Interoperability problems: Management of evolution of collaborative enterprises

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Abstract. The actual economic context forces the enterprises to collaborate together to survive against an increasingly aggressive competition. This paper starts with several definitions. Then, it presents a method to solve some enterprise modelling interoperability problems. This method is focalizing on the supply chain context and includes four parts about evolution management of one or several enterprises, performance of the supply chain, how to model only the flows that we need in this perspective and how to take into account the human aspects.

1 Introduction

In the current strong competitiveness industrial context, enterprises must react quickly to the market changes. In order to face this problem, enterprises must collaborate together. This implies at one hand high communication between their information systems and at the second hand the compatibility of their practices. An important work of change must be done for the practices standardization and harmonization. This is the concept of Interoperability.

This paper aims to present the basic definitions and concepts of interoperability and the research developed currently within the LAPS GRAI group at University Bordeaux 1: Management of evolution toward interoperable collaborative Enterprises using concepts of enterprise modelling.

2 Definitions and research domains on Interoperability

2.1 Definitions

Before presenting this work, a necessary set of definitions is given, concerning Interoperability, Collaborative Enterprises and Supply Chain to understand the topic.

Generally, Interoperability is defined as the ability of two or more systems or components to exchange information and to use the information that has been exchanged[1 2]. More precisely, IDEAS project defines interoperability as the ability of interaction between enterprise software applications. The interoperability is considered achieved if interactions can, at least, take place at three levels: data, application and business process with the semantics defined in a business context[3]. This definition is supported by the IDEAS interoperability framework as showed in Figure 1.

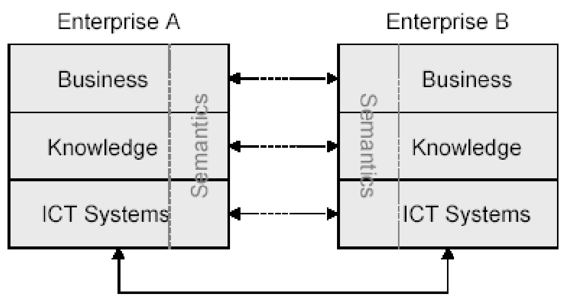

Figure 1. IDEAS interoperability framework

To develop interoperability in Collaborative Enterprises, which is defined as an organization to allow enterprises to collaborate on numerous common projects during a long time, the supply chain context was chosen. The supply chain includes all the activities associated to the transformation and circulation of goods and services, since the extraction of the raw materials to the final customer[4].

2.2 Research domains on Interoperability

According to the standard ISO, Enterprise Modelling (EM) is defined as the act of developing an enterprise model which is a representation of what an enterprise intends to accomplish and how it operates.
More precisely, EM is the representation of the structure, the behavior and the organization of the enterprise according to different points of views:

- Functional, Informational, Physical (Business), Decisional, Processes…
- Technical, Economical, Social, Human…

with two interconnected visions:

- Global: System Theory: The global view of the enterprise: objectives, structure, functions, evolution of the enterprise (dynamic), links with the environment;
- Local: Detailed description according to the concepts of activities and processes.

The role of enterprise modeling is to represent, understand and analyze through an enterprise model, the running of an enterprise in order to improve its performances[3].

The role of EM in Interoperability is to define interoperability requirements and to support solution implementation. This contributes to solve interoperability problems by increasing the shared understanding of the enterprise structure and behavior. Enterprise Modelling provides methodologies for the identification of connected roles, objects and processes between enterprises from different perspectives.

Several problems are related to Interoperability and EM:

- The enterprise models of both parts are not exchangeable (i.e. built using two different languages)
- The same term used by two parts does not mean the same thing (semantic problem)
- The models of both enterprises show differences in practices which are not aligned (output of the first does not correspond to input of the second)
- The model of both information technology (IT) systems shows incompatibility in information exchange…

Enterprise Modelling has a significant role in Interoperability, particularly in term of analysis to target the problems which can appear in an approach of implementation of Interoperability and to solve these problems.

