DESIGNING AND IMPLEMENTING CROSS-ORGANIZATIONAL BUSINESS PROCESSES - Description and Application of a Modeling Framework

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1 Introduction

Increasing interconnection of organizations is a global trend. Independent organizational units or entire organizations build temporary or permanent collaborations, which pool resources, capabilities, and information to achieve a common objective [[17]]. New business models are emerging and existing procedures are redesigned forming long running processes between various (external) partners – so called Cross-Organisational Business Processes (CBPs).

The successful implementation of CBPs requires a clear understanding of the common processes across all involved stakeholders. It also needs a structured approach to interlink internal (private) processes of an enterprise into a CBP. Ideally the implementation of CBPs starts on business level using enterprise models to identify business structures between and within companies as well as their interrelations. The main target is to achieve a common agreement between all stakeholders involved ("process owners"). Based on this agreement an interim level between design and execution (technical level) is used to perform a detailed execution oriented modelling and evaluation in a platform independent way. This technical level allows the generation of data and formats that are required for automated process execution.

Thus, the aim of this paper is the development of a framework to model interoperable business processes and to share practical experiences made within its application in the furniture industry. It focuses on the first two levels whilst details in the execution level are not regarded. It is the intension to close the gap currently existing between processes defined on a business level and executed models (Fig. 2). The focus of the framework is on supporting companies to agree on their

common CBP. The technical level model then serves as the basis for the implementation and enactment of the CBP in the organisations of the partners.

Based on the analysis of a collaboration scenario we verify characteristics and requirements that have been formulated in [[7]] and have to be addressed in a framework for CBPs (Section 2). The framework is presented in Section 3. It has been developed within the ATHENA research project (http://www.athena-ip.org). We describe the two dimensions of the framework and explain how the framework is applied. We then sketch a prototypical implementation of the framework within the furniture process (Section 4).

2 Scenario Analysis

The scenario describes the interaction between a furniture manufacturer, a retailer and a supplier. In the following we concentrate on the quotation and order part of the scenario. Fig. 1 gives an overview of the interactions between partners.

Fig. 1. Furniture eProcurement Scenario

The scenario consists of two processes, the retailer-manufacturer collaboration and the manufacturer-supplier collaboration. The retailer-manufacturer process starts when the retailer prepares a Request for Quotation (RfQ) for a decoration project. This RfQ is sent through the Internet to the manufacturer's sales department. The Sales Department takes care of RfQ processing and contacts other departments, such as product design or administration, in order to complete the quotation to be sent back to the retailer. The retailer accepts the quotation and sends back an order for requested products.

During order processing (creating Bill of Material and Production) the manufacturer has to order material in case the warehouse is understocked. This triggers the manufacturer-supplier collaboration. First the appropriate supplier is selected from the supplier portfolio of the manufacturer. The procurement department prepares and sends an RfQ to the appropriate supplier based on the information provided by production. The supplier calculates the production cost of the requested material and responds with a formal quotation including the expected amount and a forecasted delivery date. Once the manufacturer has received back the order from the supplier, it is processed and an order confirmation is sent to its retailer.

A detailed analysis of modelling and implementing the scenario at the respective partners revealed the following challenges:

- It is necessary to provide a level of abstraction on which the partners first agree on the business goals of their collaboration. To implement the

collaboration with ICT systems the involvement of technical staff is necessary. Thus a successful modelling framework should support different graphical modelling languages meeting the needs of all involved stakeholders.

- The internal business processes of each partner have to be linked into a CBP without revealing confidential private information. For instance, the supplier might use internal procedures to calculate the discounts depending on the amount of material that is ordered and previous purchase orders. These internal procedures should not be published to the partner.
- Simplified process adoption has to be achieved. E.g. a supplier interacting with different manufacturers should not require different private processes for each collaboration he is involved in.
- Depending on the level of trust between the collaborating partners, a scalable exposition of internal processes should be possible.

These requirements have already been identified in [[7]] on a more detailed level. The framework presented in the following section addresses these requirements as well as the requirements identified in the case study. It includes concepts for modeling in various levels of abstraction for different modeling languages as well as required model transformation mechanisms.

