A Methodological Proposal for the Development of an Interoperability Framework

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Abstract. The new economy and business needs lead enterprises to be interoperable in order to be competitive and sustain new market opportunities that will result from cooperation with other enterprises. Easy ways to establish business with customers and suppliers or other enterprises are needed. Within this framework various studies on how to establish interoperability among specific enterprises, supply chains and virtual enterprises, or for specific sectors, have been successfully conducted and applied. The methodological proposal described in this paper will lead enterprises to achieve an advantage situation regarding their maturity level of interoperability. It supports enterprises to be prepared to interoperate, and this aspect can be a key issue for other enterprises to select them in new businesses or new collaborative projects.

Key words: Methodology, Interoperability, Enterprise Modelling, Architecture & Platforms, Ontology

1 Introduction

Global economy, customer orientation and the rapid development of Information and Communication Technologies (ICTs) are some of the factors that have produced a new economic scenario, where information and knowledge have become strategic resources for enterprises [1]. This scenario promotes new and changing cooperation needs between enterprises from various sectors, cultures and having different organisational points of view. The collaboration is not only limited to integrated networks, supply chains, customer relationships or virtual enterprises. Enterprises expect a kind of cooperation that preserves their identity and their own and particular way of working. Within this framework interoperability will become the cornerstone to this new situation and culture, as well as a permanent research and experimentation issue.

In this paper, we present a methodology proposal of a to implement an Interoperability Framework for a particular enterprise, in which other enterprises that wish to interoperate with the it, can find the appropriate procedures, methods and tools to support their interoperability projects.

This document is divided into five sections. In Section 2, we introduce the interoperability context and include a brief description of interoperability definitions and concerns, and goals to achieve full interoperability. In Section 3, we describe what a methodology is and briefly describe some proposed methodologies for interoperability. In Section 4, we explain the methodological proposal detailed by processes, that will serve to develop the framework that will support enterprise interoperability. Finally, in Section 5, we present the conclusions reached and the future work to be done on the application and testing of the methods.

2 Interoperability Context

There are many different approaches to define **interoperability**. According to the Oxford dictionary, interoperability is the ability to operate in conjunction. The IEEE [2] defines interoperability as the ability of two or more systems or components to exchange information and to use the information that has been exchanged.

From a system-oriented point of view, interoperability is the ability of two or more systems or components to exchange information and use it without a particular effort in each system; it describes whether or not two pieces of software can work together [3]. **From a user's point of view**, interoperability is the user's ability to successfully search for and retrieve information in a meaningful way and have confidence in the results. And **from a software point of view**, it means that two systems can work together, share information and services without a especial effort, using a common syntax.

To better understand interoperability is what the research developed in this area is, it is worth to analyse this concept as compared to Enterprise Integration. To this regard, it is possible to find the definition of integration ranges in [4]. **Full integration** means that component systems are no longer distinguishable in the whole system. **Tight integration** means that components are still distinguishable but any modification on one of them may have a direct impact on the others. **Loose integration** means that a component system continues to exist on its own but can work as a component of the integrated system.

Therefore, loose integration reminds us of the concept of interoperability, where two independent pieces of software from different enterprises can work together and share information without especial effort.

There is also another way to compare interoperability with enterprise integration, if we think of the different levels of networked enterprises [5]. The way the interoperation occurs can be **integrated** when there is a standard format for all systems; it ca be **unified** when there is a common meta-level structure across constituent models; and it can be **federated** when models must be dynamically accommodated rather that having a predetermined meta-model. Therefore, federated enterprises are nearer to interoperability.

These definitions are summarised and graphically represented in Fig. 1, where the lighter colour represents less integration. Enterprises with low or no integration will be closer to interoperability concerns and projects.