3 Researches for Interoperability

The problematic of our research work is how to allow the interoperability between several enterprises in the frame of a supply chain on the basis of enterprises which don't collaborate.
To solve the interoperability problems, we can gather them in three distinct parts: problems involved in the ontology, those related to architecture and platform and those related to model of enterprise. The first allows having a common vocabulary, the second allows the interoperability by the technical aspects (software, hardware, net…) and the third models the supply chain to allow having interoperable practices at the interfaces. To solve the problems related to ontology, we have two options: either we set up a common and global ontology in all enterprises of the supply chain but the implementation is difficult and tiresome, or we set up a common ontology only to the boundaries of the enterprises. The problems related to architecture and platform aren't in our domain, therefore, we consider that they are solved. To solve

the problems related to the model of enterprise, we use the GRAI Methodology. Our start point is enterprises which don't contribute between them and we want to bring them toward the interoperability. We start from the GRAI Evolution Method (GEM[5]) to apply this work in the case of collaborative enterprise.

Therefore, to bring an answer to some of the enterprise modelling interoperability problems, we need to develop a method which has the following functionalities:

- To manage the evolution of enterprise with the definition of different steps;
- To manage the performance of the supply chain in this entirety. The notion of performance is very important because it allows to bring the activity and to share the information, to promote the cooperation between the function in the enterprises and between the members of the supply chain, and the will to increase the vision angle inside the supply chain;
- To model only the information, the flows and the services which concern interoperability of the supply chain. We don't speak about boundaries of an enterprise toward another enterprise but we speak about boundaries of the supply chain. Indeed, two enterprises don't need to be completely interoperable, but they need to be interoperable at the interface. For this reason, we have to define a supply chain boundary to separate the services which collaborate from the others;
- To take into account the human aspect i.e. the communication between different people and the human psychological aspects in the evolution of their enterprise. Indeed, in the evolution management, people are often recalcitrant to change.

3.1 Evolution management of enterprises

This approach is based on the research work of N. Malhéné[5]: The GEM approach (see Figure 2). It describes evolution process management of industrial systems. In the frame of interoperability, it is proposed to use this method, developed to manage the evolution management of an isolated enterprise, to manage the combined evolution of several enterprises to obtain an interoperable supply chain. The principle of this approach is to build system evolution like continuous processes. In practice, the evolution process is made of a sequence of steps representing the evolution of the system status.

The AS IS represents the model of existing system. The components of the system are here described and formalised: it is possible to understand better how the system is running and also to detect the points to improve.

The SHOULD BE corresponds to the strategic objectives of the system. In our approach it is described through the Business Plan of the enterprise.

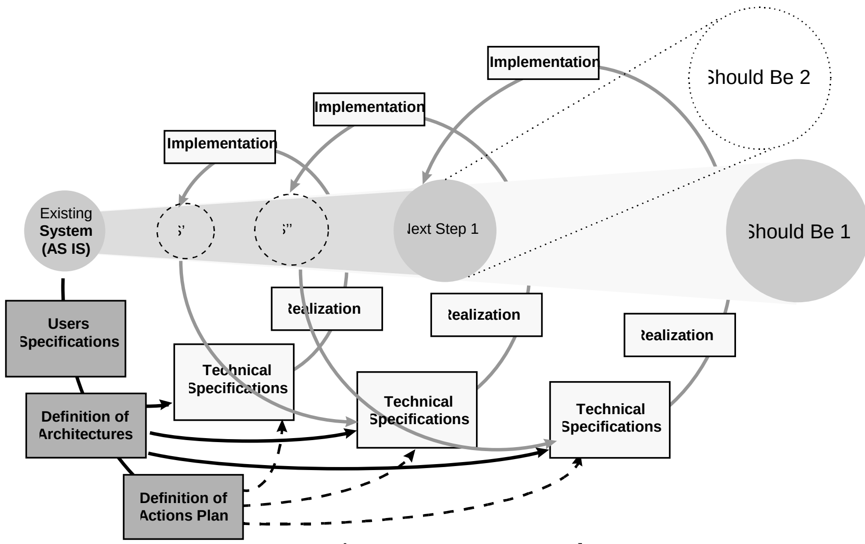

Figure 2. GEM Approach

The NEXT STEP is an intermediate stage between the AS IS and the SHOULD BE. It corresponds to the future system which will be implemented.

