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Collaborative Information System Design

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Abstract: This article deals with enterprise interoperability in order to propose lines of research about information system design in a collaborative context. The static and dynamic dimensions of collaboration are exposed and discussed. The proposed IS design approach is based on process model translation. This article also presents several perspectives, especially about IS flexibility and process model liability.

1 Introduction

Nowadays, companies are opening up to their partners (using instituted, regular or sporadic relations) and it is an inescapable characteristic of the market evolution. This need of networking rests on several aspects: concurrency, exchange improvement (of information as for goods), products increasing complexity... The capacity of enterprises to collaborate with each other (furthermore in an efficient way) becomes, by this way, a determining factor for their evolution and their ability to survive. This necessary ability to evolve and react according to their environment is based on companies' capacity to interact efficiently with the industrial ecosystem in which they live.

The notion of collaboration is a vast concept that can be applied to numerous situations: group based on the complementary nature of partners (covering increasing), groups concerning enterprises focused on the same service (power increasing), groupings of providers from a same decision-maker (optimization and safety), common buying platforms (improvement of negotiation capacity) and other original networks, permanent or limited (due to specific constraints of the milieu).

The question of enterprises collaboration and their ability to interact efficiently across collaborative networks or industrial ecosystems naturally concerns the field of information systems. Indeed, the behavior, reactivity and all the dynamic aspects of enterprise highly depend on the information system and the processes, services and data it manages. This article deals with the topic of collaboration (definitions, levels...) and proposes several main ideas related to information system design in a collaborative context.

The section two deals with the concept of collaboration and how this notion impacts on information systems. The third part deals with collaborating information system design according to the previous section remarks. Finally, part four presents several works in progress and future works related to these topics.

2 Collaboration and Information System

Collaboration is a large concept and it is necessary to position it according to numerous concepts, classifications and definitions. In this article we voluntarily chose not to discuss terms and words (in order to avoid a lexical debate on “collaboration”, “cooperation”, “communication” and so on) but to focus on conceptual collaboration levels. Next we aim to refine this study from the general concept of collaboration to the specific information systems collaboration.

2.1 Enterprise Collaboration

On the basis of some research work about enterprise collaboration, we will try to build a synthetic characterization of collaboration. Several **levels of collaboration** will be described according to two dimensions (static and dynamic), which will be used to structure this article.

First of all, [Ko05a] builds a synthesis of the IEC TC 65/290/DC standard (cf. [I02]). This standard deals with enterprise compatibility measurement. We propose to extract from this article the following **levels of compatibility** (native denominations, given in brackets, have been converted in compatibility levels):

- Level 1 (Coexistent): may exist independently in a single network,
- Level 2 (Interconnectable): may share or exchange information,
- Level 3 (Interworkable): may share functionalities or services,
- Level 4 (Interoperable): may work according to a predefined collective behavior.

This classification scale is shown in the following schema (figure 1) :

Compatibility nature \ Compatibility level	1	2	3	4
	Definition of a collaborative behavior			
Sharing of functionalities and services			X	X
Exchange or sharing of information		X	X	X
Involvement in a communication network	X	X	X	X

Figure 1: compatibility levels (adapted from [Ko05a] and [I02])

This study highlights two consequences. The first one can be directly deduced: compatibility levels introduce collaboration levels. The second consequence is indirect and puts on view temporal aspects of collaboration: in order to collaborate, enterprises have to collectively build the path, which will bring them from heterogeneity to the right level of understanding. This is a dynamic act, which brings partners to instituted, regular or sporadic relations.

[LPT03] proposes a study on the levels of understanding between enterprises (based on the concept of “common objective”). That research work, based on different results from the supply chain management field, provides the following *understanding levels* (native denominations, given in brackets, have been converted in compatibility levels):

- Level 1 (communication): sporadic data exchange,
- Level 2 (coordination): structured and instituted data sharing,
- Level 3 (collaboration): sporadic data and applications exchange,
- Level 4 (cooperation): structured and instituted data and applications sharing.