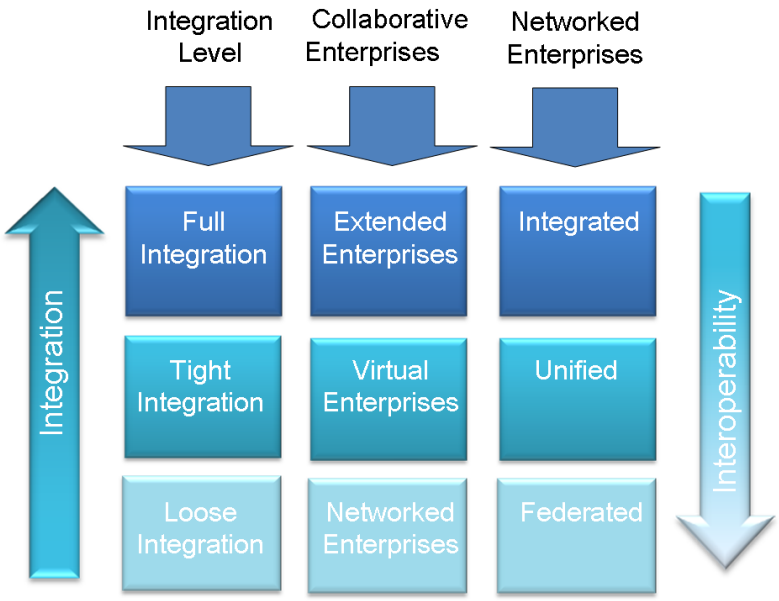

Fig. 1. Integration and interoperability levels

Interoperability is considered to be achieved if the interaction takes place, at least, in the business, knowledge and ICT layers [6]. According to INTEROP [7] there are three relevant domains to provide enterprises interoperability solutions:

- **Enterprise Modelling (EM)**: it considers how to ensure interoperability between different models. Within this framework exchange languages such as UEML[1] [9–11] and POP*[2] [13, 14] have been developed.
- **Architectures and Platforms (A&P)**: it takes into consideration the necessary technology to implement interoperable applications. Some A&P used in this area are supported by XML (Extensible Mark-up Language), SOA (Service Oriented Architecture) and MDA (Model Driven Architecture).
- **Ontologies (ONTO)**: they ensure that the semantics used are understandable by the two systems. In this area, several enterprise ontologies have been

[1] Unified Enterprise Modelling Language: first developed by the UEML Thematic Network [8] and later on dealt with by INTEROP NoE [7].

[2] Process, Organisation, Product, and other dimensions (represented by a star), proposed by ATHENA IP [12].

developed, such as TOVE which is one of the results of the TOVE Project [15]; PSL initially Process Specification Language (PSL) [16–19] based on TOVE, which is a standard for information exchange in the manufacturing industry; or the Edinburgh Enterprise Ontology (EO) [20, 21], which is a part of 'Enterprise Project', a collaborative project to provide an enterprise modelling framework for the integration of methods and tools.

In order to define a complete methodology that takes into account all interoperability aspects, it is important to define interoperability concerns and problems. In [22] the interoperability concerns are defined according to the domains.

In [23] a small number of enterprises were interviewed to know about what they needed in order to be interoperable and more specifically, about the use of EM for supporting interoperability. In [24] a set of requirements to improve the use of models to support interoperability where identified and classified. Considering all these results and according to the interoperability concerns the conditions of a good interoperability framework can be classified by domains, as follows:

- **Interoperability issues in the Strategic Business Domain:** the business strategy of each participant in the interoperability context must be defined, and therefore some questions need to be answered. To achieve interoperability the framework must cover the user's needs by taking into account policies and business and technical aspects.
- **Interoperability issues in the Operational Business Domain:** all business processes have to be modelled. The framework must therefore be defined considering different levels of knowledge and experience, for example when different regions or countries, or different industrial sectors or enterprise sizes (small, medium, large) are involved, and it must provide security and confidentiality on the information shared. Partners involved in the interoperability project must trust and feel that their contributions to the framework will not be misused.
- **Interoperability issues in the ICT Domain:** it is necessary to take into account the development issues and the execution issues. The framework needs to be easy to maintain in order to include new procedures or new concepts when new market needs emerge or new partners participate in the interoperability framework. It also needs to evolve and consider advances in communication and information technologies to support the platform.

3 Methods for Interoperability

According to the Oxford dictionary, a methodology is a system of methods used in a particular field. In the context of Software Engineering, a methodology is a collection of procedures, techniques, tools, and documentation guides that help system developers in their efforts to implement a new information system [25].

Considering the EM domain, research on interoperability has taken place as an evolution from research in the integration field. In this area the main results on methods are the **Reference Architectures** (RA) that provide the development of master planning and implementation of an 'Integrated Enterprise System' [26]. Some remarkable Reference Architectures are CIM-OSA (Open System Architecture) [27], GIM (Grai Integrated Methodology) [28, 29], PERA (Purdue Enterprise Reference Architecture) [30], GERAM (Generalised Enterprise Reference Architecture and Methodology) [31] and ARDIN (Reference Architecture for INtegrated Development) [32].

