

Inter-Organizational Business Processes Modelling Framework

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Abstract. An Interorganizational Business Process (IOBP) is an organized group of joined activities carried out by two or more organizations to achieve a common business objective. A consequence of this is that business process modelling and design used inside an organization have to be enhanced and extended to cope with interorganizational business particularities. Thus, methods are required to describe and automate interorganizational business processes in an efficient manner. Modelling IOBP involves new challenges, mainly the ability to cope with autonomy, privacy, heterogeneity, and the support for coordination through mutual agreements. As a contribution to this area, this paper proposes a framework for IOBP modelling based on MDA approach which relies on the principles of SOA. Thus, the framework considers three levels in a top-down manner: business (organizational), conceptual (logic) and technical (execution).

Keywords: Interorganizational business process, business process modelling, interorganizational business process metamodel, MDA-based framework, e-procurement.

1 Introduction

The growing importance of cooperation is a result of globalization in combination with the disappearance of political borders and above all technological advances caused mainly by the Internet. Collaboration between companies like in supply chains 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 [3].

Thus, the need for connecting information systems of collaborating organizations has become increasingly common. To achieve this, Interorganizational Information Systems (IOS) is needed to facilitate interoperation of disparate information systems of different organizations. One way of facilitating IOS deployment with less implementation effort for each e-business partner, is to apply e-business frameworks that provide standards and specifications enabling businesses to communicate efficiently over the Internet. Significant advantages, such as increased speed, efficiency, and reliability, can be obtained by automating IOBP. IOBP are the enabler of such business environments. The design and implementation of inter-enterprise information systems involves the fulfilment of particular: the flexibility and ability to cope with change, decentralized management of

IOBP, peer-to-peer interactions, preservation of enterprises' autonomy and privacy, and the required support for interoperability.

In this paper, we discuss the consequences of interorganizational relationships for the business process modelling architecture of the participating enterprises. Though, we conduct explorative research which is considered appropriate for analyzing particularities of interorganizational processes in comparison with internal processes. Having achieved this task, we present our MDA-based framework for IOBP modelling.

The remainder of the paper is structured as follows. In section 2, we cover the basic concepts of IOBP. In section 3, we explain, in detail, the aspects of the proposed generic IOBP metamodel. Subsequently, the section 4 describes the proposed IOBP modelling framework with its phases. The section 5 describes the implementation of the proposed architecture. Finally, the paper finishes giving a summary and an outlook to future work.

2 Basic Concepts of Interorganizational Business Processes

Business process is defined as a flow of related activities that together create a customer value [8]. A typical high-level business process describes the means by which the organization provides value to its customers, regardless of the function of individual departments.

2.1 Particularities of Interorganizational Business Processes

Before modelling IOBP, It is necessary to analyze the characteristics of IOBP in comparison with internal private (intra-organizational) 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 ([11], [26]). IOBP need close coordination among networking partners. In order to illustrate the IOBP concepts, we regularly refer to the following corporate procurement process example scenario depicted by the Figure 1 (Private process in grey and public process in white). The procurement application concerns two trading partners – a buyer and a seller – which are collaborating and need to network their business processes. Each of the participants has his internal business processes that are of different platform nature. For more details about this example we can refer to [3].

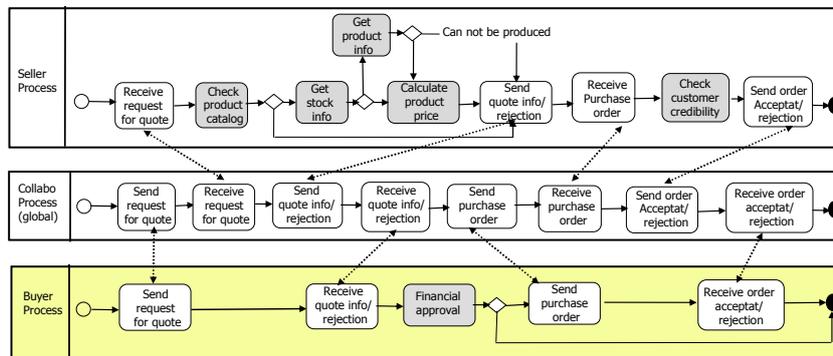


Fig.1. An example of an IOBP: collaborative, public & private processes

Important research approaches to handling the specifics of IOBP come from approaches for workflow management, e.g. ([1],[3],[5],[11],[14],[16],[20],[26],[28]), current extensions of process modelling ([2],[24],[29],[31]), and B2B standards [18], but has been limited to the process layer so far. They consider a process described either as a Private (orchestration, internal or executable), Public (local choreography, abstract or view), and Collaborative (global choreography, cross-organizational or interorganizational) in order to better separate the information density of different areas of concern. To explain specifics of IOBP modelling, we will discuss their requirements and particularities [3].