3 A Framework for the design and implementation of CBPs

3.1 Related Work

Different modelling frameworks have previously been defined for business process or enterprise modelling. These include the 'Framework for Information Systems Architecture' (Zachman Framework) [[19]] and the 'Architecture of Integrated Information Systems' (ARIS) [[13]]. Both frameworks offer modelling support from different user perspectives. The ARIS architecture distinguishes between organization, function, output, information and control views. The purpose of the Zachman Framework is to provide a basic structure which supports organization, access, integration, interpretation, development, and management of a set of architectural representations of the organizations' information systems. Although both frameworks combine different user perspectives and allow modelling on different levels of abstraction, the focus of these frameworks is on internal process modelling. They lack methods which allow modelling of cross-organisational collaborations as a creation of an external view on the organisation (as required for CBPs) is not supported.

The UN/CEFACT Modelling Methodology (UMM) is specifically designed to provide a modelling procedure for specifying CBPs, in a technology neutral, implementation independent manner [[18]]. However, there is no notion of process abstraction and no support for linking up internal processes to CBPs without revealing confidential internal information.

3.2 Dimensions of the Framework

The framework consists of two dimensions:

1. Modelling levels between design and execution of the CBP, and
2. Aggregation and filtering of information trough additional abstraction layer.

The first dimension of the modelling framework deals with the requirements of different modelling users and stakeholders involved in the business process. These levels are similar to the different types of models used in model-driven architectures, namely computational independent models (CIM), platform independent models (PIM), and platform specific models (PSM) [[11]]. However, as the focus is specifically on modelling cross-organizational business processes, different names are chosen for the three levels to distinguish the more MDI related approach as described in [[3],[4]] from the general approach of model-driven architectures:

Business level: This level represents the business view on the cooperation and describes the interaction of the partners. The CBPs modeled on this level allows for analyzing business aspects, like costs, involved resources etc.

Technical level: This level provides a more detailed view on the CBP representing the complete control flow of the process. Non-executable tasks are not regarded. Also the message exchange between single tasks is modeled on this level and can be analyzed. However, the control flow and the message exchange are specified in a platform independent manner. This supports reuse of the process models as the models on this level can be ported to execution various means.

Execution level: On this level the CBP is modeled in the modeling language of a concrete business process engine. It is extended with platform specific interaction information, e.g., the concrete message formats sent or received during CBP execution or the specification of particular data sources providing data during process execution.

The second dimension is based on the introduction of process views as an additional abstraction layer between the private processes and the CBP model as proposed by Schulz (2002) [[14], [15]]. Process views provide a process-oriented interface towards business partners. Private processes are only known to their owning organization and not exposed to the outside world. Process views are an abstraction of the private processes, containing information that needs to be published for the purpose of a specific interaction. Several tasks of a private process can be combined to one view task. This leads to the following definitions in the proposed framework:

- **Cross-Organizational Business Processes (CBP):** A CBP defines the interactions between two or more business entities. These interactions take place between two or more companies defined as valid sequences of message and/or other material input/output exchanges.
- **Private Processes (PP):** PPs refer to a specific organisation and are the type of processes that have been generally called workflow or BPM processes.

- **View Process (VP):** A VP combines one ore more PP to an abstract level that enables companies to hide critical information from unauthorized partners.

3.3 Structure of the Framework

The framework structure incorporates (Fig. 2):

- Different user groups and modellers are involved in modelling cross-organizational business processes. Their different perspectives and needs.
- The selectively hiding of internal process steps while offering a mechanism to expose CBP relevant information to partners.

At each intersection between the two framework dimensions, a possible process model can be identified to capture tasks and relationships of cross-organizational interactions. Thus, it is ensured that all relevant perspectives on CBP models as well as the processes required for the view concept are properly captured and modelled.