The evolution from the use of EM to support enterprise integration to the use of EM to support interoperability has been the objective of various projects such as UEML [8] and ATHENA [12]. The results, **UEML** and **POP*** are languages to support enterprise model exchange, as well as and guidelines and methods to support their use. But UEML and POP* do not fully support an interoperability project.

Other more methodologically-oriented proposals have been developed to try to solve interoperability problems. One of these examples is the **Model Driven Interoperability Method (MDI Method)** [33]. This is a model-driven method that can be used for two enterprises that need to interoperate not only at the code level but also at the Enterprise Modelling level with an ontological support and the final aim of improving their performances. The solution proposed by this method is mainly model-driven oriented, so it would be useful in specific cases that request this kind of architecture, but not in more general situations.

Another example is proposed in [34], where a repository to collect and maintain methods to support interoperability projects is defined. The goal of the repository is to provide guidelines on how to define and organise methods and techniques. The repository would allow the research community to store and search for methods to support interoperability.

Finally, there are some specific methodologies to define an interoperability framework in a business domain, like the **HARMONISE Project** [35] which defines an interoperability framework for tourism; and **ISIM** [36] that aims at covering the general interoperability needs of a large number of industrial sectors.

All these languages and methods can support partial interoperability issues, or are designed for specific projects. Other results are focused on one of the interoperability domains, like the specific Ontologies, or are focused on the management of the methods. They do not provide a general and comprehensive proposal. In order to achieve an interoperability maturity level, enterprises need a full guide to support current and future projects. The proposal presented in this paper guides enterprises process by process, when it comes to implement a framework considering all the interoperability concerns and domains.

4 Methodological Proposal for an Interoperability Framework

Considering the previous analysis on what interoperability is and what its concerns are, a good methodology for the development of an interoperability framework must be defined taking into account: (1) the different components identified in the enterprise application (processes, data/information, communication and resources), (2) the three interoperability domains (Enterprise Modelling, Architectures & Platforms, and Ontologies), and (3) enterprise business levels (strategic, tactical and operative).

In this paper we introduce a methodological approach that will be the first step in the definition of a methodology for the development of an Interoperability Framework.

4.1 Bases of the Proposal

Taking into account all the interoperability concerns and their classification as described in Section 2 an Interoperability Framework should include:

- Procedures where the partners, current and future ones, can easily find what to do to interoperate considering the EM domain.
- Policies and regulations about the use of the data and the information shared.
- Ontologies where terminology can be clarified for all the stakeholders.
- Utilities to easily establish collaborations that do not mean extra or high investments.
- A repository of specific tools and methods that can easily support the interoperability project.
- Exchange utilities and tools to communicate IT structures and platforms.

The main goal of the proposal is to define a process guide that supports enterprises to develop this framework that will promote and sustain other enterprises to interoperate with them.

The proposal is structured in five processes. For each one a brief description, goals activities, and results are defined.

In order to implement the framework the idea is to develop a web portal where potential partners would query about the procedures to be applied, the methods and tools that can be used to establish the interoperability and the ontology to support the achievement of full interoperability.

4.2 Processes of the Methodology

The processes defined range from an initial process, where the conceptual aspects and strategic requirements are identified, through design and implementation, to, finally, the use and the maintenance process that covers the needs that any engineering project will generate.

Table 1 summarises each process, the activities and the expected results. The results, as well as the activities, are defined considering the three enterprise layers (business, knowledge and ICT) and the three domains of interoperability (EM, A&P, and ONTO).

Process 1: Definition of Conceptual Aspects. The first process is focused on the identification of the main goals that an enterprise sets up to achieve by developing a framework that eases establishing interoperability with other enterprises. The conceptual aspects are defined from the top-level point of view of the enterprise and strategic aspects and long term enterprise objectives are taken into account to define why an interoperability framework is a need for the enterprise.

The activities would include a viability analysis in order to evaluate the costs of the implementation of the framework and the benefits that this project will provide in the long terms.

The result will be the definition of the interoperability goals and the enterprise strategy for interoperability, specific vision and future needs, and the evaluation of costs and benefits.

Process 2: Identification and Classification of Current and Future Interoperability Situations. The identification of current and potential partners must be based on the goals defined in the previous process. New aspects can be added in the previous results, when specific partners are analysed.

