Proposition of a Generic Metamodel for Interorganizational Business Processes

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Abstract. An Interorganizational Business Process (IOBP) is an organized group of related activities carried out by multiple organizations to accomplish a common business goal. A consequence of this is that business process modeling and design used inside an organization have to be enhanced and extended to cope with interorganizational business relationships. Modeling business processes that span multiple organizations involves new challenges, mainly the ability to cope with autonomy, privacy, heterogeneity, and the support for coordination trough mutual agreements. As a contribution to this area, this paper presents a metamodel that captures a wide range of IOBP elements.

Keywords: Interorganizational business process, business process modeling, interorganizational business process metamodel, MDA-based framework, B2B.

1 Introduction

Collaboration and coordination between companies are considered necessary in a business environment, where companies focus on their competitive advantage, perform only those functions for which they have expert skills and they complement their offering through partners and suppliers. Interorganizational business processes are the enabler of such business environments. The modeling of IOBP is a challenging task, due to the high degree of autonomy and heterogeneity of the cooperative organizations. The paper proposes an IOBP generic metamodel which depicts the nature of interaction between organizations through business processes under specific business requirements that emphasize the heterogeneity, privacy and autonomy of the participating organizations.

For this purpose, we conducted explorative research which is considered appropriate for gaining better insight and for analyzing particularities of interorganizational processes in comparison with internal processes. Having answered this question, metamodel elements should be derived that are considered necessary for metamodeling IOBP.

The remainder of the paper is structured as follows. In section 2, we present basic concepts of IOBP. Section 3 highlights the framework for IOBP design. In section 4, we discuss the related works. Section 5 describes the aspects of the proposed IOBP metamodel. Finally, the paper finishes giving a summary and an outlook to future work.

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2 Interorganizational Business Processes Basic Concepts

A business process is a continuous series of organizational tasks, undertaken for the purpose of creating output [25]. Among the forms of information that people ordinarily want to extract from a process model are *what* is going to be done, *who* is going to do it, *when* and *where* will it be done, *how* and *why* will it be done, and *who* is dependent on its being done [7].

This section aims to present the basic definitions and concepts of IOBP modeling.

2.1 Intra-organizational versus Interorganizational Business Processes

While intra-organizational processes comprise activities executed inside one organization only, the activities comprised in an IOBP are executed by different organizations that are working together to reach a common objective. Hence, a number of particularities arise in comparison with intra-organizational business processes [12]. IOBP usually do not have a centralized control instance or process owner. Coordination between the different organizations requires an agreement on how to interact and exchange information. However, autonomy of the different parties has to be taken into account when designing IOBP.

In order to illustrate the IOBP concepts, we regularly refer to the following corporate procurement process example scenario depicted by the figure 1.

Application example: The Procurement application concerns two organizations (enterprises) – a buyer and a seller – which are collaborating and need to interlace their business processes. The Buyer sends an initial request for quote to the Seller. The Seller checks if the requested product is offered, i.e. listed in its product catalogue. If so, then the stock information is required in order to see if the product is kept in stock. If the product is out of stock, product information is needed to check if the product can be produced or not. In cases of either having the product in stock or having to produce the product, the Seller needs to calculate its price and to send back a quote to the Buyer. If the requested product is not offered by the Seller and cannot be produced, a rejection is sent back to the Buyer. In case of having received a quote for the requested product, the buyer checks if the price corresponds to the price limit set; if so, it sends a PO to the Seller. The Seller then verifies the credibility of the Buyer. If the credibility is ok, the Seller returns an order response to the Buyer.