- *Decentralized governance of the global process.* There is no entity that designs, implements, executes, and monitors the end-to-end process [15]. 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 distributed process.
- *Need for Internal information privacy.* 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. The information provided to participate in an IOBP should not necessarily allow conclusion to the participant's internal realization of the functionality.
- *Autonomy preservation of business partners.* An IOBP assumes that each participating business in a B2B transaction is autonomous, that is, it is able to decide the conditions of the interactions, i.e., when, how and with whom. 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 [18]. The IOBP participants act autonomously and must coordinate themselves by means of interactions.
- *Interactions between business partners.* This is achieved via interactions flow (message and information exchanges) for connecting business partners.

2.2 Overview of the Current Business Process Modelling Languages

The origins of business process modelling (BPM) languages are quite diverse. Surveys comparing different types of business process modelling languages are provided in ([3],[8],[17],[18],[19]). Some approaches are mainly used in the requirements specification phase to support the communication with business domain experts. Resulting models are usually on a rather abstract level and tend to hide implementation complexity. Other approaches are more implementation oriented and sometimes seem to be a reverse engineered graphical notation of workflow languages or of Web Services orchestrations and choreographies [29]. The approaches investigated introduce a representation of the interorganizational business process, which uses either an existing modelling notation (UML2 Activity Diagrams [30], EPC [25] or BPMN [21]) or its extensions. Specific artefacts are necessary for describing IOBP, among them external organizations, roles or partner types as well as messages, business documents and channels.

Although there is abundance of BPM languages and despite their diversity, only a few were applicable for IOBP modelling in practical cases. In other words, there is no single language which fulfils all requirements identified for specifying IOBP, such as: enterprise autonomy, decentralized process owner, peer-to-peer interactions and collaborations. Thus, in this section we analyze and compare the modelling languages UMM (UN/CEFACT Modelling Methodology) [13], EPC (ARIS), UML2 AD, and BPMN.

Furthermore, UML2 Activity Diagrams, EPC and BPMN are more suitable to model public or private processes from the viewpoint of one partner instead of showing the peer-to-peer interactions between the partners as a whole. Although BPMN allows the definition of IOBP by representing the message exchange among public processes of the partners (BPMN *pools*), it does not provide the semantics to describe the dependencies of the global control flow of the message exchange.

UMM focuses on developing a global choreography of interorganizational business processes and their information exchanges. UMM models are notated in UML syntax and are platform independent models. The platform independent UMM models identify which services have to be realized in a service-oriented architecture implementing the business collaboration. This approach provides insurance against technical obsolescence. It is a top-down approach that makes use of worksheets to capture domain requirements. UMM do not provide a complete development process to generate IOBP executions. Although UMM claims independence of the technology, the main conceptual elements are those used in ebXML/BPSS because the BPSS metamodel is a subset of the UMM metamodel. Hence, this methodology influences the adoption of one standard (ebXML).

3 Interorganizational Business Process Modelling Framework

In order to accomplish inter-organizational integration at both business and technological levels, one of the main challenges is the modelling and specification of IOBP. Process interaction can be achieved via a commonly adopted process definition language (IOBP metamodel). It allows full interoperability because it enables business processes to interact at the level of any modelling element.