The USER SPECIFICATIONS correspond to the comparison between the NEXT STEP and the AS IS models. From this, the TECHNICAL SPECIFICATIONS, which include the Organisation, the Information Technology and eventually, the Physical part, are deduced. The Action Plan determines several evolution projects with a limited duration and investment.

To complete this approach, the human aspects will be taken into account. Indeed, these aspects are often those which bring problems during the evolution.

To validate each step, performance indicators are established.

3.2 Evolution toward Interoperability

There are a lot of reasons of measuring performance of the supply chain. First, it is necessary to determine the interactions between the performance of each actor and the one of the chain as a whole. Second, it is required to share the positive and negative effects of evolution into the supply chain. Third, it is necessary to align the activities and to share the information.

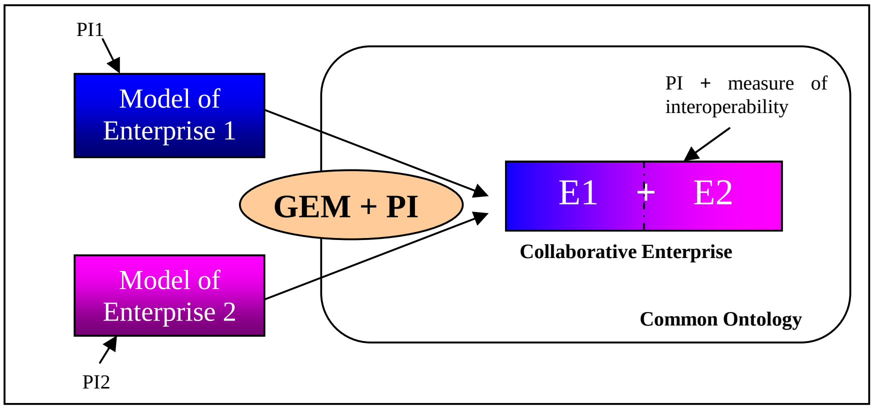

Figure 3. Approach of evolution management

In our approach (Figure 3), performance indicators (PI) are defined in the enterprise before the beginning of evolution. These first indicators will be used to set up a favourable climate to the change in order to prepare the enterprise according to the three following aspects:

- Human;
- Material;
- Knowledge management.

Then, from the beginning of evolution, other performance indicators are established to validate each step of the method. These information will allow to determine the new "Should Be".
Finally, after having obtained the collaboration into the supply chain, final performance indicators are defined in order to manage and control the supply chain in its entirety.

3.3 Modelling of enterprise operational processes

The objective of this model is to describe in the same formalism the control flows, the material flows and the information flows making up the operational processes of an enterprise. It combines some principles which come from algebra of processes[6] for the functional and behavioural part and from statecharts for the notion of state and reactivity of system by sending events and messages. It allows to describe as well the transformational processing as the event processing in a unified formalism. The central concept is the processes notion. It defined many concepts, only the main ones are described in this paper.

A *processes* is defined as a partially ordered set of step forming a data processing sequence delimited by a beginning (START) and an end (FINISH). Formally, one can specify processes P by a 5-uplet:

$$P = \langle Pid, \alpha P, \beta P, \delta P, SP \rangle$$

A step of processes is either under-processes, or an elementary step called *activity*. It is defined by behaviour rules of the form:

WHEN (condition) DO (action)

The processes are started by events. An event represents a change of state in the observed system. It appears at a given moment when a condition becomes checked. It can be carrying information in the form of a object view. One defines it by a 4-uplet form:

$$E = \langle Eid, q, OV, \tau \rangle$$

The *object view* defines an enterprise object state at a given moment. We can distinguish two types of object view: physical view describing the physical object (material flow) and the information view describing an object with the data-processing direction (information flow).