Our point of view is to use the integration concepts of *data* and *applications* and to add a third concept: *processes*. Continuously with [LPT03], we propose to complete this classification using two complementary *understanding levels* based on integration using data, applications and processes (figure 2).

	Data	Data and applications	Data, applications and processes
Sporadic exchange	Level 1	Level 3	Level 5
Instituted integration	Level 2	Level 4	Level 6

Figure 2: relative positioning of understanding levels between industrial partners

The two levels added represent higher degrees of understanding, dealing with processes sharing or synchronizing (in a context of common objective). This proposal to enrich [LPT03] results is coherent with [Ko05b] (as taking into account the “established collective behavior”) and [CD03] (which claims that interoperability is achieved if it concerns the three levels data, resources and processes are concerned).

The fifth level can be illustrated using a group answering to a call for proposal and the collective achievement of this project. The sixth level can be illustrated by the gathering of partners, which synchronize and harmonize their behavior in order to build a co-enterprise able to react as one according to some contexts (this stage is the last step before merging in to one single entity).

Such research works, among which the preceding study, allow us to identify two considerations on which the structure of this article will be based: the collaboration level of a group of partners can be characterized by its two main components: static and dynamic views. Our proposal of characterization of *collaboration levels* can be illustrated using the following graphic (figure 3):

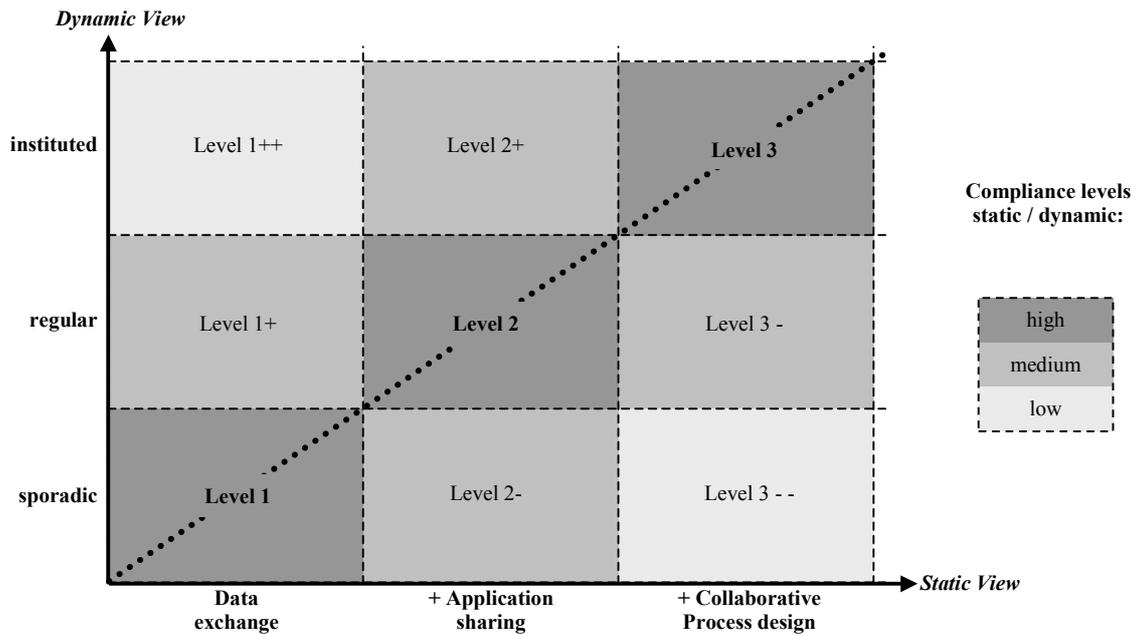


Figure 3: collaboration characterization proposal

This proposal of typology will be used throughout this article to study the design of appropriate information system in a collaborative contexte.

2.2 Enterprise collaboration and information system

To confront the previous considerations with the problematic of information system design in a collaborative context, we will study the abstract and conceptual views of information systems (IS).

