

BARRIERS DRIVEN METHODOLOGY FOR ENTERPRISE INTEROPERABILITY

David Chen and Nicolas Daclin

IMS-LAPS, University Bordeaux I

351 cours de la Libération, 33405 Talence cedex, FRANCE

david.chen@laps.ims-bordeaux.fr

In order to perform enterprise interoperability projects in an organised and efficient way, this paper presents a methodology which aims at helping establishing interoperability in enterprises in a step-by-step manner. A novel barrier-driven approach is adopted. An interoperability framework is elaborated to structure interoperability issues and concerns. An interoperability measurement approach is drafted to characterise the degree of interoperability achieved. A structured approach is defined showing the main phases to follow to use the interoperability framework and interoperability measurement methods.

1 INTRODUCTION

Developing enterprise interoperability in the industrial context is a complex project. Although some fragmented knowledge and solutions for interoperability have been accumulated since years, a complete interoperability methodology is still missing. Existing engineering methodologies such as for example GRAI methodology, CIMOSA, PERA, etc. were developed in the context of enterprise integration rather than interoperability. As part of INTEROP (2003) and ATHENA (2003) initiatives, our aim is to elaborate an enterprise interoperability methodology to help analysing, searching and implementing interoperability solutions in a structured way.

Interoperability is generally defined as the ability for two (or more) systems to exchange information and to use the information that has been exchanged (IEEE, 1990). In the context of enterprises, interoperability refers to the ability of interactions (exchange of information and services) between enterprise systems. Enterprise interoperability is considered as significant if the interactions can take place at least at the three levels: data, services and process, with a semantics defined in a given context (IDEAS, 2003).

Enterprises are not interoperable because there are barriers to interoperability between enterprise systems. Barriers are incompatibilities of various kinds at the various enterprise levels. There exist common barriers to all enterprises. Consequently the methodology we propose aims at a barrier-driven approach to identify the common barriers, measure the importance of the barriers using metrics and search solutions to remove barriers (Chen *et al.*, 2006).

The methodology presented in this paper consists of three main parts: (1) enterprise interoperability framework, (2) structured approach, (3) enterprise interoperability measurement. The paper is structured as follows. Section 2 presents the basic dimensions of the interoperability framework. It defines the domain of enterprise interoperability and structures interoperability concepts, problems and solutions. The framework allows linking interoperability barriers to possible

solutions for removing the barriers. Based on the framework, section 3 discusses the measurement of degree of interoperability. Three kinds of measures are outlined, namely interoperability potential, compatibility and performance measures. Section 4 defines a structured approach with the main steps to follow and the actors involved in an interoperability project. In section 5 a simplified example will be presented to illustrate the use of the methodology. Future works and conclusions will be given in section 6.

2 ENTERPRISE INTEROPERABILITY FRAMEWORK

The term 'framework' refers to an organising mechanism to structure concepts or 'things' in a certain ways. Recently several initiatives on interoperability have proposed interoperability frameworks to structure issues and concerns in quite different ways. The European Interoperability Framework in the eGovernment domain (EIF, 2004) defines three types of interoperability: semantic, technical and organisational. A similar approach was also proposed in e-Health interoperability framework (NEHTA, 2006) which identified three layers: organizational, informational and technical interpretabilities. In manufacturing area the IDEAS interoperability framework (IDEAS, 2003) defines three main layers (Business, Knowledge and ICT) with two additional vertical dimensions (Semantics and Quality attributes). More recently the ATHENA Interoperability Framework (AIF) proposes to structure interoperability issues and solutions at the three levels: conceptual, technical and applicative (ATHENA, 2003).

Our goal is to tackle interoperability problems through the identification of barriers which prevent interoperability to happen. The Interoperability Framework we proposed (Chen *et al.*, 2006) (INTEROP, 2006) is barrier-driven and has taken into account the basic concepts addressed in the existing frameworks. In particular in the European Interoperability Framework, interoperability is studied from three aspects: Semantic, Technical, and Organisational. In our proposal, these three aspects are considered as problems (barriers) to be tackled rather than interoperability to be established. Consequently three categories of barriers are defined: conceptual barriers (syntax/semantic incompatibilities), technological barriers (additional incompatibility due to the use of computer), and organisational barriers (related to the incompatibilities of method of work, organisation structure,..). In summary the three main framework dimensions we identified are:

- *Interoperability concerns* which defines the content of interoperation that may take place at various levels of the enterprise (data, service, process, business).
- *Interoperability barriers* which identifies various obstacles to interoperability in three categories (conceptual, technological, and organisational)
- *Interoperability approaches* which represents the different ways in which barriers can be removed (integrated, unified, and federated)

Figure 1 shows the interoperability in its simplified form with only two dimensions.

lop barriers lop concerns	CONCEPTUAL	TECHNOLOGICAL	ORGANISATIONAL
BUSINESS			
PROCESS			
SERVICE			
DATA			

Figure 1. Interoperability Framework (here only the first two dimensions)

The focus of the interoperability framework is structuring barriers to interoperability and solutions for removing the barriers. This is important for retrieval and reuses the existing knowledge. For example, PSL (Process Specification Language) allows removing the conceptual barrier (syntactic and semantic barriers) for process interoperability using unified approach. This interoperability framework is partially implemented in Metis modelling tool¹ using the Metis Enterprise Architecture Framework (MEAF). It aims at supporting the search and analysis of available solutions. More details on the framework and the additional dimensions associated to the framework can be found in (INTEROP, 2006).

3 ENTERPRISE INTEROPERABILITY MEASURE

The fact that interoperability can be improved means that there exists metrics for measuring the degree of interoperability. Measuring interoperability allows a company knowing its strengths and weaknesses to interoperate with a third company and to prioritize actions to improve their collaboration ability. To day few methods are developed for measuring interoperability. Existing approaches mainly focus on maturity measure (C4ISR, 1998) (Kasunic, 2004). Maturity can be seen as a kind of interoperability potential. The term maturity model was popularized by the SEI (Software Engineering Institute) when they developed the Capability Maturity Model (CMM) in 1986. Five maturity levels have been proposed (CMM, 2004), namely initial, repeatable, defined, managed and optimizing. Several other models have been developed in different disciplines and focusing on different levels of the enterprise, for example: the Service-Oriented Architecture Maturity Model (Bachman, 2005), the Extended Enterprise Architecture Maturity Model (IFEAD, 2004), the NASCIO (2003) Enterprise Architecture Maturity Model and the Organisational Interoperability Maturity Model (Clark *et al.*, 1999). These models aimed at evaluating processes within organizations and identifying best practices useful in helping them increase the maturity of their processes.

More focused on interoperability issues, the LISI (Levels of Information Systems Interoperability) proposed a maturity model for measuring interoperability in five levels of maturity: isolated, connected, functional, domain, enterprise (C4ISR, 1998). Some similar approaches have been developed based on LISI, for example

¹ Troux Technologies, "Metis". <http://www.troux.com/products/metis/> (accessed: 2006).

the TENA model identifies six levels (isolated, co-habitable, syntax, semantic, seamless, and adaptive). These maturity models for interoperability were mainly developed for the arm systems of the US department of defence.

Based on these existing maturity models, ATHENA project has elaborated for the manufacturing enterprise the EIMM (Enterprise Interoperability Maturity Model) to address interoperability issues at all levels of the company (ATHENA, 2005). Defining the EIMM involves two tasks: (i) identifying the main areas of concern on which an enterprise need to work in order to achieve interoperability both internally and externally, (ii) defining the maturity levels that describe the improvement path for each area of concern.

In our methodology three types of interoperability measurement are considered: (i) potential measurement, (ii) compatibility measurement, and (iii) performance measurement. This allows going far beyond existing approaches which only consider maturity evaluation.

The interoperability potential measurement is concerned with the identification of a set of characteristics (maturity) that have impact on the interoperability. These measures are performed on one enterprise/system without the necessity to know its interoperation partner. The objective is to evaluate the potentiality of a system to adapt and to accommodate dynamically to overcome possible barriers when interacting with a third partner. For example, an open system has a higher potential of interoperability than a closed system. Our methodology will make use of EIMM to measure interoperability potential of a company.

The interoperability compatibility measurement has to be performed during the engineering stage i.e. when systems need to be re-engineered in order to establish interoperability with a known partner. This measure is performed when the partner/system of the interoperation is known. The measure is done with respect to the identified barriers to interoperability. The highest degree of compatibility means that all the barriers to interoperability are removed. The inverse situation means the poorest degree of interoperability. For measuring the interoperability compatibility, we have developed EIDM (Enterprise Interoperability Degree Measurement) (Daclin *et al.*, 2006) (ATHENA, 2007) based on the interoperability framework.