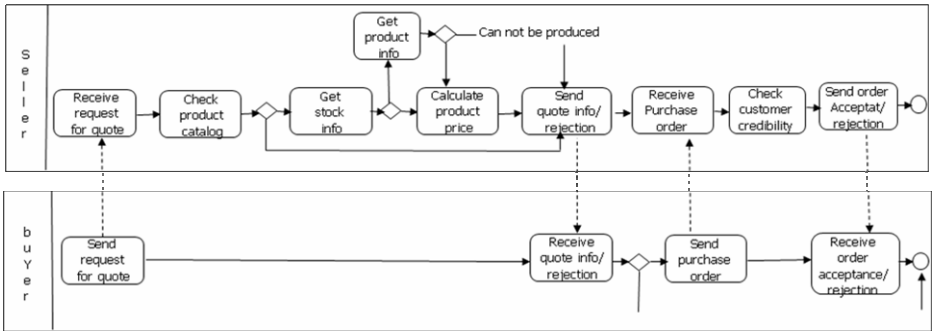

Fig.1. An example of an IOBP

In order to make IOBP work, each involved organization has to implement not only its internal processes (private processes), but also its external behavior (public processes). Hence, in IOBP modelling it is common to distinguish between internal and external activities of business processes. Adopting the approaches used by ([5],[16],[12],[19],[26],[33],[35],[36,[41]), we consider a process described either as a Private (internal or executable), Public (abstract or view), and Collaborative (cross-organizational or interorganizational) as illustrated in figure 1, figure 2, and figure 3.

• *Collaborative Business Processes* define the interactions (vertical dashed arrows in figure 1) between two or more business companies. These interactions take place between the defined public processes and are defined as a sequence of message and/or other material input/output exchange as depicted in figure 2. The collaborations between the involved parties are modeled as interaction patterns between their roles. It is shown by two or more public processes communicating with each other.

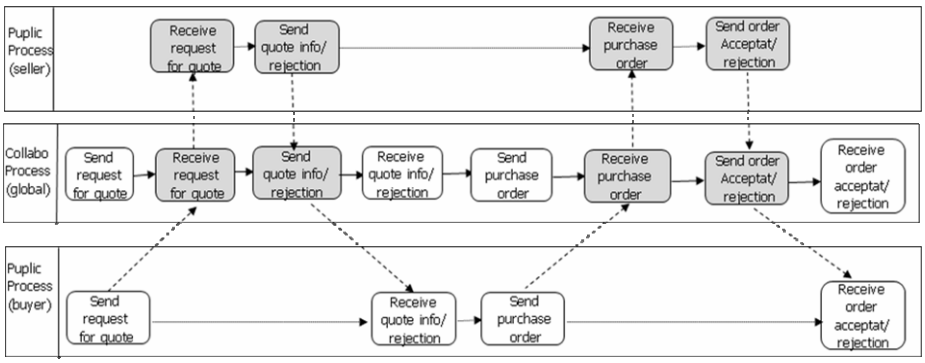

Fig.2. An example of an IOBP: Collaborative & Public processes

• *Public Process* abstracts information from one or more private processes and thus enables companies to hide critical information from unauthorized partners. It is an interface to the outside world which extracts only that kind of information which is necessary for interaction with one or more potential partners. A public process defines an external message exchange of an organization with its partners according to a message exchange protocol like PIPs (www.rosettanet.org). Thus a public process can be seen as general interaction description of one or more private processes from the perspective of one partner. Seller's public activities are represented in grey and Buyer's public activities are represented in white in figure 2.

• *Private Processes* are internal to an organization. They contain data not to be revealed by default (private activities are represented in grey and public activities are represented in white in figure 3). On private process level, organizations model their internal business processes according to a modeling approach that is most suitable for internal demands independently of the modeling methodologies used by the business partners [34]. For example a Seller wants to hide the "Check product catalog", "Get stock info", "Get product info" ,"Calculate product price", and " Check customer credibility" activities from Buyer.