Models can be distinguished between mandatory and optional models for the CBP implementation (Fig.2). On the business level it is compulsory for all involved parties to create a view model, specifying the externally visible business context for a specific CBP scenario. This can be used for partner communication on management or business analyst level. Also required is a CBP model which specifies from a high level business perspective how the partner processes are interweaved.

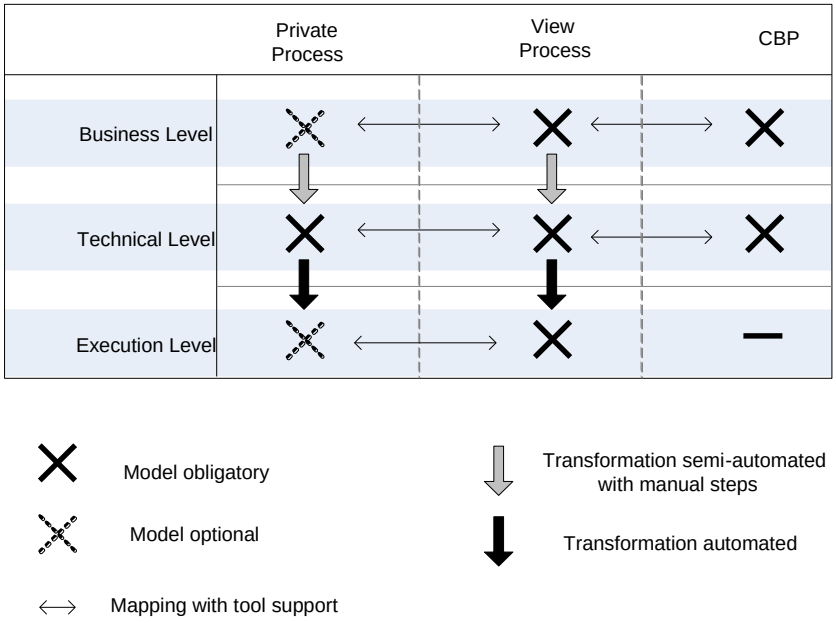

Fig. 2. Modeling Framework

The inter-enterprise coordination builds on a distributed business process model where partners manage their own part of the overall business process. A CBP specifies tasks that each of the parties is required to perform as agreed in their contract (specified in terms of business level models). Although the CBP model will not be executed and therefore does not exist on execution level [[15]], it is required for the specification of the message exchange on the technical level. It can be used for monitoring purposes in the actual enactment phase. A process view can be considered as a proxy for its corresponding private process. In other words, a process view is outsourcing its implementation to its corresponding private process [[15]]. Therefore it is mandatory that both models are specified on the technical level. The framework allows for creating various views on the same internal processes when interacting in a different context. It is the intent that a process modeller can leave a private process unchanged and create a special view process which can be adapted to satisfy specific business requirements. This is possible on all levels of abstraction.

3.4 Modelling Procedure

To complete the modelling framework, a modelling procedure is required that describes in which order models have to be created to make best use of the framework and to ensure best possible integration of existing models. Concerning the creation of views and CBPs, three possible procedures can be identified.

An inside-out approach where each company starts with the identification of their private processes and the creation of interaction specific views (cp. the dashed arrows 1 in Fig. 3). The views are then combined into CBPs (dashed arrows 2). Depending on how well the process views of the process partner fit, variations on the own view might be necessary to finalize the modelling activities (dashed arrows 3).

In an outside-in approach, the partners start identifying a common picture of the interaction in terms of a CBP model. Each partner then has to create its views according to the process steps that he will be executing. This also might need iterations for redefining the CBP (solid arrows 1 and 2 in Fig. 3). As a last step the partners have to define their private processes (solid arrows 3).

The third scenario is that one partner starts with its private processes and offers a process view to its partners. The partners can use this process based interface to link it to their internal processes via process views. This would conform to a bottom up approach for one partner and a top down for the others. Which procedure is suitable depends on existing partner processes and the relationship between the different organizations.