For each of these sets of partners and situations, it is necessary to identify domains involved in the interoperability, areas and processes, policies and current tools used to support the own enterprise's processes and the detail level. Each potential interoperability situation will promote different problems to be solved. A first approach in order to define these problems and risks can be assumed from the classification of interoperability problems in [22]. The main results will be:

- A classification of current and potential partners.
- Identification of interoperability situations and assessment of their viability.
- The development of procedures to carry out for each of the situations.
- Reference Enterprise Models to represent the business processes that are involved in each of the interoperability situations.
- A first definition of ontological needs.

Process 3: Design of Procedures and Platform. This process will include the design of user procedures, business processes, data bases, and specific platforms for each of the situations identified in **Process 2**, taking into account the three domains and the three enterprise levels.

1. Definition of external user procedures: how an enterprise can use this framework in order to be an interoperability partner. Commercial and business agreements and other organisational aspects must be included. (EM)

2. Design of References Models and identification of the parts of these models that can be public to support interoperability with various potential enterprises. (EM)
3. Selection of the ontology tool and ontology design. (O)
4. Design of specific data bases including the shareable data. Design of suitable data exchange interfaces to support automatic data exchange. (A&P, O)
5. Selection of communication exchange areas and protocols. (A&P)

Process 4: Implementation of the Interoperability Framework. Taking into account the design results from the previous process, the platform to support the interoperability framework must be implemented. In this process technologies available must be evaluated and the viability study must be considered.

The framework will be implemented as a web portal with restricted access to partners, who must establish an agreement on the use of the platform contents and future interoperability concerns. The portal must fulfil the needs of information, procedures, tool repositories and an ontology platform.

As a final activity an experimental partner must test the platform in order to validate and verify its use before the final version.

Process 5: Use & Maintenance. The use of the platform will provide feedback in order to improve and to enlarge the interoperability situations and requirements. New conceptual aspects may appear, new ontological concepts must be added or reviewed and new techniques, tools and EMLs will be proposed to improve the framework.

5 Conclusions and Future Work

The methodological proposal developed in this paper will guide enterprises to create utilities and procedures that will support and encourage other enterprises to interoperate with them. The implementation of a portal where other potential business partners can find strategic, organisational and tactical guides to promote and ease new interoperability projects will increase the benefits and the successful results of all the enterprises involved. This framework will be a competitive advantage when new market opportunities arise.

The methodological proposal will support the interoperability projects taking in account all the domains and concerns established for the project: EM, A&P and ONTO.

Therefore engineers involved in the project must also consider specific processes and objectives of the enterprise. To this regard the project may pay more attention to on of the domains or enterprise layers. New activities may be added to customise the framework in accordance with particular objectives, requirements or businesses. Future work will be focused on the use of the proposal in order to implement the framework in a particular enterprise. This will allow us to test its applicability and to improve the proposal with new requirements and concerns.

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Table 1. Summary of the proposal

N.	Processes	Activities	Techniques	Outputs
1	Definition of Conceptual Aspects	Definition of scope and constraints	Information collecting techniques	Specific vision and future needs
		Definition of strategic goals concerning interoperability		Enterprise strategy for interoperability
		Identification of current and potential interoperability partners		Interoperability goals
		Viability analysis	Analysis of costs and benefits	Evaluation costs/benefits
2	Identification of Interoperability Situations	Identification of interoperability problems	Brainstorming	Interoperability situations and diagnostic about their viability
		Identification of Business Processes and areas involved in interoperability situations	EML	Interoperability scenarios
		Classification of interoperability situations	Ontology Engineering	Ontology specification
		Evaluation of needs		Classification of partners
		Design of Business Process models	EML	Reference Enterprise Models (BP)
3	Design of Procedures and Platform	Design of procedures and data bases for supporting documentation and information about partners	Software and Ontology Engineering	External user procedures definition
		Design of the web portal		Design and technical specifications of software
		Design of the ontology		Ontology and architecture components of the framework
		Design of data exchange procedures and interfaces		Data exchange interfaces design
		Evaluation and selection of the supporting technologies (A&P) for the development of the framework		
4	Implementation of the Interoperability Framework	Development and testing of the components	Software and Ontology Engineering	Web portal: ontology, data exchange procedures, repository of Reference Models
5	Use and Maintenance	Execution and control	Quality improvement techniques	IF tested, new requirements and releases