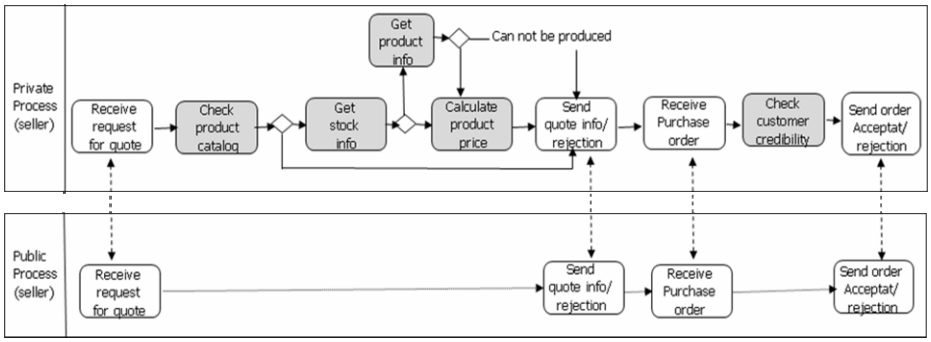

Fig.3. An example of an IOBP: Public vs. Private processes

To explain specifics of IOBP modeling, we will discuss the requirements and particularities of interorganizational business processes.

2.2 Particularities of Interorganizational Business Processes

The approaches investigated until now introduce a representation of the interorganizational business process, which uses either an existing modeling notation or its extensions. Specific artifacts are necessary for describing interorganizational business processes, among them external organizations, roles or partner types as well as messages, business documents and channels. With regard to the allocation of tasks to the actors in the interorganizational business process, partition concepts have become popular.

Important contributions to handling the specifics of IOBP come from research on workflow management, e.g. the Public-To-Private Approach ([1], [40]) and the View-based Process Model ([11], [26], [27], [33], [35], [36]). Hence and based on a literature review ([8],[19],[20],[22], [23],[41]), we deduce in the following the most important specific particularities for IOBP modeling.

1. *No central governance of the global process*. There is no entity that designs, implements, executes, and monitors the end-to-end process [24]. This requirement follows the assumption that central governance reduces the autonomy of the parties and may require visibility to details that are not necessarily visible in a purely distributed process. Then the organizations can hide their processes from other organizations. In interorganizational environments the internal business processes are one key competence of the organizations they want to preserve from the other organizations. In order to support these requirements, a flexible information hiding mechanism is required.

2. *Autonomy of business Partners*. Each partner has a full autonomy to design, implement, execute and monitor its internal processes, provided they comply with the partner's obligations toward the other partners [23]. The IOBP participants act autonomously and must coordinate themselves by means of interactions.

3. *Generation of executable processes*. The distributed execution of an IOBP starts with a common process model that all partners share and that is business oriented.

From this model every partner extracts those parts that he has to execute and augments them with arbitrary information he needs for execution [12]. Thus the used modelling language should be able to transfer the IOBP from business level into an IT-oriented workflow model on technical level like e.g. BPEL.

4. *Support of organizational units and roles*. Because different partners are involved in an IOBP, it is important to describe the organizational units with the communication and reporting relationships within the IOBP. Furthermore, the role defines the requirements profile of an organizational unit, particularly necessary for workflow applications. Thus, the modelling language should be able to describe the different organizational units and roles of the partners within the IOBP [41].

5. *Support of activity semantics.* For interoperability reasons, trading partners have to exchange electronic business documents. Since each partner has its own systems and culture, they could use different terms and metadata structures to represent their data, even when referring to the same domain of interest. Inefficiencies concerning the electronic exchange of data and information can be eliminated by the definition of central semantic and syntactic standards for exchange objects (for example business documents) as well as transfer methods (transmission medium, exchange protocols etc.) in order to achieve semantic interoperability [13].

2.3 Overview of the Current Business Process Modeling Languages

To specify IOBP, big efforts have been made during recent years and many languages have been proposed. The origins of process modeling languages are quite diverse (see Table 1). Today, there are a lot of conceptual business processes modelling languages available. This section discusses the evaluation of four well-known of them which are used generally in the intra-organizational case.

Table 1. Comparison of business processes modeling languages.