In terms of the different levels of abstraction, the current practice in process modelling is the outside-in approach. CBPs are first defined on business level, refined on the technical level and then implemented into an executable model for each partner [[18], [11], [13]]. Further research should address an approach where models of existing organization-internal processes can be made available on business level, providing information about existing executable processes. Managers could use this information while negotiating with business partners and an improved adoption to existing processes could be achieved.

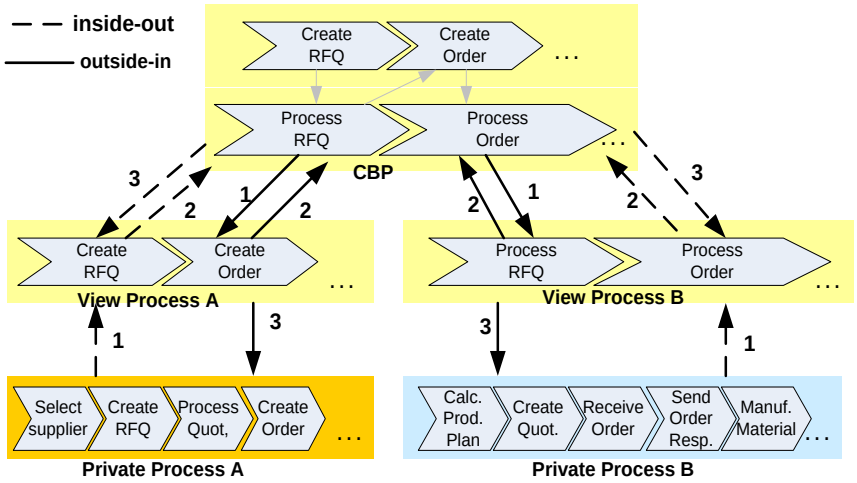

Fig. 3. Modeling procedures (outside-in vs. inside-out) illustrated with processes from the eProcurement scenario

4 Application of the Modeling Framework

The implemented prototype of the modelling framework includes the following modelling languages and tools (Fig. 4):

- On the business level ARIS [[13]] and MO²GO [[9]]: The two modelling tools are chosen to illustrate the capability to follow the CBP concept in different tools and methodologies. ARIS supports eEPC (extended Event-driven Process Chain) [[6]] and MO²GO supports the Integrated Enterprise Modelling (IEM) [[16], [10]]. Both languages offer graphical notations which are easy to understand for business analysts and allow to analyse business aspects, such as costs, involved resources etc. Thus both languages fulfil the requirements for business level modelling in general but for both languages concepts are needed which allow for a collaborative modelling. Common representations as well as differences are identified but finally both tools are able to transfer the required data to the technical level via PIM4SOA [[2]].
- On the technical level Maestro [[12]]: This tool provides a more detailed view on the CBP representing the complete control flow and message exchange of the process. The graphical notation allows to replace or delete non-executable tasks which should not be considered on this level.
- On the execution level BPEL4WS [[1]]: BPEL4WS is a de facto standard for Web services choreography and transactions and thus it was chosen as execution language.

PIM4SOA [[2]], a metamodel defined in the ATHENA project, is used for the transformation between the different levels. For a detailed discussion of appropriate modelling languages for the different levels see [[7]]. Beside of the already addressed and closely related MDI approach other related approaches aim at defining a common set of modelling constructs for business process modelling languages [[6]] but do not integrate different dimensions, for example [[19], [5]].

4.1 Business Level Modelling with ARIS and MO²GO

In order to enrich the eEPC with functionalities required to model CBPs new constructs have been implemented. To abstract from sensitive process information, the EPC is extended by the object type *process module*. This construct depicts a closed logical unit that reflects a reasonable and clearly limited part of a business process. A process module can substitute a single function as well as a sub-process. To supplement correlation between view and private process models, each view process has a unique ID. A similar mechanism is defined as process type for IEM.

