Framework for Enterprise Interoperability

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Abstract – **This paper aims at contributing to establish a science base for enterprise interoperability. To day the domain of enterprise interoperability is not precisely defined and the concept of interoperability itself is still confusing and interpreted from many different points of view. This paper presents a framework for enterprise interoperability which is developed within the frame of INTEROP NoE. The purpose of the framework is to identify the basic dimensions regarding to enterprise interoperability and to define its domain of research. The paper will also clarify some confusing concepts around the notion of interoperability. Complementary dimensions to this framework are also presented and the use of this framework to capture and structure enterprise interoperability knowledge is discussed. Future work and conclusion will be given at the end of the paper.**

Keywords - **Interoperability, framework, standard, enterprise modeling, science base for interoperability.**

1 INTRODUCTION

To day, develop enterprise interoperability is no more a necessity to demonstrate. The ability for an enterprise to interoperate with others is not only a quality and advantage for gaining competitiveness in the market but also becoming a question of survival for many companies, especially for SMEs. Indeed, to reduce the cost, shorten the delay and propose continuously new products on the market, enterprises call for more interoperations during the entire product lifecycle, and in a networked organisational environment [INTEROP, 2007].

Two main European initiatives relating to interoperability development have been carried out: ATHENA Integrated Project (IP) and INTEROP Network of Excellence (NoE). ATHENA (Advanced Technologies for Interoperability of Heterogeneous Enterprise Networks and their Applications) consists of a set of projects and leads to prototypes, technical specifications, guidelines and best practices for interoperability [ATHENA, 2003]. INTEROP (Interoperability Research for Networked Enterprises Applications and Software) aims at integrating expertise in relevant domains for sustainable structuration of European Research on Interoperability of Enterprise applications [INTEROP, 2003].

However, interoperability still means many things to many people and is often interpreted in many different ways with different expectations. Definitions on interoperability abound, but definitions do not allow a clear understanding [Chen et al., 2003; 2004]. This situation is not only true in industry but also in research communities and sometimes even within a working group. Without a clear and shared understanding on the precise meaning of interoperability, research and development efforts cannot be efficiently carried out and coordinated. Consequently, the purpose of this paper[1] is on the one hand to clarify the enterprise interoperability concept, and on the other

hand to define the enterprise interoperability domain allowing to capture and structure the knowledge of the domain [INTEROP, 2007].

There are many definitions about interoperability. For the purpose of our research, the three following definitions have been considered.
- Ability for two (or more) systems or components to exchange information and to use the information that has been exchanged [IEEE, 1990]
- Ability for a system to communicate with another system and to use the functionality of the other system [Vernadat, 1996]
- Ability of interaction between enterprises. The enterprise interoperability is achieved if the interaction can, at least, take place at the three levels: data, application and business process [IDEAS, 2003].

The IEEE definition is the most referenced one but it is restricted to information interoperability. The definition of Vernadat introduced the concept of exchange of functionality i.e. service, thus it complements to IEEE one. The definition given by IDEAS better reflects Enterprise interoperability and is complementary to the two previous ones.

In summary Enterprise interoperability is the ability to (1) communicate and exchange information; (2) use the information exchanged; (3) access to functionality of a third system.

The hypothesis of the research we made is:
- Enterprise systems are not interoperable because of barriers to interoperability
- Barriers are incompatibilities of various kinds at the various enterprise levels
- There exist common barriers to interoperability and generic solutions to remove barriers

Consequently our research adopted a barrier driven approach and is problem solving oriented.

Considering interoperability as a generic concept is the basis of our research; common problems of non-interoperability and

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[1] This paper is based on the work performed in INTEROP NoE, DI: Domain *of* Interoperability.

solutions to overcome them can be identified and developed for any enterprise. This led to defining enterprise interoperability research as an engineering discipline by separating it from business related research. In other words, interoperability is seen as a support to allow business collaboration happen but not business collaboration itself.

The research work presented in this paper was inspired from or influenced by the following approaches: LISI (Levels of Information Systems Interoperability) [C4ISR, 1998], IDEAS interoperability framework [IDEAS, 2003], European Interoperability Framework [EIF, 2004], ATHENA Interoperability Framework [ATHENA, 2003].