	Petri Net	EPC	UML 2 AD	BPMN 2
Issue Edition	C. A. Petri, 1962	Keller, Nüttgens & Scheer, 1992	OMG, 2004	BPMI, OMG, 2009
Perspective	IT Perspective	Business perspective	Object-Oriented perspective	IT/Business perspective
Source domain	Formal specification	Business engineering	Software engineering	Business engineering
Specification	Academic	Proprietary	Open	Open
Purpose	Analysis, verification	Description, Analysis	Description, enactment	Description, enactment

Although there is an abundance of business process modeling languages, only a few were applicable for IOBP modeling in practical cases. One major requirement of business/IT specialists in practice is that business process modeling languages should be widely used in industry and in commercial products. This is the case for EPC [32] and UML [39]. UML is of additional importance because there is a strong

organization (OMG [39]) behind UML pushing it. This is also the case for BPMN [4]. Another reason of importance is the ability of formal analysis, optimization and verification, which is the case for high level Petri Nets [29]. Thus, in this section we analyze and compare the modeling languages High Level Petri Nets, EPC (ARIS), UML2 AD, and BPMN. An overview of the evaluation results can be found in Table 2. Our evaluation scale ranges from comprehensively fulfilled (depicted by +), partially fulfilled (+/-) to not fulfilled (-).

Note that we selected those four languages among many others like IDEF3, BPML, RAD, and DFD ([7],[8],[9],[24],[37]) because they either provide a set of interesting concepts and/or are supported by a prominent industrial consortium.

Despite their diversity, all the different modeling approaches have their pros and cons. However, the comparison presented in this section shows that no single language fulfills all requirements identified for specifying IOBP.

Table 2. Comparison of business processes modeling languages (cont.).

	Petri Net	EPC	UML 2 AD	BPMN 2
Support of private, public, IO Processes	+/-	+/-	+/-	+
Representation power	+/-	+/-	+/-	+
Support of analysis control	+	+/-	-	-
Interaction patterns protocols	+	+/-	+/-	+/-
Semantic annotations	-	+	+/-	+
Support of involved role	+/-	+	-	+/-
Tool support notation	+/-	+	+/-	+
Mapping to exec. language	+ (BPEL)	+/-(BPEL)	+(BPEL)	+(BPEL)

3 Framework for Interorganizational Business Process Design

To meet the IOBP particularities we have presented above, we propose a novel approach for building an IOBP based on a Model-Driven Architecture (MDA) as illustrated in figure 4. The framework is characterized by a set of transformations/mappings (horizontal and vertical) at and across different layers.

The MDA is a framework for software development driven by the Object Management Group (www.omg.org). The following three models are at the core of the MDA: (1) *Computation Independent Model (CIM):* This is the most abstract model within MDA independent of computational technology; (2) *Platform Independent Model (PIM):* This model is defined at a high level of abstraction; it is independent of any implementation technology. It describes a software system that supports some business; (3) *Platform Specific Model (PSM):* A PIM is transformed into a PSM for each specific technology platform. Processes at PIM level shall be described in such a way, that they can be transformed to process execution languages on PSM level.

We note that the term of *metamodel* is put in relation with the OMG's MOF (Meta Object Facilities) [28], which is an abstract framework, and a four-layered architecture for defining and managing metamodels, neutral of any technology ([3], *[16] [18])*. Metamodels are simply referred to as being just "models of models" [13]. While a *model* is an abstraction of phenomena in the real world, a *metamodel* is an abstraction of the model itself. A Metamodel comprises an explicit description (formalized specification) of constructs, rules and notation for building domain-specific models.