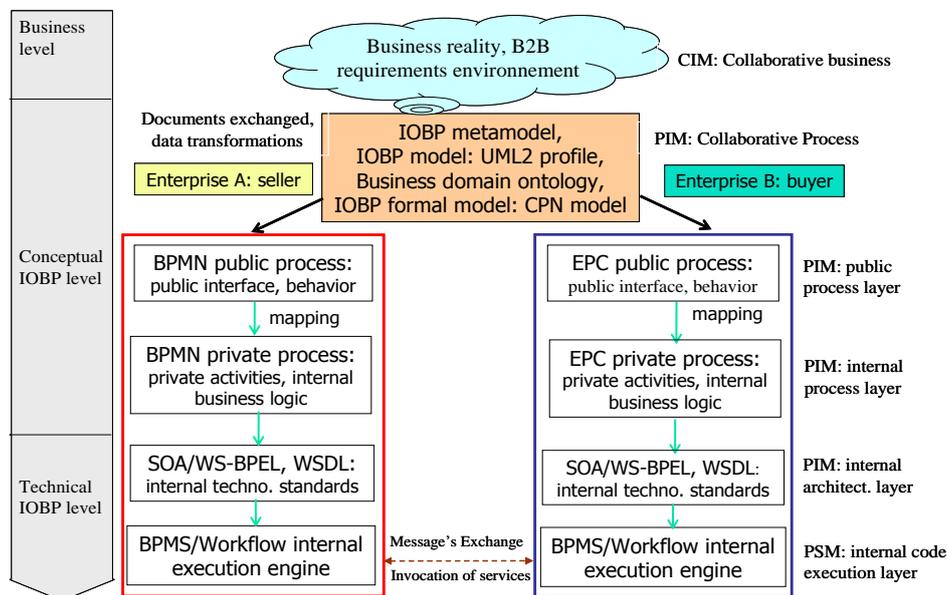


Fig.2. Framework for IOBP modelling

To meet the IOBP specifics we have presented above, we propose a new framework for building an IOBP based on a Model-Driven Architecture (MDA) [22]. The MDA-based development process is characterized by a set of vertical transformations across different layers using Atlas Modelling Language ATL [4]. The vertical transformation in the downward direction corresponds to process automation approaches where conceptual process models are transformed to executable processes. Multiple languages and standards are emerging to support IOBP modelling and existing approaches have been enriched to address IOBP specific modelling requirements ([10],[15], [16],[18],[19], [31]), but they do not fulfil the inter-organizational interactions issues. In [24] the authors proposed architecture to derive public processes from collaborative processes. However, they focus on the use of a centralized broker to implement and govern B2B interactions. In [2] instead they design collaborative processes in a decentralized manner.

Therefore, in the Figure 2 we depict our proposed framework which supports: the design of IOBP independent of particular B2B standards (WS-BPEL, ebXML, RosettaNet, etc.); and the automatic generation of public interfaces based on an IOS standard from conceptual IOBP models. The MDA-based framework is decomposed into four steps:

Step 1: Collaborative business requirements phase at CIM layer

The collaborative business requirements phase at CIM level consists in analyzing the problem domain and identifying the business requirements. This is jointly carried out by the business partners. In this phase, also referred to as agreement of the inter-organizational collaboration, the partners are determined by the common goals of the collaboration and the aspired beneficial situation of all partners. The common purposes of the collaboration have to be defined as synthesis of the individual ones. Hence, we should capture the process participants (partners and the roles they fulfil) and their communication relationships. We also define the collaborative agreement parameters and the hierarchy of common business goals to be fulfilled by partners. Then we identify the IOBP required to achieve common business goals. In this phase we define architecture for the product, service and information flows, including a description of the various participants and their roles.

Step 2: IOBP model & metamodel definition phase at PIM layer

The modelling and design of an IOBP raise a challenge related to increasing interoperability of business processes between organizations. Hence, due to the number and heterogeneity of modelling languages, easy (horizontal) exchange of business process models is required. This is performed by suggesting a common metamodel which facilitates model transformations as well XML-based exchange formats for business process models.

The IOBP is modelled with UML profile- i.e. a set of stereotypes, tagged values and constraints - in order to customize and tailor the generic UML metamodel for the specific needs of modelling the collaborative space in B2B. This profile instantiates the generic IOBP metamodel proposed for this context. This metamodel is discussed in the next section. Therefore, the use of a UML Profile allows us: provide a vocabulary more suitable to model IOBP; add semantics and constraints to the UML metamodel from the modelling domain of IOBP; and reuse existent UML case tools to model IOBP.

Step 3: Generation of Public and private processes phase at PIM layer

Although IOBP define how partners will coordinate their activities, these processes are not executable. IOBP require the definition of public and private processes each partner has to implement for executing common process. A public process defines the public behaviour of the role an enterprise performs in an IOBP at PIM layer. It defines the public

and externally visible behaviour of a partner in terms of the activities that support the receiving and sending of messages with each other. The public process can be derived from the IOBP.