The performance measurement has to be performed during the operational phase i.e. run time, to evaluate the ability of interoperation between two cooperating enterprises. Criteria such as cost, delay and quality can be used to measure the performance with respect to barriers and concerns during a basic interoperation cycle. Therefore, each type of measurement has to be valued with local coefficients in order to get a global coefficient ranging from “poor interoperability” to “good interoperability”. The performance measurement is part of EIDM developed within the frame of ATHENA A8 project. Details about both EIMM and EIDM approaches can be found in (ATHENA, 2007).

4 STRUCTURED APPROACH

The structured approach aims at defining the main phases to follow in a sequential way with possible iterations between the phases. Depending on whether the methodology is being applied to an individual company or a pair collaboration partners each phase will involve the use of the EIMM or the EIDM. Four main phases and activities are identified:

(i) Definition of objectives and needs: It aims at defining the interoperability performance targeted, evaluating the feasibility and cost as well as project planning.

- Define needs of interoperability for each area of concern defined in the EIMM.
- Define needs of interoperability in terms of enterprise level and approach (integrated, unified, and federated) as defined in the EIDM.

(ii) Analysis of existing system: The main goal of this phase is to identify actors, applications and systems involved, and interoperability problems encountered.

- Analyze the as-is situation, define the to-be situation and the gaps between them.
- Identify barriers to interoperability, measure existing interoperability using EIDM (compatibility measurement), analyze strong and weak points.

(iii) Select and combine solutions: It consists in searching and selecting available interoperability solution elements through the interoperability framework.

- Provide recommendation in the form of a conceptual solution (i.e.: standards to be adopted, which solutions to use and where to apply them, etc.).
- Combine and construct a company specific a technical solution taking into account the objective and constraints of the company

(iv) Implementation and test: In this phase, solutions to remove the barriers will be tested and evaluated.

- Implement the technical solutions elaborated.
- Carry out performance measures and compare to the targeted interoperability degree and performance.

The most crucial activity is to identify the barriers to achieve the interoperability degree targeted by the companies. Identifying barriers is only concerned with those 'things' that need to be shared and exchanged between two systems/companies. Interoperability requires a common basis for those elements.

After having identified barriers, solutions need to be searched to remove the barriers. Consequently one needs to map the barriers onto the knowledge/solution repository which is structured according to the framework. Queries can be expressed in terms of barrier types. Solutions found may need to be adapted or combined.

Once the solution(s) implemented, a new measurement needs to be done to verify if barriers are removed effectively using the proposed solution(s). In some cases the interoperability is improved but there still exist some incompatibilities. A new iteration is required to adapt the solution or use other solutions till all barriers are completely removed. Performance measures may also be required at the test phase

The methodology is participative and four groups of actors are defined based on the GRAI methodology:

- Project board: the top-level management members of the company. They give the objectives of the project.
- Synthesis group: the main responsible people of the company. They ensure the follow-up of the project and check the results at various stages.
- Specialist group: experts in interoperability and methodology. They give advice to the synthesis group, build various models and perform analysis.
- Interviewees group: company people to be interviewed by specialists. They provide information needed by the other groups.

It is necessary to plan the meetings and tasks to perform. Usually, several iterations are needed to get a validated analysis and models representing the as-is situation of the company.

5 APPLYING METHODOLOGY

The methodology is partially applied in the frame of the ATHENA A8 project (SME Interoperability in Practice). The case was provided by SAP based on a Carrier-Shipper Scenario (ATHENA, 2007). The study focuses on the application of EIDM to the scenario, where an SME shipper uses the services of multiple larger carriers. It aims at showing how we uncover interoperability barriers, classify interoperability barriers in a coherent framework, classify interoperability solutions in the same framework and use the framework to select the right solutions to each barrier.

The application started by modelling the scenario of interoperation. In the scenario, a set of needs and objectives for new solutions have been defined from the point of view of an SME shipper. For examples, (Semi-) automatic integration of Carrier Services, data and process mapping, user interface, predefined and easy configurable adapters, and configuration etc. The targeted interoperation the all four enterprise levels (business, process, service, and data). Federated and unified approaches are preferred to full integration to keep autonomy/flexibility at the two sides.

During the analysis phase, EIDM was used to identify the barriers between the two companies. Figure 2 shows the process depicted in the scenario and summarises the main barriers that were identified and dealt in the project.