An example for using process modules is shown in Fig. 5. In this figure the private process of the furniture manufacturer's order processing is shown on the left side. This process contains two sensitive sub processes: the checking of the solvency of the retailer and the calculation of a price discount. If the retailer orders more than 10 products a month 10% discount is given, in all other cases the retailer gets no discount. This process has to be distributed to several retailers in order to show them the sequence of the order processing so that they can inform their staff and configure their workflow engines. The manufacturer wants to hide his discount system from certain customers; the solvency check should be hidden always. Thus he creates two different views of the same internal process for two classes of retailers by subsuming the area labelled as "abstraction area 1" and "abstraction area 2" into process modules.

Apart from creating views of private processes in a collaborative scenario it is also necessary to define the business scenario on a high level of abstraction. Therefore, a new model is proposed that enables business experts to specify the scenario in an abstract manner while hiding sensitive process information. The model aims at adapting and optimizing the complete collaboration, therefore all organizations involved are displayed. It gives an overview of all view processes that are part of the CBP including the organisational units that are in charge of these process steps. On this level of abstraction it is not easy to organize the interaction between the participants. The reason is the lack of information concerning the internal procedure within the linked process modules. One way of dealing with this problem is describing the needed input as well as the produced output of the view processes. In the overall concept this is expressed by the input/output states in IEM or objects in eEPC. The direction of the connection shows whether the object for the view process is input or output. The specification regarding time, amount and quality gives an example about possible attributes that should/could be taken into account.

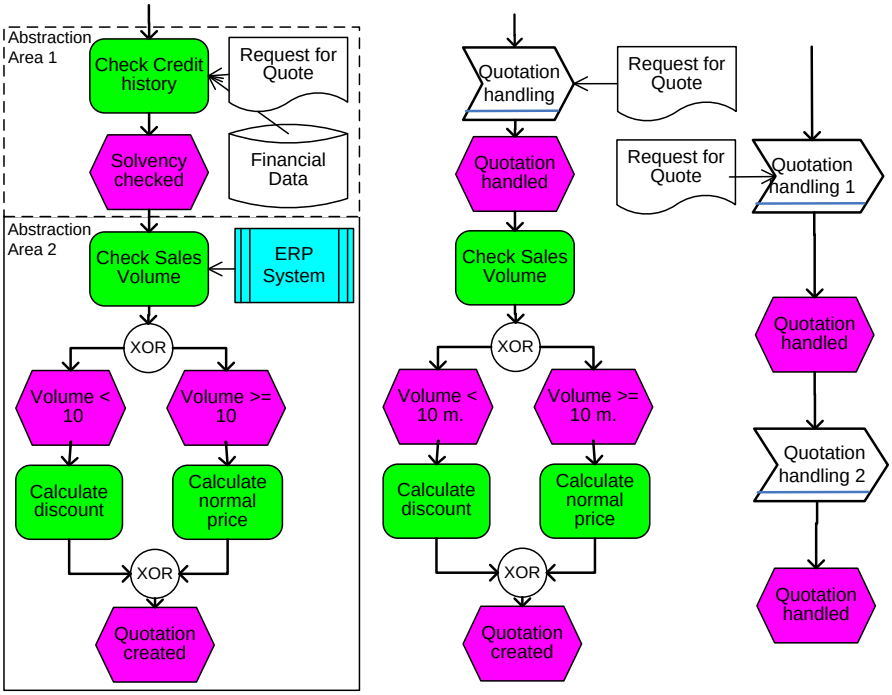

Fig. 4. Private Process of Manufacturer and derived View Processes for Retailers

The steps described so far correspond to the first part of the inside-out modelling procedure displayed by fig. 3. The manufacturer derived a View Process for the retailer and described the overall CBP. Thus, the retailer captures his role in the scenario and starts to derive a View process from its Private Process, which is responsible for ordering new products. Subsequently, he tries to match his View Processes to the View Process given by the manufacturer. If this is not possible, further negotiations and a change of the View Process proposed by the Manufacturer might be necessary.