2 ENTERPRISE INTEROPERABILITY CONCEPTS

There are many concepts relating to interoperability. This section presents the basic concepts for the purpose to define the enterprise interoperability Framework and Domain. These concepts are identified based on the state-of-the-art on interoperability researches.

2.1 Interoperability barriers

Interoperability barrier is a fundamental concept in defining the interoperability domain. Many interoperability issues are specific to particular application domains. These can be things like support for particular attributes, or particular access control regimes. Nevertheless, general barriers and problems of interoperability can be identified; and most of them being already addressed [Kasunic *et al*, 2004], [EIF, 2004] [ERISA, 2004]. Consequently the objective is to identify and categorise common barriers to interoperability. By the term 'barrier' we mean an 'incompatibility' or 'mismatch' which obstructs the sharing and exchanging of information. Three categories of barriers are identified: *conceptual*, *technological* and *organisational*.

2.1.1 Conceptual barriers

The conceptual barriers are concerned with the syntactic and semantic incompatibilities of information to be exchanged. These problems concern the modelling at the high level of abstraction (such as for example the enterprise models of a company) as well as the level of the programming (for example low capacity of semantic representation of XML).

- Syntactic incompatibility can be found whenever different people or systems use different structures to represent information and knowledge. For example the UEML initiative [UEML, 2002] aims at providing a neutral model to allow mapping between different enterprise models built using different syntaxes.
- Semantic incompatibility is considered as an important barrier to interoperability as the information and knowledge represented in most of models or software have no clearly defined semantics to allow unambiguous understanding of the meaning of information. At current stage, the most known technique to solve this problem is the semantic annotation and reconciliation using ontology.

Conceptual barriers are the main barriers to interoperability.

2.1.2 Technological barriers

The technological barriers are concerned with the use of computer or ICT (Information and Communication Technology) to communicate and exchange information. Typical technological barriers are for example incompatibility of IT architecture & platforms, infrastructure, operating system etc. In other words technological barriers exist because of the lack of a set of compatible standards to allow using heterogeneous computing techniques for sharing and exchanging information between two or more systems[2]. From a pure technical perspective these problems concern the standards to present, store, exchange, process and communicate data and information through the use of software systems. Examples of technological barriers are:

- Communication barriers, e.g. incompatibility of the protocols used to exchange information.
- Content barriers, e.g. different techniques and methods used to represent information, or incompatibility in the tools used to encode/decode the information being exchanged.
- Infrastructure barriers e.g. use of different incompatible middleware platforms.

Moreover even standards exist in some of these areas; there still exist such barriers because of the fact that different standards and different versions of the same standards are being used. Quite often different versions of a standard are incompatible. Furthermore, IT technologies support different versions of a standard, address different portions of the standard, interpret the standard differently, and even extend the standard in a proprietary way to address shortcomings.

Technological barriers are additional barriers with respect to conceptual ones. Technological barriers are concerned only if when computers are used in an interoperation.

2.1.3 Organisational barriers

The organisational barriers are concerned with the incompatibilities of organisation structure and management techniques implemented in two enterprises. For example the organisation structure barrier is related to the way of assigning responsibility and authority. These can be seen as 'human technologies' or 'human factors' and are concerned with human and organisation behaviours which can create obstacles to interoperability. Indeed if two companies have different organisation structures (ex. hierarchical vs. networked) and management techniques, some necessary mappings may need to be done before the two sides become interoperable at an operational level.

- Responsibility needs to be defined to allow two parties knowing who is responsible for what (process, data, software, computer,…). If responsibility in an enterprise is not clearly and explicitly defined, interoperation between two systems is obstructed.
- Authority is an organisational concept which defines who is authorised to do what. For example, it is necessary to define who is authorised to create, modify, maintain data, processes, services, etc.
- Organisation structure refers to the style by which responsibility, authority and decision making are organised. For example we can talk about centralised vs. decentralised organisations, or hierarchical vs. matrix or networked organisation structures.

Organisational barriers are additional barriers. Compared with conceptual barriers (centred on information problems) and technological barriers (concerned with machine problems), organisational barriers originate from the problems of humans.

2.2 Interoperability concerns

This section defines the interoperations that can take place

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[2] The term system is here used in a general manner and can mean enterprise, human-being or computer system.

from the various concerns (or viewpoints) of the enterprise. Although the definitions are mainly given from a point of view of IT based applications, they apply to non-computerised systems as well. This categorisation is based on the ATHENA Technical framework [Guglielmina et al., 2005].