The activity is an elementary stage in processes. One defines it by a 10-uplet form:

$$A = \langle Aid, FIA, FOA, CIA, COA, RIA, ROA, \delta A, IA, SA \rangle$$

The *functional entities* represent the active resources (i.e. the agents or actors) of the considered enterprise. They provide and carry out the necessary functional operations by the activities. We can distinguish three fundamental types of functional entities in an enterprise: the men, the machines (built material entities able to carry out operations on request) and the applications (systems software). In a formal and generic way, a functional entity is defined by:

$$R = \langle Rid, OVR, CapR, FOR, fR \rangle$$

3.4 Weak Aliens Problem (WAP)

We can differentiate two different cases of heterogeneity: material heterogeneity and Semantic Heterogeneity.

In the case of material heterogeneity, for a long time, the distributed systems have been few interoperable. Today, large progress have been done and architectures of multi-agents systems in particular have strongly contribute to reduce the question of information transport, in an independent way of the material conditions i.e. machines and/or subjacent operating systems.

In the case of semantic heterogeneity, we can say that the applications which interact on the basis of agent have often been defined and built by different people, in different places at different times, with different aims, with different vocabularies... So the agents live in a "semantically open" world[7].

According to J-P Sansonnet[7], three different situations of communication exist:

- NAP: Global ontology which hold all particular ontologies and there is no problem of semantic heterogeneity;
- SAP: The agents do not have any intersection and they can't communicate;
- WAP: Ontologies are different but however they have an intersection.

Now, we wonder if we have to eradicate or confront the heterogeneity.

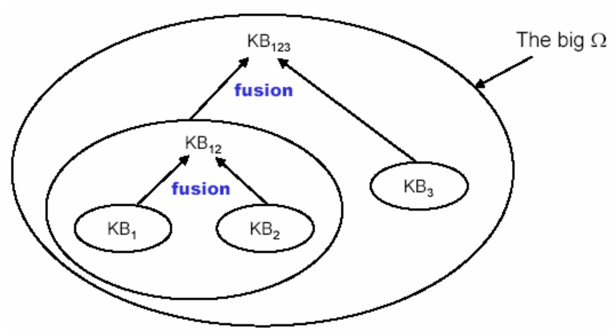

Figure 4. Eradication of heterogeneity

The semantic heterogeneity by the fusion of all particular ontologies in a global ontology can be eradicated (see Figure 4).

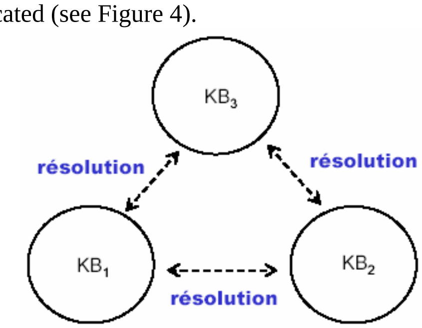

Figure 5. Confrontation of semantic heterogeneity

The semantic heterogeneity can be confronted by the resolution of the individual problems. In this perspective, three strategies can be defined to confront the heterogeneity. Firstly, the concepts can be expressed within the meaning of description logics (see Figure 6)

Kbase Agent1	**Kbase Agent2**
Termes : A,B,C, D, E	Termes : A,B,C, E, F,G
TBox :	TBox :
$A \equiv E \wedge C$	$F \equiv \forall s.C$
$D \equiv \forall r.C$	$G \leq C$
$B \leq E$	$E \leq G \wedge F$
$A \leq C$	$A \equiv B \wedge C$
	$A \leq C$

Figure 6. Description logic

Secondly, they can be expressed under the form of lexical concepts graph (see Figure 7)

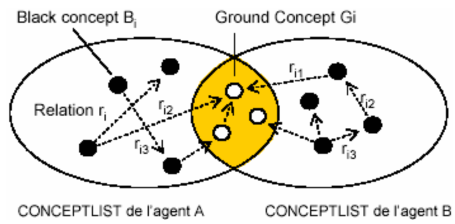

Figure 7. Graph of relations

Thirdly, we can express them under the form of concepts expressed in algebraic topology (see Figure 8).