An internal executable process or orchestration processes is derived from a public process. The internal business logic includes the activities for producing and processing the exchanged information as well as data transformations and invocations to internal systems. This phase consists on defining the private view, for each partner, of the role the partner performs in the IOBP. To do that, internal activities, which are required for generating the information to be sent and processing the information to be received from partners, have to be added to the public process to define the corresponding private process.

Step 4: Internal code execution phase at PSM layer

A Service Oriented Architecture (SOA) and Web Services are good candidates to be used for defining an IT architecture model within a conceptual viewpoint. So, in the technological level, the internal processes can be implemented as Web Services [23]. To do that, metamodels of the selected IOS standards should be provided (EPC and BPMN in the Figure 5). The platform-specific IT model must contain the necessary platform-specific information (e.g. concrete message formats sent or received by partners, the transport protocols used, etc.) in order to put the IT architecture model in operation. Then, the specifications of business processes and system interfaces by using IOS standards (BPEL) are derived from internal respective processes. Hence, internal private processes are thus transformed into automated Java application with user interaction by desktop integration mechanisms such as Web portals.

4 The Proposed Inter-Organizational Metamodel

Before we present our approach for IOBP metamodeling we will briefly refer to some related work done in the field of Workflows/Business Process metamodels ([3],[6],[7],[12],[16],[27],[29]), but it misses some research clearly addressing the case of the IOBP metamodel, and there is no explicit consideration of generic business requirements is made to relate to generic interorganizational scenarios. Thus, we present a generic IOBP metamodel as depicted in Figure 3.

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

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. Examples of these events include change in delivery date, change in price, etc. The behavioural aspects of the metamodel are those analogues to [17].

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

The organizational aspects of the metamodel embed the concepts of process stakeholder and collaboration role. Roles which are defined internally by the individual partners have to be assigned to the roles defined in the IOBP model. We can distinguish

two major categories of “process stakeholder”. In the first one the stakeholder may be a person, a computer program, an organizational unit, a position in the enterprise but it is an entity which exists apart from the process. In the second category the stakeholder defines a role which is played in the process 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 an IOBP.

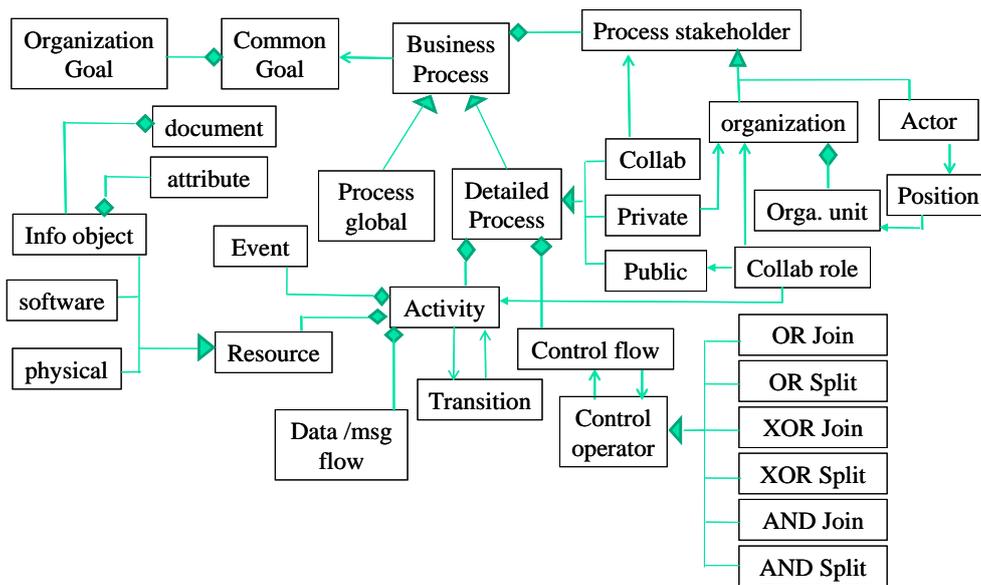


Fig. 3: Inter-Organizational business process metamodel

- *Informational aspects: What is produced/exchanged?*

There may be lot of things behind the resource concept. On one hand resource artefacts 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.