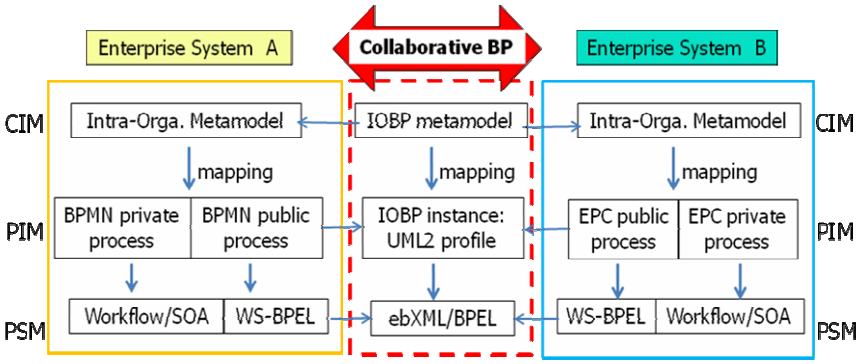

Fig.4. MDA-based framework for IOBP design

The vertical dimension distinguishes the different layers of abstraction applied in MDA and the horizontal dimension represents the collaborative modelling between two enterprises A and B. Business process models of enterprise A and B have to be shared at different level of abstraction in order to agree on and develop IOBP. The gaps between these abstraction levels are overcome by vertical transformations like presented in [19]. We assume that enterprise A and B use different business process modelling tools and languages at the PIM/PSM MDA layers. To develop IOBP both enterprises have to provide public parts of their models as basis for discussion for collaborative modeling. The vertical transformation in the downward direction corresponds to process automation approaches where conceptual models are transformed to executable processes. Both enterprises have to exchange at least parts of their models as a basis for collaborative modeling (UML 2 [39], ebXML [41]). Hence, models of enterprise A (BPMN [4]) and B (EPC [32]) are shared at PIM layer.

4 Description and Evaluation of the Related Works

Before we present our approach for IOBP metamodeling we will briefly refer to some related work in the following propositions done in the field of Workflows/Business Process metamodels.

List et al. [22] developed a generic metamodel composed of 5 contexts. They are inspired from the work of [7]. On a high level, this metamodel addresses the following views: Business Process Context Perspective, Behavioral Perspective,

Functional Perspective, Informational Perspective, and Organizational Perspective. The functional perspective represents what process elements are being performed, and what flows of informational entities, are relevant to these process elements. The behavioral perspective basically describes the order in which the different activities are executed. The organizational perspective describes the organization structure and, in particular, the resources and in which way these are involved in the BP. The informational perspective describes the information that is involved in a BP, how it is represented, and how it is propagated among the different activities. The business process context perspective captures important business process context information like process goals and performance measures or process type. However, this metamodel is not well adapted to represent interorganizational relationships.

In the proposition of Morley [25], the metamodel is based on two assumptions. First, the underlying modelling approach is a top-down one. A Process is initially defined by the Purpose assigned to it. It can be described at several levels of granularity, but the last level is the only one to be detailed. This is particularly useful when drawing cartography of all the enterprise business processes. Then, the notion of Activity is a central concept, due to the influence of the standard process definitions dedicated to enterprise modelling. The starting point is to model the Activities and then to define the suitable organization with Roles and Actors. However, this metamodel is not well adapted to represent interorganizational relationships.

Kradolfer [17] develops a workflow metamodel that allows defining the functional/structural, informational, behavioral, and organizational aspects of workflows. The workflow metamodel is modular in the sense that the various elements (workflows, organizational entities, etc.) can be specified independently of each other, and in that no assumptions are made in which context the elements are going to be used. For instance, activity assignment, control and data flow are not specified with the activities themselves, but only when the activities are used within a workflow. The metamodel is activity-centric in that it allows to “think” in terms of activities/workflows and their results instead of states or transitions. However, this metamodel lacks the representation of some IOBP elements (private and public business processes).

Saidani and Nurcan ([30], [31]) provide a start points for the definition of a methodology allowing the design of adaptive and flexible BP metamodels according to the situation at hand. They have introduced the concepts of BPM-chunk and business method. They promote the fact that the final business process model has to be created from the set of proposed chunks in order to suit to a particular situation. Their approach aims to make easier the definition of flexible and customized meta-models. However, this metamodel do not consistently support interorganizational model requirements and concepts.