The interoperability of communication is a basic condition to allow interoperability happen. It relates primarily to the interconnection of systems and equipments as well as communication means. From an IT point of view, it is concerned with communication protocols (i.e. from cable connection to the protocol of layers 1 to 4 of the OSI model), and of interfaces (layers 5 to 7 of OSI model). Interoperability of communications is considered already achieved and is not subject of discussion in this paper.
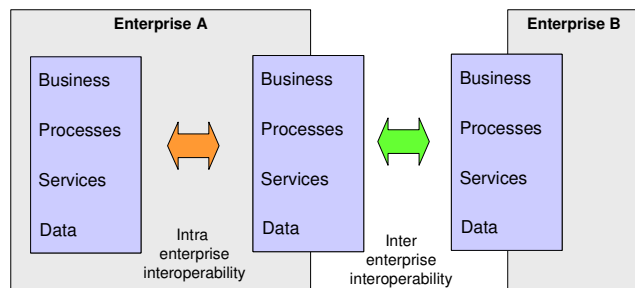

Figure 1. Adapted from ATHENA (2005)

In the domain of Enterprise Interoperability, the following four interoperability concerns are identified as shown Figure 1: Data, Service, Process, and Business. In the enterprise, data is used by services (or functions to provide a service). Services (functions/activities) are employed by processes to realise business of the enterprise. From another point of view, the goal of an enterprise is to run its business. To realise the business, one needs processes. Processes employ services/functions which in turn need data to perform activities.

2.2.1 Interoperability of data

The interoperability of data: It refers to operate together different data models (hierarchical, relational, etc.) and the use of the different query languages. Moreover, their contents are organized according to conceptual schemas (i.e. vocabularies and sets of structures of data) which are related to particular applications. The interoperability of data is concerned with finding and sharing information coming from heterogeneous data bases, and which can moreover reside on different machines with different operating systems and data bases management systems.

Data interoperability plays an essential role in enterprise interoperability. It is concerned with the ability to exchange both non-electronic data (documents) and machine transportable data (data files, data stored in a database) and use the data/information exchanged. Data interoperation may occur when two partners simply exchange two data files (example Excel files); or in the case of process interoperability or service interoperability. Typical barriers prevent data interoperability are for example conceptual ones such as different semantics and syntax to represent information, but also technological one (different database technologies and coding techniques) and organisational ones (database management, security policy,…).

2.2.2 Interoperability of service

The Interoperability of services: It is concerned with identifying, composing and operating together various applications (designed and implemented independently) by solving the syntactic and semantic differences as well as finding the connections to the various heterogeneous data bases. The term `service' is not limited to the computer based applications; but also functions of the company or of the networked enterprises.

Service interoperability deals with the capability of exchanging services (works) among partners. Service interoperability has two main problems: service exchange between a service demander and a service provider; interconnection between different services to form a complex service (the last case is related to process interoperability as well). A service is performed by a resource (computer type, machining type, human type) to provide an operation. Issues relating to service interoperability are concerned with the description (both from the syntax and semantic aspects) of the services required and provided, the mechanisms to search and discover a distributed service provider, the ICT supports for service discovery, composition, and the organisational issues relating the management of service exchange, etc.

2.2.3 Interoperability of process

The interoperability of processes: it aims to make various processes work together: a process defines in which order services (functions) are provided according to the need of a company. Generally in a company, several processes run in interactions (in series or parallel). In the case of the networked enterprise, it is also necessary to study how to connect internal processes of two companies to create a common process.

More precisely process interoperability is meant by linking different process descriptions (be they documents, or supported by software) to form collaborative processes and perform verification, simulation and execution. Usually different process description languages are used to define different process models for different purposes. Typically barriers prevent process interoperability are different semantics and syntax used in different process modelling languages; incompatible process execution engines and platforms, different process organisation mechanisms, configurations and managements. Developing process interoperability means to find solutions to allow mapping, connecting, merging, translations of heterogeneous process models and applications. It IS to note that for interoperability reasons, these solutions are concerned with the connection points of the processes not with the processes as a whole. The latter would lead to process integration.

