- **Policies** for the development of platform-independent technologies that can be adapted to different systems.
- **Infrastructures** to support **process management** (Work flow, EM tools, etc.)

- **Infrastructures** to support the {control} of both internal processes (auditing, register of the use of the services) and those of external entities.
- **Services for public use** if they exist, their use is recorded or they are planned for the future.

Table 6 shows each potential interoperability level and the measurement results for these parameters.

Parameters for the Semantics view

The Semantics view is concerned with ensuring that the precise meaning of any exchanged information can be understood by any other processes, people, collaborative external enterprises and ICT applications. So, taking in account that Ontology domain addresses the semantics necessary to ensure interoperability (Duque, Campos, Jimenez-Ruiz, & Chalmeta, 2009), the high level of maturity will be achieved if the use of ontologies is applied to support collaborations and internal business management. The proposed parameters are:

- **Databases** and contexts where these databases operate. Existing mappings
- **Collections of terms**: whether they exist and whether there are methods to collect and process them.
- **Planning technologies and infrastructures** for supporting these collections of terms and mappings.
- **Mapping** between own collection of terms and public thesaurus.
- **Planning** about acquiring (ontology} tools and training human resources on the use of them.
- **Ontology** developed to support both semantic webs and collaboration processes.

Table 7 shows each potential interoperability level and the measurement results for these parameters.

3.3 Maturity measuring methodology

In order to evaluate the potential interoperability level, a step based methodology has been developed.

The phases of the methodology will be carried out progressively and iterations can also take place. This means that it is necessary to repeat or improve part of the results from the previous phase as the measurement project advances.

During of the application of the methodology it is necessary to collect information. The main technique employed is a questionnaire that must be developed considering the parameters already defined for each view. Each parameter is transformed into one or several questions on a questionnaire, which is adapted to the enterprise taking into account its business processes and the (current and potential) collaborations that were previously identified and which may be internal (between departments) or with external entities. The questions can be quantifiable in absolute values, scored on a given scale (from 1 to 5), with yes/no answers or as a percentage (for example % of employees with a higher education). In any case, each question must include a section where the respondent can describe whether this aspect needs improving or not, or if the current situation is seen to be sufficient.

While the questionnaire is being developed, weightings must be defined for each of the questions and must be established which results correspond to each of the levels, taking into account the previous descriptions produced in the tables for each of the views.

Next, each phase of the methodology is described in greater detail. Figure 1 shows graphically the phases proposed and the main results obtained from each phase, according to the enterprise views defined.

Figure 1. MM-IRIS Methodology and results.

Phase 1: Project planning

The basic aim of this phase is to define the conceptual aspects of the enterprise as regards interoperability, taking into account the business view and the strategic and cultural goals.

Since it represents the beginning of the project, it is necessary to define the personnel that will be involved in the work, to establish the scope (areas and/or processes) to be evaluated and possible restrictions concerning time or costs, and to estimate and schedule the project in order to control it.

In this phase the parameters of the business view are taken into account in order to develop questionnaires and interviews to evaluate the strategic plans, the policy of the enterprise and the preparation degree to cope with the challenge of improving its potential interoperability.

The techniques to be utilized in this phase are information collection techniques, above all face-to-face interviews with company managers and more especially with those who are more deeply involved in the strategic and improvement projects at the enterprise, such as quality, information technologies or I+D managers. Documents about quality standards, the company mission and its vision are also collected. This first result makes it possible to evaluate whether it is feasible to continue with the rest of the phases or if it would be better to limit the study and measurement to the interrelations among the departments in order to carry out a preliminary assessment of internal interoperability in the company. In an enterprise where the business strategy does not include fundamental aspects such as policies on external collaboration or strategies for improving these collaborations or the ICT, there will be no point in evaluating their potential interoperability maturity in further detail in the remaining views.

The results are: **planning**, where criteria and priorities are established in order to delimit the scope of the project and its feasibility; **definition of the strategy** for

carrying out the following phases of the measurement project, and **evaluation** of potential interoperability in the Business view.

Phase 2: Definition and classification of collaborations

After identifying the fact that the enterprise has established or planned certain policies or needs in relation to interoperability as part of its strategic plans, the second phase has three basic aims:

1. To identify and classify the internal **collaborations** for each of the processes
2. To identify and classify the **external entities** with which situations of interoperability take or may take place, considering each of the enterprise's business processes.
3. To identify the current **collaborations** with these external entities, taking into account processes and departments involved.

The first step is to study and review the organizational structure of the company, the process map and to identify the collaborations that exist between each department for each of the enterprise's business processes.

The process map and the organizational structure are then used to identify and classify the types of collaboration that can be set up and the stakeholders, for example financial institutions, governmental entities, large, small or medium-sized supplier enterprises and large, small or medium-sized customers.

It is necessary to have reliable up-to-date information about the business processes that the company carries out, the departments involved and its business strategy with respect to other supplier or purchaser entities which it may interoperate with.