5 The Proposed IOBP Generic Metamodel

There is a lot of work done on the definition of intra-organizational business process metamodel ([2],[3],[5],[10],[12],[16],[17],[22],[25],[30],[34]), but it misses some research clearly addressing the case of the interorganizational business process

metamodel. Relying in the approaches of these metamodels, we extend and adapt them into one combined high level generic metamodel addressing all the requirements of the IOBP seen before.

For this aim we structure our metamodel into four aspects according to the metamodel developed by Curtis et al. [7]: *functional, behavioral, organizational, and informational*. Besides the four business process aspects, there are further non-functional requirements a business process metamodel should fulfill: *enactability, ease of use, correctness criteria, evolution, and reuse.*

For readability reasons, we display the most important concepts in each of the four aspects separately in a UML class diagram.

- *Functional aspects: What has to be performed?*

The functional aspects of the metamodel are shown in figure 5. The concept of activity is one of the core concerns of every metamodel we studied. To enable an exchange of process data using IOBP, information might be hidden via "private process", "public process", and "collaborative process" process elements, which hide critical private process data.

Events are things that "happen" during the course of a business process. There exist three types of events: *interrupt*, *temporal*, and *trigger*. Examples of these events include change in delivery date, change in price, etc.

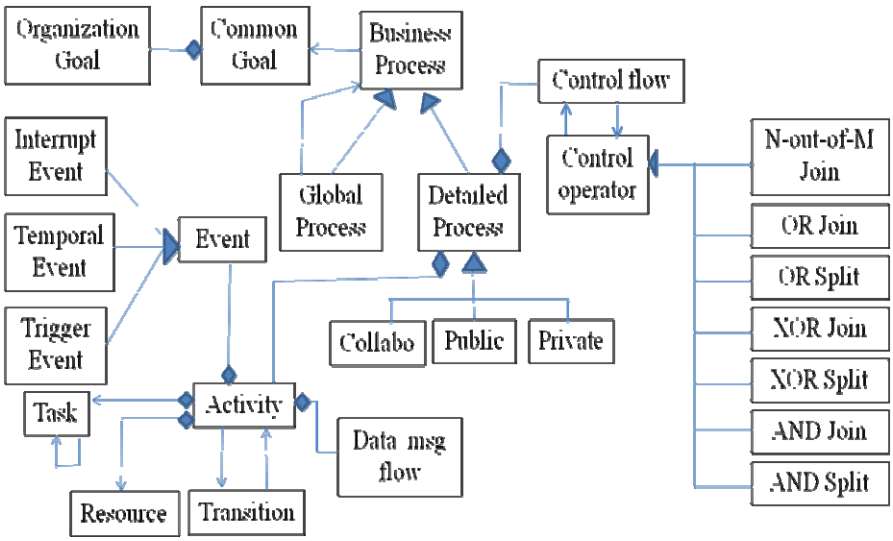

Fig. 5. Functional & Behavioral aspects metamodel

The figure 6 depicts the application of the metamodel functional aspects to the purchase order processing IOBP example seen before in the section 2.1.