2.2.4 Interoperability of business

The interoperability of business: It refers to work in a harmonised way at the levels of organization and company in spite of for example, the different modes of decision-making, methods of work, legislations, culture of the company and commercial approaches etc. so that business can be developed and shared between companies.

In other words business interoperability is concerned with how business are understood and shared without ambiguity among interoperation partners. Business interoperability explores interoperability from a business perspective and identifies the fundamental artefacts related to business issues. These issues range from the business vision and culture to the ICT infrastructure support as well as the compatibility between different organisation structures, methods of work, accounting systems and rules, labour legislations etc. Developing business interoperability means find way to make those issues be

harmonised or at least understood through necessary mappings and negotiations. It is worth noting that for interoperability reasons, these solutions are concerned with the connection points of the business not with the business as a whole. The latter would lead to business integration.

2.3 Interoperability approaches

Defining research in the interoperability domain is not only a matter of identifying barriers and solutions for removing barriers but also studying the way in which these barriers are removed. Establishing interoperability requires relating entities together in some way. According to ISO 14258 (Concepts and rules for enterprise models) [ISO 14258, 1999], there are three basic ways to relate entities together: integrated, unified, and federated as illustrated in Figure 2.
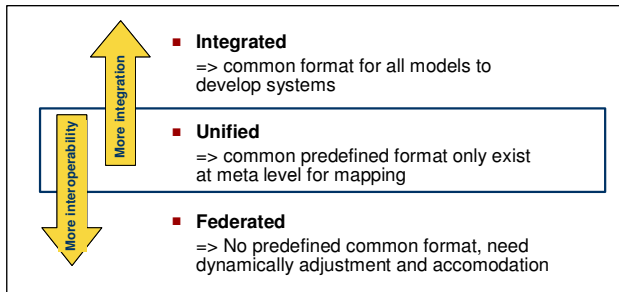
Figure 2. Basic approaches to develop interoperability

2.3.1 Integrated approach

Developing interoperability through an *Integrated Approach* means that there exists a common format for all models. Diverse models are built and interpreted using/against the common template. This format must be as detailed as the models themselves. The common format is not necessarily an international standard but must be agreed by all parties to elaborate models and build systems. Example of developing interoperability using an integrated approach is ebXML.

The integrated approach is more oriented to full integration rather than full interoperability. This approach is suitable when designing and implementing new systems rather than reengineering existing systems for interoperability. To some extend, the reengineering approach is more adapted to developing intra enterprise interoperability rather than inter enterprise one.

Standardisation at system level (not at meta level) is a key issue to develop interoperability through integrated approach. However, in some areas such as for example enterprise modelling, mature standards are still missing. The newly released standard EN/ISO 19440 (Constructs for enterprise modelling) [ISO 19440, 2004] which is at its origin defined for an integrated approach has not gained general acceptance for use to build enterprise model, instead it is considered as a reference at meta-modelling level for mapping different models one to another.

The integrated approach ensures the global consistency and coherence of the system. Various components of the system are designed and implemented using a common format (or standard) so that interoperability is seen as designed-in quality (of the system's components). Interoperation between various parts can be obtained 'a priori' without any interfacing effort.

2.3.2 Unified approach

Interoperability can also be established using a *Unified Approach*. It means there is a common format but it only exists at meta-level. This format is not an executable entity as it is the case in integrated approach. Instead it provides a mean for semantic equivalence to allow mapping between models and applications. Using the metamodel a translation between the constituent models is possible even though they might encounter loss of some semantics or information.

Most of research results developed in the domain of interoperability adopted the unified approach. For example UEML (Unified Enterprise Modelling Language) aims at defining a neutral format at meta-modelling level to allow mapping between enterprise models and tools. The STEP initiative elaborated in ISO TC184 SC4 also defined a neutral product data format at meta-modelling level to allow various product data models exchanging product information.

The unified approach is particularly suitable for developing interoperability for collaborative or networked enterprises. To be interoperable with networked partners, a new company just needs to map its own model / system to the neutral meta-format without the necessity to make changes on its own model / system. This approach presents the advantage to the integrated approach because of reduced efforts, time and cost in implementation. It is also adapted to the situation where a large company needs to interoperate with SMEs. Normally a SME works with more than one big company; to interoperate with different companies, the unified approach seems to be a suitable solution.