Information about the organization and the hierarchical structure of the company and its process map will be used as working documents. The results of identifying and classifying the departments involved in each process will be as follows:

- An **interdepartmental interaction matrix** for each department showing the other departments it is collaborating with (for each process it is involved in).
- Classification of **processes** in which interoperability exists or could exist with external institutions, **current partners** or collaborators and future **partners**.
- A **matrix of external collaborations** considering interactions for each department, which identifies (for each process in which a particular department is involved) the types of stakeholders it currently or potentially collaborates with.

Phase 3: Measurement and collection of results

This phase measures the maturity by applying information collection techniques and by taking into account the collaboration matrices that were obtained earlier and the parameters for the Process Management, HR, Knowledge, ICT and Semantics views.

It is essential to know the degree of involvement of the staff responsible for the departments in the enterprise to obtain a questionnaire that is adapted to their characteristics, while also being simple for respondents to answer and easy to understand. As mentioned above, in developing the questionnaire weightings are designed for each of the questions.

The main result from this phase is the questionnaire for evaluating potential interoperability maturity, adapted to the structure and processes of the enterprise. During the phase in which the questionnaire is being developed, different iterations may occur that lead to a redefinition of some of the aspects identified in phase 1 until a final questionnaire is obtained adapted to how the interactions take place in the course of the day-to-day undertakings of the enterprise. Other outcomes that will therefore occur in this phase include:

- Review of the documents obtained in Phase 1.

- Definition of **tactical goals**.
- **Questionnaires** to evaluate the potential interoperability for each process
- Completed questionnaires.

Phase 4: Analysis and quantification

With the answers given in each of the questionnaires, and taking into account the levels and weightings assigned to each parameter, a detailed analysis must now be performed to identify current situations and those which have been considered to be in need of improvement.

Since the study is conducted by processes and views, one particular process can have a high level of interoperability in one view and with respect to one group of collaborators, but at the same time have shortcomings or a low level in another aspect or view.

In this phase data analysis techniques and cost/benefit analysis must be used, and the members of the work team must meet to compare results with the users. The results are the *potential interoperability levels* and the identification of *needs of improvement*, both of them detailed for each process, collaboration (internal, current and potential with external entities) and view.

Phase 5: Proposals for improvement

Once the results from the questionnaires have been quantified, an analysis must be conducted to study and evaluate the points or processes where the level of interoperability reached needs to be improved. In this analysis the strategic aspects identified initially in the first activity must be taken into account. The result of this evaluation is a proposal for projects arranged in order of priority, in which the current "AS-IS" situation and the one that is sought (or "TO-BE") are both established.

Traditional cost/benefits analysis is a very useful tool to define the priority of the projects within the interoperability project. However, organizational, technical and operational aspects should also be considered.

The results are a proposal including: *medium and long-term interoperability improvement projects*, interoperability *future needs*, and a *viability analysis*.

4. A CASE EXAMPLE

The MM-IRIS maturity model was applied to a large textile enterprise to be validated and provides some practical aspects that can guide similar applications in other cases. The enterprise is a large company from the textile sector that is firmly rooted in both the Spanish national and the international markets. It has a complete supply chain, logistics centers separated from its centers of production, and suppliers of finished and semi-finished products in different countries.

It has different types of customers including micro/small, medium-sized and large enterprises, with a wide range of technologies and policies. Like any company, it has relations with public or governmental and financial institutions.

An evaluation of the firm's potentiality to interoperate both with customers and with suppliers of raw materials and intermediate or finished products will allow have a number of benefits for the company. For example, it will be able to develop strategic plans that help it to improve these collaborations, make more reliable choices (in terms of results) regarding possible partners in interoperability projects, and evaluate certain aspects that, due to the production and supply structure, are crucial to the enterprise.

Next the procedure adopted for the application of the MM-IRIS in this company is described.

Project planning

Initially an introductory meeting was held with managers from the company and those in charge of a number of different departments. At this meeting the basic concepts and aims of the work to be carried out were explained and the benefits that the enterprise would gain from collaborating in the project were also outlined. More specifically these benefits were: (1) a reappraisal of its organizational structure and process management; (2) measurement of the level of potential interoperability; (3) diagnosis of its situation in this area; and (4) definition and study of the feasibility of projects for improving interoperability in the short and medium term.

Following this meeting a work team was set up that included both research personnel and management staff from the company's Quality and Information Systems departments.

After conducting a preliminary research task, a questionnaire was administered to managers in order to be able to determine the scope of the project as far as processes and departments were concerned. This first activity made it possible to define the conceptual aspects, the scope and areas of the potential interoperability evaluation, taking into account the business view, as described in phase 1, and the parameters that were defined for this view.

This evaluation of conceptual aspects of interoperability made it possible to detect the fact that the enterprise applies interoperability principles (although not explicitly) to carry out different transactions and processes involving external collaborators, such as financial and governmental institutions, suppliers and customers. A suitable but insufficient policy regarding the use of ICT as a support for business processes was also found to exist.

The project was carried out following the steps from the methodology. Once the conceptual aspects had been established taking into consideration the business view, the documentation was reviewed and the information about the organization of the company and the management of its business processes was updated.