- Reix, in [Re02], defines the concept of information system as *an organized set of resources (hardware, software, people, data, processes) able to acquire, treat, store and export information (as data, text, pictures, sounds, etc.) in the organizations.*
- Bernus, in [BS98], considers that an *information system must ensure that the right information is available at the right place at the right time.* The notions of *right place* and *right time* refer to a process management system which synchronizes the treatment and the carrying of information inside the IS.
- Morley, in [Mo02], presents the IS as *the composition of two subsystems:*
 - *the information management system (including actors, data and processes),*
 - *the computing system (including hardware and software resources, data base and functions).*

Those three points of view (Reix, Bernus and Morley) emphasize several invariants of the field of information system modeling. We can sum up these principles according to the following representation: The information system supports the enterprise's *processes* by firstly, managing *services* and *functions* available in the company and secondly, dealing with *information* (carrying and storing). *Actors* and *resources* of the enterprise, totally involved in the whole information system, are located outside our illustration (figure 3) because of the nature of our main objective: IS design.

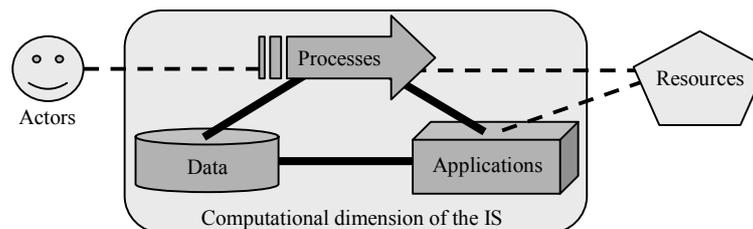


Figure 4: a vision of the information system

That view of information system (and particularly of its computable part) offers the advantage of being coherent with the points exposed at paragraph 2.1 about collaboration levels and the static characterization criteria (data, applications and processes). Consequently, we will use that logical representation of IS to study the consequences of collaboration on IS of partners:

- **Data conversion:** to be flowing, interactions between information systems need tools able to convert data efficiently (style, format). It is crucial that data can be transmitted effectively between partners of the collaboration. In other words, even if each partner should be able to preserve its privacy and to establish the specific access rights to the informational field it allows, collaboration between enterprises implies to clearly separate the semantic meaning of data and their syntactic form for an optimal informational integration.
- **Management of applications:** generally, services and applications of diverse partners are not built to be compatible. Nevertheless, IS collaboration implies the interaction between partners' applications to be as flowing as possible (even if they are provided by heterogeneous IS). It is crucial to be able to manage external accesses to those applications (and the associated rights). Technical solutions such as EAI (for Enterprise Application Integration) or ESB (for Enterprise Service Bus) provide concrete support to that kind of services and applications interoperability.
- **Orchestration of processes:** processes can be seen as the “musical partition” to be played and accompanied by the information system (and the workflow management system) by piloting the data management and the calls of services or applications. In a collaborative context, the running of collective processes (impacting all partners) must be transparent but should impact the running of internal processes (in IS of partners). That is why, collaborative processes must include components coming from private processes of partners (cf. [Ad05]). Finally, these private processes should be protected against an external malicious reading but they should also offer a partial access: at least the definition of the applications they provide, data they need and information they send out... This is probably the price of a pertinent building of collaborative processes.

Besides, if collaboration between information systems may be formalized by using those three concrete levels (data, applications and processes), there are also several secondary components of that point of view: interactions between different levels (applications create, use, modify data; processes need applications and transmit data, etc.).

As for the characterization of the dynamical dimension of the collaboration between information systems, the projection of the temporal criteria on the plane of the IS modeling leads us to the following remarks:

- **Internal own-knowledge and conceptual compartmentalization:** temporal discontinuity and fractioning of collaboration imply that the potential partners master and know their own IS perfectly. Indeed, it is necessary to efficiently define formats of exchanged data, modes of access and use of applications. Public and private parts of each partner should also be defined. Finally, components of one IS (of one partner) may be prepared to be compartmentalized in order to deal with the possible involvement of an enterprise into several distinct collaboration networks, for different timing, at different moments (but eventually overlapping).