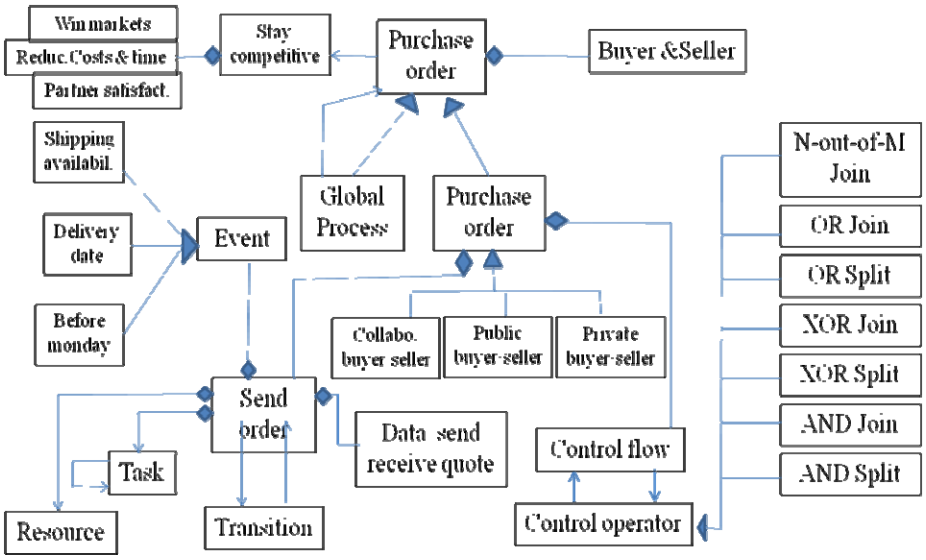

Fig. 6. Example of Functional & Behavioral aspects metamodel

- *Behavioral aspects: How is produced? (Control flow, data flow,, rules)*

The behavioral aspects of the metamodel are shown in figure 5 (analogue to [22]). Specification of control flow is essential in IOBP for the coordination of business process participants. Our metamodel supports the basic (sequence, branch) structures in order to be programmatically complete. Activities and events are connected by sequence flows indicating the order in which activities will be performed or events occur in a business process. Conditional expressions and various split and join restrictions are provided for advanced branching and synchronization patterns.

- *Organizational aspects: Who does it? (Stakeholder, role, and organizational unit)*

The organizational aspects of the metamodel are shown in figure 7. We can distinguish two major categories of "process *stakeholder*". In the first one the stakeholder is concrete. It may be a person, a computer program, a department, a position in the enterprise but it is an entity which exists apart from the process. In the second category the stakeholder is abstract. It defines a role which is played in the process and covers a set of properties (skills, capabilities, degree of responsibility …) which may be expected from the concrete stakeholder which will be assigned to this role. Hence, the modelling of IOBP requires an additional role model different to the internal role model. It should allow specifying the role of the organization as a whole in a public business process. A "*collaboration role*" defines the observable behavior that a party exhibits when collaborating with other parties in the public process.

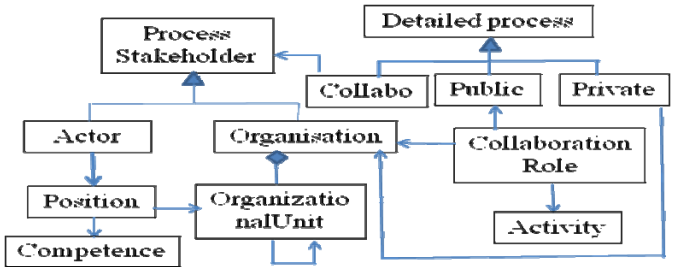

Fig. 7. Organizational aspects metamodel

The figure 8 depicts the application of the metamodel organizational aspects to the purchase order processing IOBP example seen before in the section 2.1.

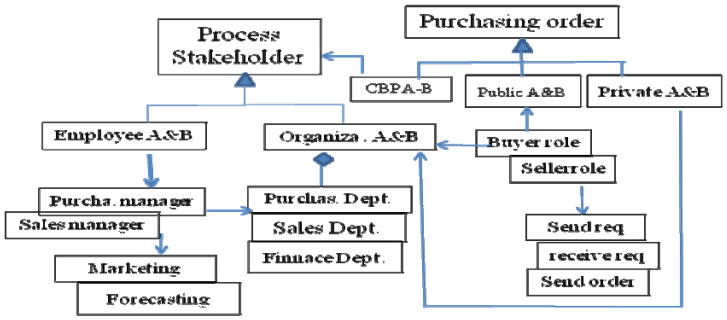

Fig. 8. Example of organizational aspects metamodel

- *Informational aspects: What is produced/exchanged? (physical resource, business document, service, software application, information object)*

The informational aspects of the metamodel are shown in figure 9. There may be lot of things behind the resource concept. On one hand resource artifacts are considered to be pieces of information. On the other hand they are concrete products like material, service or information. The resource may be of different nature according to the nature of the field covered by the metamodel. Some focuses on software process and others on manufacturing or service supplying processes.