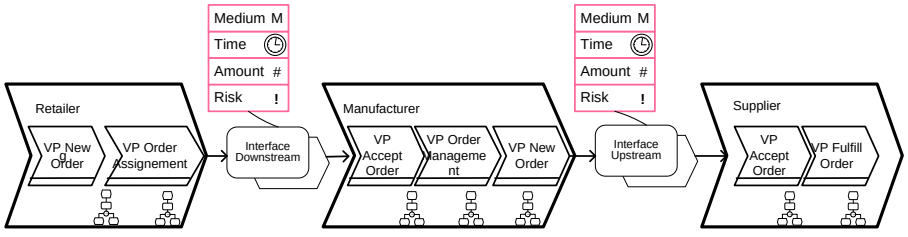

Fig. 5. CBP – Overall View

4.2 Technical Level Modelling with Maestro

The business level models created within ARIS or MO²GO are transformed to the technical level using PIM4SOA models [[2]] as an intermediate format. In particular the view processes are transformed. An XMI file format implementing the PIM4SOA metamodel is used to transfer a MO²GO model to Maestro. The processes in MO²GO can be annotated to indicate executable, non-executable processes or processes requiring user interactions. This information are used to transform only execution relevant processes. On the technical level the process models are then imported into the Maestro tool.

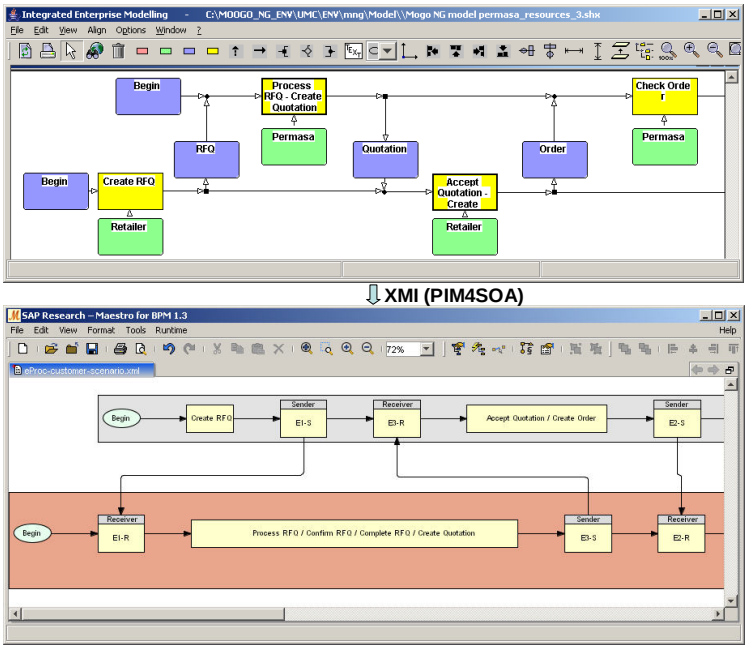

Fig. 6. Transformation of a Mo²Go Model to a Maestro Model

On the technical level the view processes are linked to existing private processes to realize the information hiding principle and are also connected to the final CBP. In this step also the message exchange between the view processes is specified. Maestro supports the creation of the CBP with a graphical modelling interface and guided procedure that leads the user through the necessary design steps. Maestro also generates all technical information describing the linkage between private processes and view processes that is then relevant for the process execution.
During technical level modelling the user also specifies the services that are called during runtime to execute the different steps in the view processes and private processes of the partners. This information is necessary to generate executable business process models.

5 Summary and Future Research

Interoperability requires a consolidated and consistent understanding across all stakeholders. To ensure a correct cooperation between two or more entities it is mandatory to build an appropriate process model. This can lead to a stronger amplification of all the cross-interface activities and constraints between the entities. We presented an approach for designing and implementing CBPs. Business level models, e.g. enterprise models, illustrate the organisational business aspects as a prerequisite for the successful technical integration of IT systems or their configurations. The technical model derived from the business level model secures the technical realisation of the process interaction and represents the bridge to the process execution.

Future work will address the realization of the (semi-)automated transformation between the levels. We will also focus on enactment of the cross-organisational business processes. Thereby, two alternatives will be considered: first a transformation of the technical level models into BPEL processes and the execution in a BPEL engine, second the direct export of technical level models in an engine that is capable of executing cross-organisational business processes.

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