- **Flexibility and safety of IS:** because of the previously mentioned hypotheses of an enterprise belonging to several distinct networks (versatility of partnership), information systems have to be extremely flexible. Answering to new, unexpected and innovative collaboration requests is a strong component of that view of the collaboration concept. Like wise, integrating and managing evolutions and changes of a running collaboration is a fundamental and substantial issue. After all, the variety of types of collaboration (instituted, regular or sporadic) implies an increasing need of information systems to be safe and secure while adapted to this opening (this is the price to be a trustable partner).
- **Robustness of processes:** the third level of collaboration (cf. §2.1) is characterized by the establishing of a collaborative behavior. This principle rests on one (or several) collaborative process(es), defining the dynamical part of the collaboration and certifying that partners share the same vision of the collective behavior of the network. The collaborative process (or a model of this process) is a key-point of the collaboration. It must be trustable (without being necessarily stable because of the flexibility constraints) and a point of reference for the partnership. Hence, it seems to be legitimate to think that the building of such a collaborative process should be complemented with activities of risk management and robustness improvement.

The aim is then to propose a solution including answers to these questions, definitions and requirements.

3 Proposal about Collaborative IS design

The purpose of this third section is, first to propose a logical structure able to carry the partnership between enterprises (and their IS) by meeting the main requirements identified among the study of the collaboration concept (part 2). Secondly, this section aims at showing a design method of such a kind of collaborative structure (as a software system). This part essentially treats the static view of the collaboration (the dynamic one will be discussed in the fourth section).

3.1 The concept of collaborative information system (CIS)

Dealing with *data conversion* between partners, *application management* in the network and *processes orchestration* according to the global behavior of the collaboration, reveal the necessity of:

- acceding to several components and characteristics of the IS of partners,
- having an independent and intermediate entity available (trustable third party), located in the middle of the network. This mediator should manage the specificities of each partner but also the structural and functional conventions specific to the collaboration. We call that entity, support of interoperability, *Collaborative Information System (CIS)*:

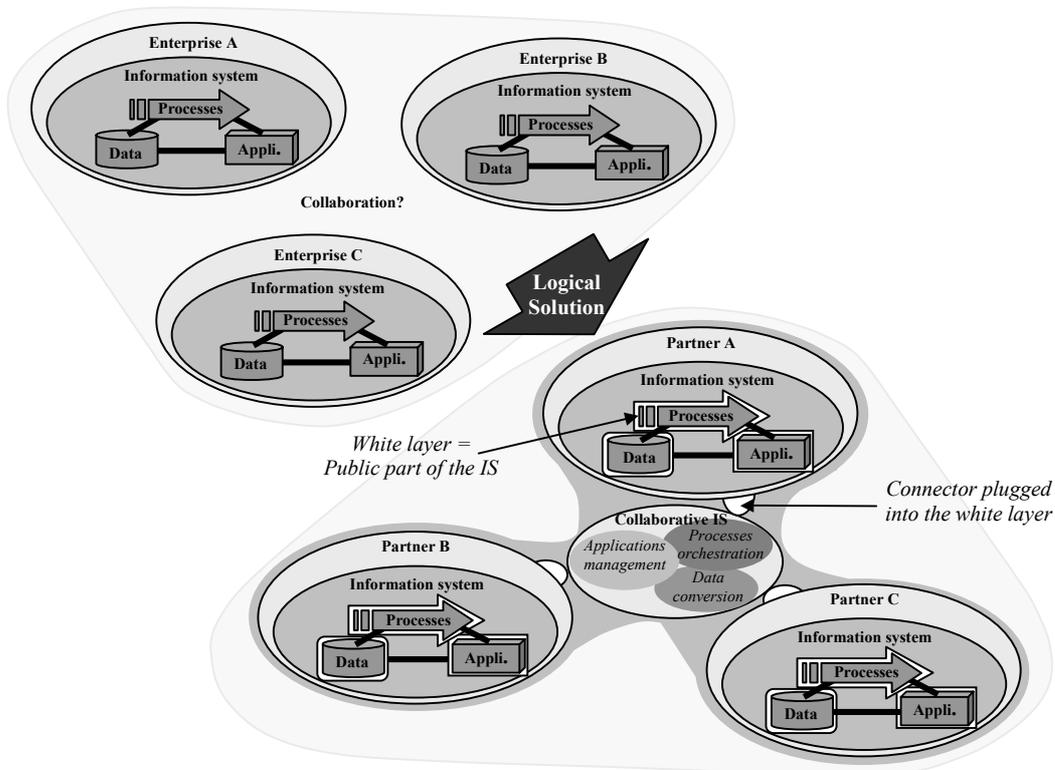


Figure 5: our proposal on a logical plane for information systems collaboration

This CIS is based on connectors, plugged into the partners' information systems and able to deal with the public and private parts. These connectors can access the public data applications, and processes of partners in order to provide the CIS the information needed (access rights and other specific features have to be managed at this level). Thanks to these modules (connectors), the CIS may be able to carry out the collaboration by driving and controlling collaborative processes, by managing calls of applications from partners and by carrying and translating data from one partner to the other (when it is necessary and legitimate according to global processes). This concept of CIS relates to a logical architecture, technical point of view is not mentioned here and might differ from that conceptual view.

Concerning the public/private notions, visibility and access to processes, applications and data of partners' information systems come from enforcement of pre-established collective conventions (connectors and CIS control the conventional decisions taken by the community of partners involved in the network). According to this point of view, internal processes can be private, public or semi-private (if only part of a process is visible, for instance inputs and outputs of a service), applications can be private, public or controlled (if the access is restricted) and data can be private or public.

3.2 Elements to define the Collaborative Information System

Based on the previous delimitation of the concept of CIS, seen as the cornerstone of collaboration, one can reasonably ask for the contents of such a system: which knowledge should be available to define this CIS? What concrete characteristics of the network and of partners should be assembled to be in a position to design this Collaborative Information System?

Morley, in [Mo02] assumes that if numerous authors focused on the crucial role of the concept of information in the IS field, nowadays standard reference approaches are oriented onto the concept of process. [AD02] points out that an inter-organizational information system has the specific function to support processes going through the organization's boundaries. Furthermore, Vernadat in [Ve99] defines a process as a *set of partially ranked steps, executed in order to achieve at least one objective*. Thus, from simple information management systems, information systems become systems in charge of driving informational activities (thanks particularly to workflow management tools). According to these ideas, we can infer that defining and designing such a CIS can be based on modeling the specific inter-organizational processes involved in one collaboration, as precisely as possible.

Formalizing those collaborative processes (seen as knowledge supplier) appears to be the next important question. In addition, formalizing the CIS to support the collaboration is a central question too. Modeling processes is a classical topic (cf. [BMM05]) and Touzi in [TBP05] proposes to use BPMN language (Business Process Modeling Notation from BPMI¹) to describe collaboration's specific processes. Furthermore, Touzi suggests using UML (Unified Modeling Language established by OMG²) to model CIS:



Figure 6: main objective

One can summarize the general principle of our approach as follows: we aim at building a UML model (of the adequate collaborative information system) by using the global knowledge (about the concerned collaboration) contained into BPMN models. However, it is relevant and essential to wonder if such an equation is homogeneous:

- what surface of the knowledge space of the collaborative network does a BPMN diagram cover?
- what are the points of view covered by the UML model of an IS?

¹ Business Management Initiative. International consortium working on processes field.

² Object Management Group. International, open membership, not-for-profit, computer industry consortium.

The CIMOSA method is dedicated to enterprise modeling. CIMOSA describes four points of view of enterprise (seen as system), which give elements to answer the first question: *functional view* (scenarios and processes), *informational view* (information and data), *organizational view* (hierarchical structures and organizational charts) and *resources view* (competences and availabilities). As processes models, BPMN diagrams are mainly centered on the *functional view*. Nevertheless, BPMN formalism is one of the languages designed in [Sa04] as able to completely describe a process but also to link it with other views of the enterprise: a BPMN diagram includes connections with information (by dealing with exchanges of messages) and with resources (by allowing parallelism and synchronization).