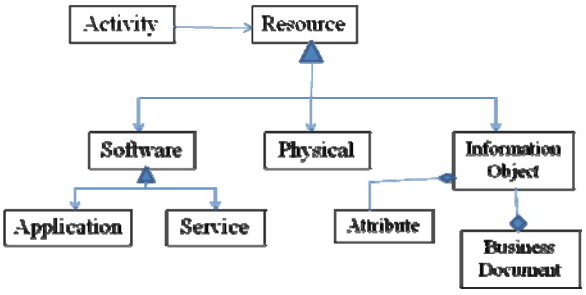

Fig. 9. Informational aspects metamodel

In other words, informational aspects represent elements describing information, material or other artefacts that are objects used by the process activities, e.g. Business documents, material that is to be sent, money that is to be received, etc. This is inspired by the workflow data patterns as well as by the input/output view of ARIS [22]. Specification of data flow must additionally consider autonomy and privacy of organizations.

The figure 10 depicts the application of the metamodel informational aspects to the purchase order processing IOBP example seen before in the section 2.1.

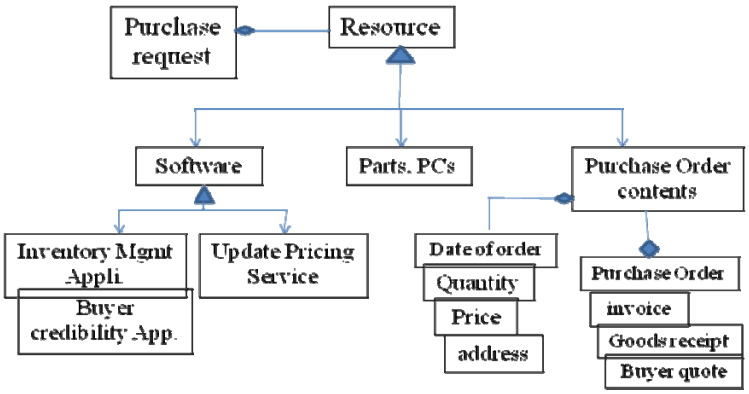

Fig. 10. Example of Informational aspects metamodel

6 Conclusion and Future Research

The increasing interest in process engineering and application integration has resulted in the appearance of various intensive works related to business process metamodeling both in academia and in the industry. The importance of IOBP has been widely recognized, leading to a variety of approaches and proposed solutions to their design and implementation. To describe and analyze existing approaches to model business processes we first described requirements distinct for interorganizational scenarios. For the representation of the IOBP elements the approaches of the intra-organizational business process modeling languages like EPC, BPMN, and UML 2 AD were adapted and extended because they do not address conveniently the particularities of the interorganizational business process. So, we developed an IOBP independent generic metamodel common to these languages which ensures the best suitability to model IOBP.

Modelling IOBP requires specific constructs and methodologies, and requires a high-level model and the corresponding executable one for exchanging and merging behaviors, resources and activities. Our current research activities focus on employing the MDA approach such that, based on a platform independent model of an IOBP, it is possible to automatically derive business process specifications expressed in the specification languages best suited for any of the different activities.

The developed generic IOBP metamodel provides the capability to represent and model business processes independent of notation or methodology, thus bringing these different approaches together into a cohesive capability.

As further work, we will validate the metamodel by instantiating it with a case study example in order to verify the completeness of the proposed concepts, then completed it with the necessary transformations to the involved business process models (EPC, UML2 AD, and BPMN) according to the MDA approach.

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