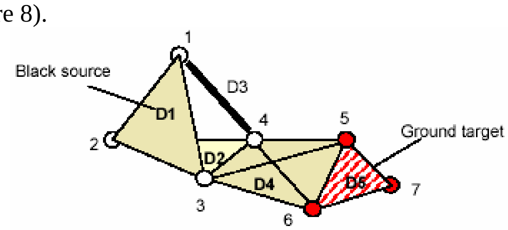

Figure 8. Simplicial complex

To apply this last representation on a more concrete example in our domain, we can use this graphs to represent the decision frame (blue arrows (Figure 9) of a GRAI grid[1] example (Figure 10).

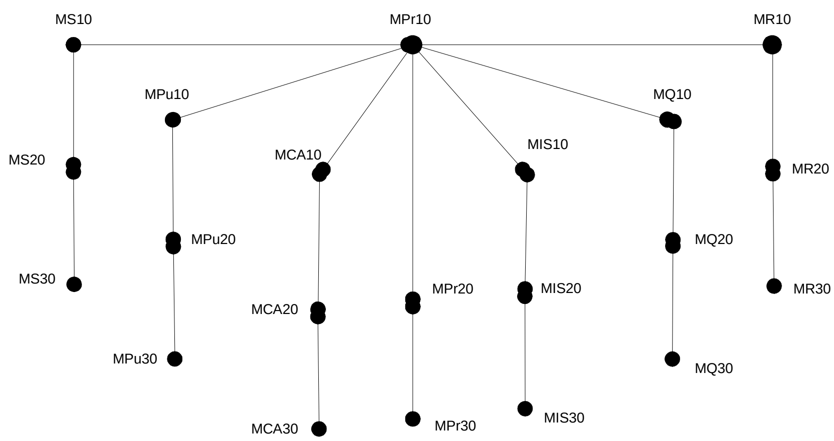

Figure 9. Simplicial complex representation apply to the GRAI grid example

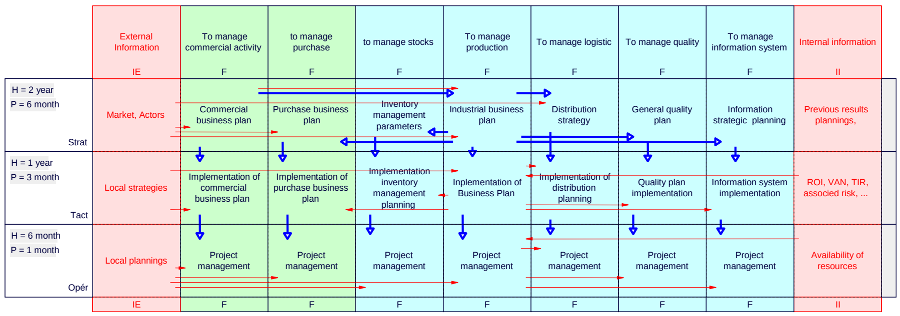

Figure 10. The GRAI grid example

4 Conclusion

This paper has presented a method to manage the evolution of enterprises from heterogeneity to interoperability. This method is articulated around four parts, each one filling a particular task:

- To manage the evolution of enterprise;
- To manage the performance of the supply chain in its entirety;
- To model only the information, the flows and the services which concerned interoperability of the supply chain;
- To take into account the human aspect.

These research works are only beginning. In the future, we will detail each aspect to develop the global method.

5 References

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