Concerning the second question, UML is a language dedicated to several complementary points of view (essentially of software systems and thus significant for IS modeling). Considering [BJR04] and [Ro04], we can propose to focus on four dimensions: the *architectural dimension* (structure of the physical components: component and deployment diagrams), the *behavioral dimension* (dynamic description: sequence, activity, collaboration and state-transition diagrams), the *functional dimension* (tree of the functions available in the system: use-case diagram) and the *structural dimension* (logical structure: class and object diagrams). In our context, the problematic of generating UML model from BPMN diagrams may be illustrated by figure 7 (where arrows between points of view and dimensions mean “provide the knowledge for”).

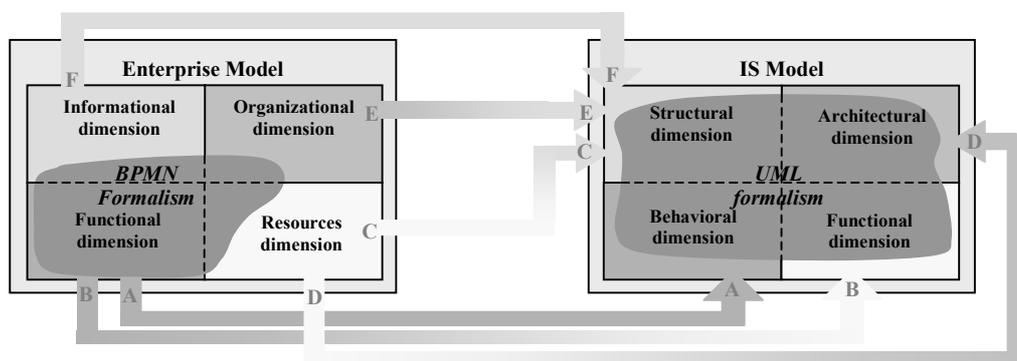


Figure 7: covered areas and relations between enterprise modeling and IS modeling

One can notice that collaborative process model in BPMN allows the definition of behavioral and functional views of IS model (arrows A and B). Besides, structural dimension (links C, E and F) and architectural view (link D) are just partially covered.

It seems obviously difficult to be able to produce the model of an IS architecture (no matter if it is a logical one, based on structural view, or a physical one, based on architectural view) starting from process model without providing additional knowledge (kind of architecture, nature of components). Furthermore, if BPMN goes over the edge on informational, organizational and resources dimensions, it is not sufficient to cover the whole partnership and its attributes: it is necessary to complete that knowledge with information from model of partners and the collaboration itself.

3.3 Design method proposed (compliant with MDA practice)

Previous observations showed the necessity of completing extracted information (from BPMN processes models) with additional knowledge describing logical and technological structures of information systems. We propose the following approach in four steps:

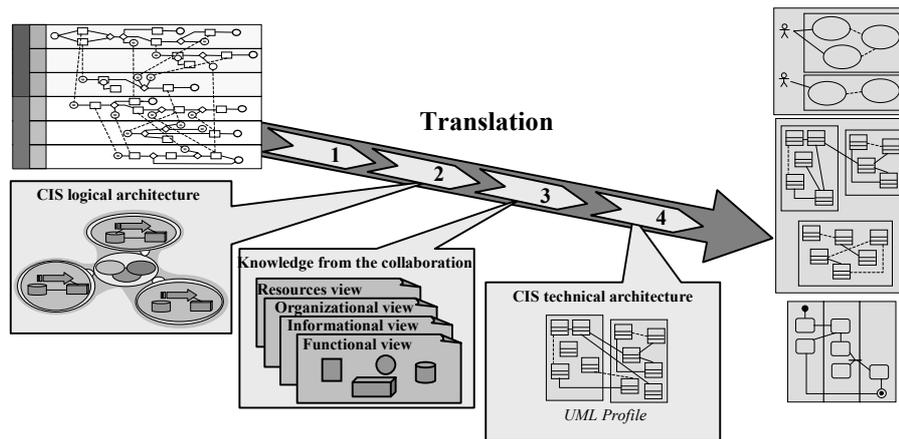


Figure 8: design method of the collaborative information system

- Stage 1: the translator extract from BPMN diagram the knowledge describing the enterprises network considered.
- Stage 2: that knowledge is injected in the logical architecture specifically chosen for the CIS (depending on the translator culture).
- Stage 3: the obtained result is enriched with complementary knowledge from enterprise modeling field (specific model of partners and of the network itself). This step implies human intervention. [BMM05] proposes to use the concept of agent for such an enrichment task.
- Stage 4: finally, the obtained logical model is projected on the chosen technological architecture in order to provide an exploitable UML model.