Definition and classification of collaborations

The most significant groups of potential collaborators were identified for each of the business processes, and the common features and the most relevant aspects to be taken into account with a view to possible collaborations were also defined. This information was then used to create a matrix which allowed current and potential collaborations to be identified for each process. The collaborations matrix was used as the basis for developing the interoperability questionnaire, which was done in a particular way for each process by asking only about the collaborations that had been identified.

In Figure 2, a partial example of the internal collaboration matrix, for each macro-process and departments involved, obtained is shown. The departments are coded by letters and in the matrix **X** shows if there is collaboration between the department in the column and in the row, for a micro-process in particular.

Figure 2. Internal collaboration matrix.

Measurement and collection of results

Development of the questionnaire required several iterations, and the initial versions were reviewed by the managers in the team to analyze how appropriate and easy to understand the questions were.

Once the final version of the questionnaire had been obtained, it was applied with the collaboration of the managers in the Quality and Information Systems departments. This

generated more confidence in the different managers who were interviewed and enabled more reliable results to be obtained more efficiently.

As an example Figure 3 shows a partial matrix of process collaborations, with one of the questions applied, considering the parameter about **Formalization of processes** and the use of EM. In this matrix the current situation can be valued from 1, the worse situation, to 5 the best situation. The users also can identify if there are needs of improvement in the column **OK/NO**.

Figure 3. Question example and collaboration matrix.

Analysis and quantification

After obtaining the filled-in questionnaires, the results obtained by the members of the research group involved in the project were then analyzed and quantified. One implicit result was the positive evaluation of the efficiency and correctness of the questions that were posed. Statistics and comparisons of data were carried out in parameters where the answers could be grouped and quantified. A qualitative report was also drawn up that included not only an evaluation of the answers, but also a list of the points in which the greatest need for improvement was detected.

The final result was a detailed evaluation of the potential interoperability for each process and view.

Proposals for improvement

In addition to this diagnosis in relation to interoperability, a proposal was also put forward for short- and long-term improvements in those departments where the most urgent needs were detected, including the corresponding feasibility study for the short-term projects that were identified.

Lessons learned

The MM-IRIS maturity model provides a series of clear steps to be followed and a set of results that allow a detailed evaluation of the potential interoperability to be performed. At the same time, an analysis of different organizational aspects of the enterprise can also be conducted.

The development of the questionnaire as the central and fundamental task in the evaluation of maturity in potential interoperability must be a job that is carried out in close collaboration with qualified staff from the firm.

Results cannot be only quantitative and it is necessary to take into account other aspects that are deduced from meetings and from open questions where managers can suggest improvement needs and bear in mind other specific situations.

In addition to an evaluation of its level of maturity in the area of potential interoperability and the aspects in need of improvement, the enterprise also gained other benefits from applying MM-IRIS, such as:

- Department managers improved their knowledge and training in relation to interoperability aspects.
- Business processes were reviewed, above all those in which it collaborates with external institutions.
- The enterprise was already carrying out some of its collaborations efficiently, but evaluating them by means of this work enabled it to detect aspects that could be improved and that were not being implemented properly.
- Definition and classification of current and potential collaborators.
- Having criteria that enabled it to evaluate and select possible collaborators.

5. CONCLUSIONS AND FUTURE WORK

In order to improve all the aspects that affect the capacity to interoperate, first it is necessary to be able to evaluate the AS-IS situation, considering aspects related with process management, organizational features, human resources and the semantics of the company.

In addition to knowing their capacity to interoperate with known collaborators, enterprises also need to know how prepared they are to establish relations in the future. Evaluating the level of potential interoperability (taking into account all the views of the enterprise with details of each process) enables the company to become aware of its strong points in this field and of the improvement projects it could consider in order to raise better chances of collaboration. To support these objectives, it is necessary to have a set of methodological guidelines to indicate the procedures to be carried out.

The level of interoperability potentiality cannot be improved in such a way that it goes straight from an initial level (level 1) to an interoperable level (level 5); instead it is necessary to implement projects that allow the processes of the enterprise to gradually evolve from one level to the next one. It is also important to note that not all the processes in an enterprise require the same level of interoperability. In some processes a medium level may be sufficient while in others requirements imposed by the market or by other stakeholders may call for the highest level.

Parameters related with the domains of interoperability and with the conditions that the company processes must fulfill in order to be prepared for new collaborations, while also taking into account different views, can be used by the management of an enterprise as a solid foundation on which to carry out diagnoses and proposals for improvement projects.

With regard to future work in this area, some reflections need to be made on the new proposals that research on interoperability is evolving towards, and more particularly on the recommendations suggested by Future Internet Enterprise Systems Cluster (*Community Research and Development Information Service*, (CORDIS). Research recommendations point to the idea that a new notion of enterprise and enterprise network is arising. Various lines of research that take the new scenario into account have been suggested, e.g. incorporating the role of enterprise culture in enterprise collaboration or the notion of sustainability, including economic, environmental and social dimensions.

Bearing this proposal in mind, the evolution of the work presented in this paper should consider new characteristics for measuring potential interoperability that take into account the aspects of this new approach by including parameters in each view in order to evaluate them.

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