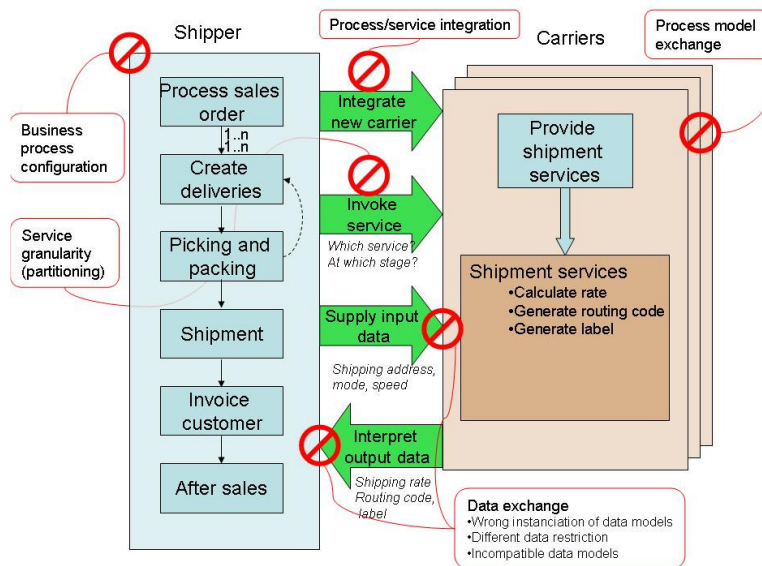


Figure 2. Scenario mapped with interoperability barriers

The barriers identified and presented in figure 2 are mapped to the interoperability framework. For each barrier, a template was used to describe in detail the levels of enterprise concerned, the interoperability problem encountered, the ATHENA solutions identified and possible adaptations necessary to implement the solutions. Table 1 shows an example of data exchange barrier described using the template.

Template elements	Description
Enterprise levels concerned	Data, Service
Barriers to interoperability	Conceptual barrier - Incompatible syntactic and semantic representation of data at each interacting partner
Interoperability problem	Different models adopted by the companies makes data exchange difficult as enterprises cannot exchange their data automatically
ATHENA solutions identified	- Conceptual solutions: Annotation of proprietary models according to common ontology to allow data reconciliation - Technical solutions: A3 tools, WSDL Analyzer
ATHENA results evaluation – Relevance to SMEs	- Adoption of the common generic ontology reflecting the business domain - The WSDL Analyzer detects mismatches between data a service expects and provides - Relevant for SME which receive required interfaces of big companies which expect that their smaller business partners adapt to their interfaces
Planned Adaptations	Possibility to manipulate the generated mappings between heterogeneous interfaces.
Remarks	There exist other solutions for data mapping. However, none of them is directly concerned with Web service interface compatibility

Table 1. Incompatible syntactic and semantic representation of data

During the phase of search of solutions, some ATHENA solutions were selected according to their ability to remove the identified barriers. Each solution is described at the two levels of abstraction: (i) conceptual solution independent of a technology, (ii) technology solution. In the implementation and test phase, a new interoperability measurement needs to be performed to evaluate the gap between the targeted interoperability degree and achieved one.

This case study allows validating the efficiency of the methodology to establish interoperability by identifying the barriers (incompatibilities) between the elements that must be exchanged and shared. More detail on this study can be found in (ATHENA, 2007).

6 CONCLUSIONS

To avoid hazardous demarche in an interoperability project, it is necessary to use a methodology with a structured approach. This paper presented an interoperability methodology which will enhance the interoperability research and development. There are different ways and strategies to deal with interoperability using methodology; our approach is barrier-driven and bottom-up. The strength is its three interrelated components: interoperability framework; interoperability measurement

and structured approach. The proposed methodology is particular adapted to SMEs. Typically barrier-driven approach aims at tackle interoperability problems by identifying directly the causes of non-interoperability. This contrasts some top-down or holistic approaches which needs more time and investment to accomplish.

The main advantages of using this methodology are to allow on the one hand, an efficient classification and retrieval of interoperability solutions according to the barriers, promoting reuse of existing solutions; and on the other hand characterising the degree of interoperability from three different aspects and letting a company knowing its strength and weakness.

The proposed methodology applies to both intra and inter enterprise organisation, including extended enterprise, virtual enterprise as well as collaborative and networked enterprises.

Future works are concerned with further identifying and structuring interoperability barriers and solutions in the framework, to implement the framework in a tool to support industry use, and to refine metrics for interoperability measurement. Another work being performed is to define a formal model for describing the proposed concepts as ontology.

ACKNOWLEDGEMENT

The author thanks and acknowledges the members of ATHENA A8 project and INTEROP DI (Domain Interoperability) participants for their contributions to the methodology, case study and interoperability framework.

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