These stages are here formally identified in order to clarify the method. In fact, there are not so obviously distinguished in real implementation. Steps 1, 2 and 3 are in fact one single global stage dedicated to logical modeling (for instance it might be an iterative cycle involving the three steps almost simultaneously).

This approach (cf. [TBP06a]) seems to be compliant with the MDA³ practice. Indeed, according to [O03], the following connections might be done:

- *Platform Independent Model (PIM)*: that part covers stages 1, 2 and 3 from figure 7, that is to say the building of BPMN models of collaborative processes and the translation into UML diagrams modeling the CIS,
- *Platform Model (PM)*: that element describes the generic technological architecture chosen for the CIS (for instance based on a UML profile)
- *Platform Specific Model (PSM)*: that part refers to the results of stage 4.

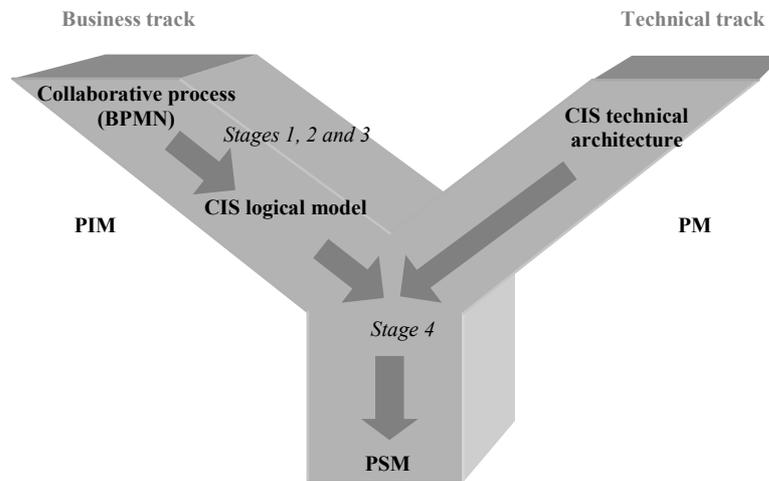


Figure 9: approach MDA (Model Driven Architecture) and CIS design

The CIS design method proposed finally is coherent with results presented in [EI05], which underline the need of enterprises integration by means of *conceptual models* (logical point of view) then *technical models* (physical point of view) both implemented from *business analysis* (collaborative processes could be a good example of such an analysis).

³ Model Driven Architecture, available at <http://www.omg.org/mda/>.

4 Perspectives on collaborative IS design

This section will show some of our current research works and their connections with the previous considerations. The third part refers abundantly to research works concerning IS design from the “frozen knowledge” encapsulated in collaborative processes models (that is to say the static part of the collaboration concept as shown in part 2). We now present some research work of PhD in progress. Such works will particularly be located on the dynamic dimension of the concept of collaboration (according to Figure 3 in the second section).

4.1 Collaborative processes cartography

We currently try to define a system of reference for collaborative processes. This ambition comes from several statements made while studying the topic of BPMN model translation into UML model:

1. BPMN language is not yet universally used or recognized,
2. The CIS design method to propose (cf. section 3) needs a partial “automated translation” which implies incoming BPMN models to respect some conformity conventions: current results on translation rules (cf. [TBP06b]) show how crucial it is to use collaborative processes models following specific standards in order to manipulate and to translate easily.
3. The will of collaborating taken by a group of partner does not systematically imply the definition of the precise collective behavior of that partnership. Building processes models and furthermore collaborative processes models is a delicate and demanding activity.