2.3.3 Federated approach

In the case of using a *Federated approach*, there is no common format at all. To establish interoperability, parties must accommodate and adjust 'on the fly'. Using the federated approach implies that no partner imposes their models, languages and methods of work. This means that they must share an ontology.

The federated approach can also make use of meta-models for mapping between diverse models/ systems. The difference to unified approach is that this meta-model is not a pre-defined one but established 'dynamically' through negotiation. Consequently this approach is more suitable to 'Peer-to-Peer' situations rather than the cases mentioned in the unified approach. It is particularly adapted to Virtual Enterprises where diverse companies joint their resources and knowledge to manufacture a product with a limited duration.

Using the federated approach to develop enterprise interoperability is most challenging and little activity has been performed in this direction. A main research area is the development of a 'mapping factory" which can generate on demand customised AAA (Anybody-Anywhere-Anytime) mapping agents among existing systems. It is worth noting that a specific support for the federated approach is seen in entity profiles, which identify particular entity characteristics and properties relevant for interoperation (ISO 15745 and ISO 16100).

All the three approaches allow developing interoperability between enterprises systems. The federated one is considered as the most interesting approach to develop full interoperability. However, the choice depends on the context and requirements. If the need of interoperability comes from a merger of enterprises, the integrated approach seems to be the most adapted one. In this case there is only one common format for all partners, and all models are built and interpreted according this one. If the need of interoperability concerns a long term based collaboration, the unified approach seems a possible solution. For that, a common meta-model across partners' models provides a means for establishing semantic equivalence allowing mapping between diverse models.

Finally, for a need of interoperability originated from the short-term collaboration project (e.g. virtual enterprise); the federated approach can be used. To interoperate partners must dynamically adapt to achieve an agreement.

Figure 3 summarises enterprise interoperability concepts with the aim to define a ontology of enterprise interoperability (adapted from [Naudet, 2007]).
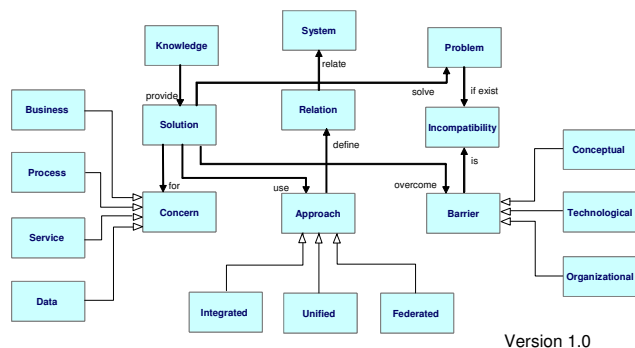

Figure 3. Towards a Ontology of Enterprise Interoperability

3 FRAMEWORK FOR ENTERPRISE INTEROPERABILITY

The term 'framework' refers to an organising mechanism for structuring and categorising 'things' relative to a domain. A framework does not provide an operational solution to solve a business problem. The interoperability framework presented in this report aims at structuring the concepts of enterprise interoperability research domain. The framework has three basic dimensions: interoperability concerns, interoperability barriers and interoperability approaches.

3.1 Problem space vs. solution spaces

The first two dimensions: Interoperability concerns and Interoperability barriers constitute the problem space of enterprise interoperability (see figure 4). The intersection of an interoperability barrier and an interoperability concern is the set of interoperability problems having the same barrier and concern. The three dimensions together constitute the solution space of enterprise interoperability. The intersection of an interoperability barrier, an interoperability concern and an interoperability approach is the set of solutions to breakdown a same interoperability barrier for a same concern and using a same approach.
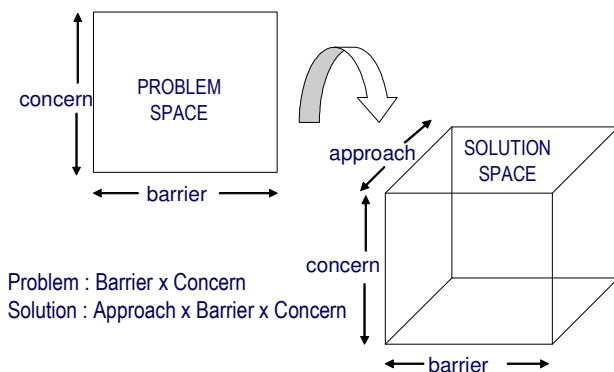

Figure 4. Problem vs. Solution spaces

The necessity to elaborate such a framework has been discussed in INTEROP WP1 D1.1 deliverable [INTEROP, 2004]. Existing interoperability frameworks (for example, IDEAS Interoperability framework [IDEAS, 2003], ATHENA interoperability framework [ATHENA, 2003], European Interoperability Framework [EIF, 2004] etc. do not explicitly address barriers to interoperability, which is a basic assumption of this research; they are not aimed at structuring interoperability knowledge with respect to their ability to remove various barriers.