IOBP metamodel related work

The definition of a CBP metamodel is not a particular new approach; much work has been performed in this area. However the focus of this work is different. The proposed solutions differ from each other in the implementation details, in the scope of issues addressed, and in the level of privacy and autonomy granted to the participating organizations ([7], [12], [16], [27], [29]). In this section, we give an overview of the related work regarding the CBP metamodelling. In order to compare and evaluate the reviewed CBP metamodels, including our consolidated metamodel, we focused on the following four requirements: decentralization of the collaborative process governance, technology independent based development, autonomy and privacy of business partners, and

interactions between partner roles. We consider these requirements as the core characteristics that should be fulfilled by business organizations when they plan to develop business collaboration. While past approaches strive to enable the operation of a collaborative process, no explicit consideration of generic business requirements independent of technology standards (high level abstract metamodel) is made to relate to generic collaborative scenarios. Therefore, in these approaches the definition of technology-independent process models is not supported. Henceforth, the use of workflows to manage collaborative processes is not well appropriate. Also the extension of particular technological-dependent metamodels, such as EPC or BPMN, represents a constraint for flexibility and interoperability. EPC is a proprietary one that is only supported by IDS Scheer ARIS [25]. Instead, our proposal uses the well-known standard UML2 notations in order to facilitate the learning of the implementation tool by business analysts and system designers.

5 Implementation of IOBP Modelling Framework

Architecture of an Eclipse-based IDE is under current development, which contains interoperable and integrated modelling tools and model transformation engines that support the proposed framework.

This IDE is based on the Eclipse open development platform [9], and supports the IOBP UML2 profile defined and the model transformations that are necessary to carry out the verification of IOBP. By providing an Eclipse-based IDE, we take advantage of a well-known development environment and the Eclipse platform extension mechanisms that enable the creation of editors and model transformation machines as well as the reuse and integration of existing tools.

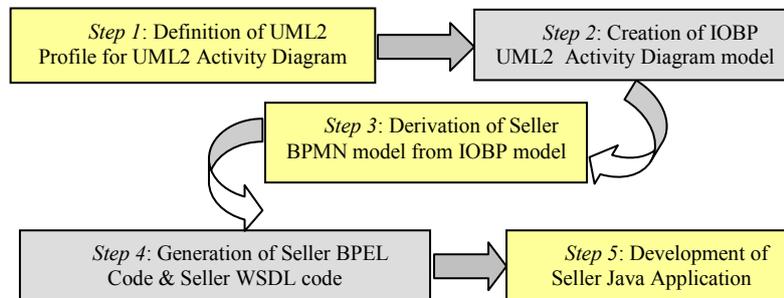


Fig. 4: Main steps of the transformation engines

In order to support the design and implementation of IOBP, we add to the Eclipse IDE the following components which will be used as showing by the Figure 4:

- A set of Eclipse-based plug-ins, which support the definition of UML2 profile models. The Eclipse-based plug-ins for EPC, BPMN, BPEL and WSDL, which are provided by the Eclipse community, are added to this IDE. Tools should also be added to support the building of SOA models.
- A set of Eclipse-based plug-ins in order to support the proposed model transformations required in the framework. They are based on ATL tool that supports the building of model transformation machines.

6 Conclusion and Future Research

This research presents a proposed architecture to build integrated interorganizational information systems using top-down methodology which is based on MDA and relies on the principles of SOA paradigms. We first have paid special attention to the requirements distinct for interorganizational interactions. Secondly, the problem of exchangeability of business process models between organizations, more specifically the public views on these models was being addressed. Hence, for the representation of the IOBP elements we provide a generic IOBP metamodel in order to instantiate it as global business process from which the internal business processes of the partners can be derived. Then, we proposed a framework for modelling IOBP based on MDA and relies on SOA paradigm. So, we developed an IOBP model as UML 2 profile which ensures the best suitability to model IOBP in high abstract level. In this way, the generated solution can be reused to implement it with different IOS technologies.

There are several open issues in this paper that we plan to address in the future. First, we will validate the framework by instantiating it with a case study example in order to verify the completeness of the proposed concepts. Second, we plan to further investigate the integration of bottom-up approaches to allow the reuse of existing processes or systems of the enterprises via Web Service composition.

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