Thanks to these observations, we believe that the building of collaborative processes models takes on a significant weight. It seems to be reasonable to build a formal phase of design of collaborative BPMN diagrams (in order to obtain trustable and adequate models). The approach we propose will be based on two steps:

- Building of a collaborative processes cartography: the field of those particular processes is not a well-defined universe. We propose to define several pertinent characterization criteria to locate collaboration and the associated processes in the space of collaborative behavior. The goal is to obtain a system of reference allowing the compartmentalization of collective processes and therefore the use of generic or dedicated models (to build specific processes diagrams).
- Proposal of a method to build collaborative process models. It will be based on the cartography built to assist the modeling phase of BPMN diagrams drawing. The models thus obtained will then be compliant with the requirements of the translator (as built according to a specific method whose purpose is to meet the specific conventions of the translator).

Starting from the results of [KD96], the first characterization criteria on which we will base the cartography of this unknown field are the following:

- **Nature of the collaboration:** [KD96] proposes four groups of collaboration types (seen as a base of constructs) which are the following: *enterprise / client*, *enterprise / supplier*, *enterprise / service provider*, *enterprise / concurrent*. These relations help to locate one particular collaboration case and the associated processes on a first axis.
- **Nature of the network:** [KD96] and [AD02] propose different types of network from *centralized network* (where a principal collaborates with several partners more or less significant) to *chaotic network* (where each partner may have specific relation with one another, including *supply chain network* or other well-known standard models).
- **Dynamic aspect of the collaboration:** This characteristic has been exposed in section 2. It concerns temporal aspects of collaboration. It helps to define if a network is based on *sporadic*, *regular*, *cyclic* or *instituted* relations.

This list of criteria underlines the first ideas on which we base our current activities on collaboration characterization. This study will assist the modeling of collaborative processes as exploitable BPMN diagrams.

4.2 Robustness of processes and flexibility of information systems

The previously presented notion of processes cartography brings two additional perspectives. The first one deals with adaptability and flexibility of collaborative information system. The second one is linked to risk management in collaborative processes models.

First of all, being able to evolve in the field of collaborative processes give us some flexibility as far as our propositions in this article are concerned. Indeed, processes (and collaborative processes) may dynamically evolve and the collaboration may also change with time. CIS supporting the partnership should follow the change and this fact is a critical issue of these research works. Thus, being able to instantaneously locate the collaboration (and the involved processes) in a system of reference is a significant asset for CIS evolution. One can imagine modifying the collaborative processes models in an almost continuous way (and, at the same time, the CIS supporting these processes). Such considerations allow us to think we will be able to follow the dynamic change of collaboration.

Secondly, using generic models of collaborative processes (associated to specific places in the collaboration system of reference) brings the possibility of categorizing activities. Stamping activities can help identifying risks associated to one nature of activity and by this way to one complete process. Indeed, we can assume that one particular sort of activity will carry its specific sets of generic risks (usually linked to that kind of task). For instance, one activity of *transport* will systematically be concerned by the same kind of risks (different from the ones associated to one activity stamped *conception*). Such considerations should help the risk identification, their analysis and treatment.

We believe these observations should leads to further research works in the field of interoperability management and especially in the fields of collaboration support in a robust and dynamic way.

Conclusion

This article is based on three parts. The first one explores the notion of collaboration and assumes that it particularly implies information systems collaboration. This observation brings us to discuss the concept of collaboration itself and its two identified dimensions (static and dynamic). Information systems interoperability is also discussed by introducing the notion of collaborative information system (as a mediator between partners' IS), which is a vector of *data* transmission, *application* management and *process* orchestration.

The second part presents a proposal of CIS design method. This suggestion rests on models translation: from collaborative processes BPMN diagrams to CIS UML model. It includes several stages (such as knowledge extraction and logical architecture filling). The partial model so obtained is a trustable and advanced base to be enriched with additional information on partners and the network itself.

The third part exposes the perspectives and lines of research appeared thanks to the first results. The topics mentioned in that section concern flexibility and adaptability of collaborative information system (thanks to collaboration localization in a collaborative processes cartography) but also robustness of collaborative processes (through a risk management approach).

This article shows a view of the concept of enterprises' collaboration based on the characterization of the partnership, which, from our viewpoint, seems to us to be the most relevant one: modeling of collaborative processes of the network.

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