3.2 The two basic dimensions

Based on the concepts, and categorisations presented in part 2, the two basic dimensions of the enterprise interoperability framework are shown Figure 5: (i) interoperability concerns, (ii) interoperability barriers.

Some examples of interoperability barriers and problems are also shown in the figure. For example, the intersection of conceptual barriers and process concern, one of the interoperability problems encountered is the impossibility of exchanging process model information between IDEF3 and BPMN models because of the syntax incompatibility of the two models.

Figure 5. Enterprise Interoperability Framework (two basic dimensions)

Adopting the barriers-driven approach to tackle interoperability problems implies that research is bottom-up to find knowledge and solutions to remove barriers. Although the three categories of barriers concern all the four levels, conceptual and organisational barriers are more important at the higher levels while technological (barriers due to the use of ICT) ones have more impact on the lower levels.
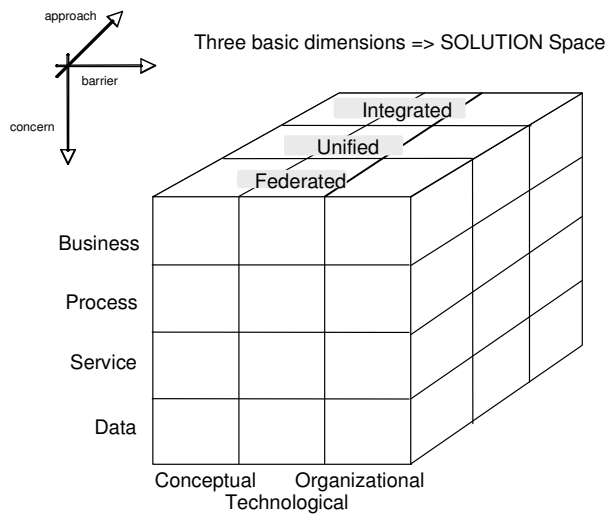
3.3 The third dimension

The third basic dimension (Interoperability approaches) added to the two dimensional framework allows categorising knowledge/ solutions of enterprise interoperability according to the ways of removing the barriers. As discussed in part 2, this dimension considers the three basic approaches to develop interoperability: integrated, unified and federated.

The Enterprise Interoperability Framework with its three basic dimensions is shown Figure 6. We recall the three basic dimensions as follows:

- *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 6. Enterprise interoperability framework

The third dimension allows to capture and structure interoperability knowledge and solution according to their ability to remove interoperability barriers. For example, PSL (Process Specification Language) [Schelenoff et al., 2000] contributes to remove *conceptual* barrier (both syntax and semantics) concerning *process* through a *unified* approach. Figure7 shows the position of PSL solution in the framework.
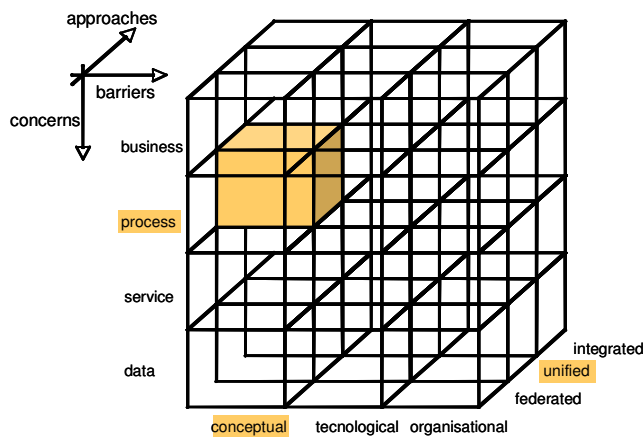
Figure7. Position of PSL in the framework

To help capturing the knowledge/solution and mapping onto the framework, a template was proposed. Figure 8 shows a simplified example of the template to describe PSL solution.

Interoperability knowledge/solution template	
Name of the knowledge/solution: PSL	
1. Interoperability concern	Process level
2. Interoperability barrier	Conceptual (Syntax and sematics)
3. Interoperability approach	Unified approach
4. Interoperability problem	different process models use different process langues and are not interoperable
5. Interoperability knowledge	Define a neutral Process Specification Language (PSL) and related ontology as a metamodel to allow mapping between different process models
6. Example (optional)	
7. Remarks	Initially proposed by NIST, now moved to standardisation at ISO level
8. References	ISO CD 18629 (2001), Industrial automation systems and integration, Process Specification Language (PSL), JW8/ISO 184/SC4/SC5

**Figure 8. Template example to collect PSL solution**

3.4 Complementary Dimensions

The third dimension (Interoperability Approaches) discussed above can be replaced by other complementary dimensions according to the objective related to a particular usage of the framework. In other words the third dimension can be considered as an open dimension i.e. it can be replaced by a user defined one. At the current stage of research, the three following ones are identified.

3.4.1 Interoperability engineering dimension

This dimension aims at defining a set of phases (steps) to follow for establishing interoperability between two enterprises (or any two business entities). The system life cycle phases defined in ISO 15704 Standard [ISO 15704, 2001] has been adapted and the three main phases have been defined as follow: (1) Requirements definition, (2) Design specification, (3) Implementation. Figure 9 shows this dimension in relation to the two basic dimensions of the Framework.

Using this framework in an interoperability project, the Requirements definition phase identifies possible barriers to interoperability that exists between two enterprises and the interoperability concerns to be addressed. At the Design specification phase search/develop interoperability solutions for removing the barriers is done. Implementation phase allows implementing and testing the solutions and measuring the interoperability achieved.
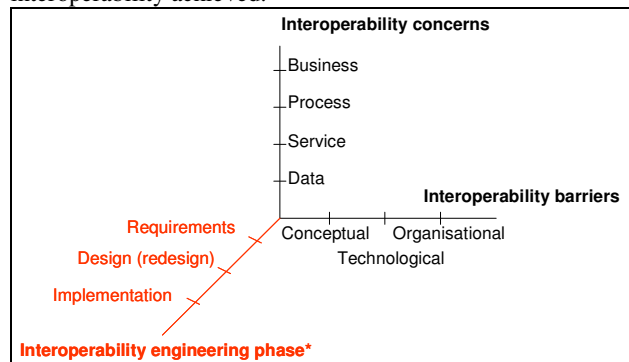
Figure 9. Interoperability engineering phase dimension

3.4.2 Interoperability measurement dimension

The degree of interoperability is a measure characterising the ability of inter-operation between two enterprises (or systems). It enables partners knowing their agility in term of interoperation. At the current stage of research, three types of measurement are identified as shown Figure 10: (1) Interoperability potentiality measurement, (2) Interoperability compatibility measurement, and (3) Interoperability performance measurement. The interoperability degree of a given enterprise (or a system) can be defined by a vector characterised by the three measurements [Daclin *et al*, 2006].

The potentiality measurement is concerned with the identification of a set of system properties that have impact on the interoperability. This measure is performed on one enterprise/system without knowing its interoperation partner. The objective is to evaluate the potentiality of a system to adapt and to accommodate dynamically to overcome various possible barriers. For example, an open system has a higher potential of interoperability than a closed system.

The compatibility measurement has to be performed during the engineering stage i.e. when systems are re-engineered in order to establish interoperability. 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 means there is no barrier to interoperability. The inverse situation means the poorest degree of interoperability.

The performance measurement has to be performed during the test or operation phase i.e. run time, to evaluate interoperations between two cooperating enterprises. Criteria such as cost, delay and quality can be used to measure the performance. 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".
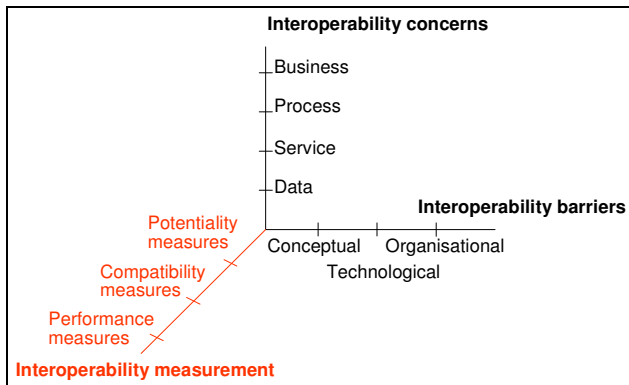

Figure 10. Interoperability measurement dimension

3.4.3 Interoperability knowledge dimension

From the abstraction level point of view, there are two types of knowledge/solution: conceptual and technological as shown Figure 11. The notion of conceptual vs. technological solution also comes from engineering design where one distinguishes between conceptual design and technical design. Conceptual design aims at specifying a conceptual solution which is independent from technology for implementing the solution. For a given conceptual solution, there may exist several different technologies to implement the solution. The technology choice is made at technical design stage. This technical design also called detail design.
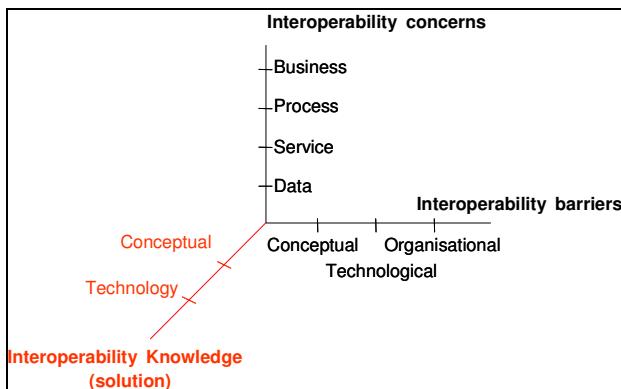

Figure 11. Interoperability knowledge/solution dimension

Conceptual solution also means conceptual description of a solution. In this case, a conceptual solution describes the "ideas" that allow to solve a problem without specifying how to concretise the "ideas" i.e. how to implement the "ideas".
Conceptual solution can also be a conceptual representation of an existing technical solution. In this case, only generic aspects of the solution (for example functions) are 'filtered' and represented without specific technological details.

With this dimension, it is possible to positioning interoperability knowledge (solution) in the framework in a more precise way. For each category of barriers (conceptual, technological, organisational), solution can be conceptual, technological or both. For example the 'semantic annotation' is a method to move semantic barrier concerning the all four levels (conceptual knowledge/conceptual barrier/all levels concerned). A* tool developed in ATHENA project is a technological solution to remove semantic barrier concerning all the levels (technology knowledge/conceptual barrier/all levels concerned).

4 CONCLUSION

This paper has presented a Framework for Enterprise Interoperability; the problem and solution spaces defined the domain of enterprise interoperability. With respect to the existing interoperability frameworks (ATHENA, IDEAS, EIF,…), the proposed Framework is barrier-driven. In other word, if a problem or a solution can not find its place in the framework, it is not an interoperability problem or solution.

The complementary dimensions allowed 'personalising' the framework according to a specific user need.
Concerning the interoperability concept itself, focus is on the 'ability' to interoperate. Research should also focus on developing solutions allowing improving the potential ability to interoperate with a third system.

Interoperability extends beyond the boundaries of any single system, and involves at least two entities. Consequently establishing interoperability means to relate two systems together and remove any incompatibilities in between. Incompatibility is the fundamental concept used in defining the scope of interoperability domain. It is the obstacle to establish seamless interoperation. The concept 'incompatibility' has a broad sense and is not only limited to 'technical' aspect as usually considered in software engineering, but also 'information' and 'organisation', and concerns all levels of the enterprise. Another fundamental consideration is the generic characteristic of the interoperability research. Indeed there are generic problems and solutions regardless of the content of information exchanged between two systems.

The proposed framework with its defined problem and solution spaces would serve as a basis to identify and define a science base for enterprise interoperability. One of the on-going works is to identify possible contribution from 'System Science' to develop interoperability.
Benefits and application of the framework is to allow a better understanding of enterprise interoperability research problems. Furthermore knowledge and solutions can be structured in the framework to allow gap analysis so that future research orientation can be defined to close the gaps. It also contributed to the standardisation work in this area. The draft International Standard CEN/ISO 11354 (Framework for Enterprise Interoperability) elaborated by CEN TC310/WG1 and ISO TC184 SC5/WG1has adopted the proposed framework.

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