A Multi-level Modeling Framework for Designing and Implementing Cross-Organizational Business Processes

Ulrike Greiner[1], Sonia Lippe[1], Timo Kahl[2], Jörg Ziemann[2], Frank-Walter Jäkel[3]

[1]SAP Research, Karlsruhe (Germany) / Brisbane (Australia)

[2]DFKI, Saarbrücken (Germany)

[3]FhG IPK, Berlin (Germany)

Abstract. Increasing cooperation of organizations leads to the necessity of efficient modeling and implementation of cross-organizational business processes (CBPs). Various stakeholders that pursue different perspectives on processes are involved in the design of CBPs. Enterprise modeling supports a common understanding of business processes for different stakeholders across organizations and serves as basis to generate executable models. Models include knowledge of internal processes as well as demands for CBPs. The paper presents concepts and a first prototype of a modeling framework supporting process designers to get a common agreement on their processes across different companies on different levels of abstraction.

1 Introduction

Increasing cooperation between 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 [1]. New business models are emerging and existing procedures are redesigned forming long running processes between various (external) partners – so called Cross-Organizational Business Processes (CBPs).

The successful implementation of CBPs requires a common agreement between all stakeholders involved ("process owners") and a clear understanding of the common processes. Ideally modeling of CBPs is supported by a modeling framework that starts from enterprise models identifying business structures and interrelations between organizations on business level. To come from business level models to executable processes, detailed execution oriented modeling and evaluation have to be performed on a platform independent technical level. To support re-use of process models and enable enterprises to keep up with the constant change in business relationships well-defined (and possibly largely automated) model transformations between the business level and the technical level should be provided.

This paper presents such a framework to model interoperable business processes. Furthermore practical experiences made with the application of the framework in the furniture industry are presented. The paper focuses on the first two levels whilst details in the execution level are not considered. It is the intension to close the gap

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currently existing between processes defined on a business level and executed models (Fig. 2).
First characteristics and requirements that have been formulated in [2] and have to be addressed in a modeling framework for CBPs are verified based on the analysis of a collaboration scenario (Section 2). The framework developed within the ATHENA research project (http://www.athena-ip.org) is presented in Section 3. We then sketch a prototypical implementation of the two dimensions of the framework. The focus within this work is on control-flow as a fist implementation goal. In section 4.1 a concept is shown how to hide sensitive information in collaborative scenarios on a business level whereas section 4.2 targets the transformation from a business to a technical level as a first step for the execution of CBPs.

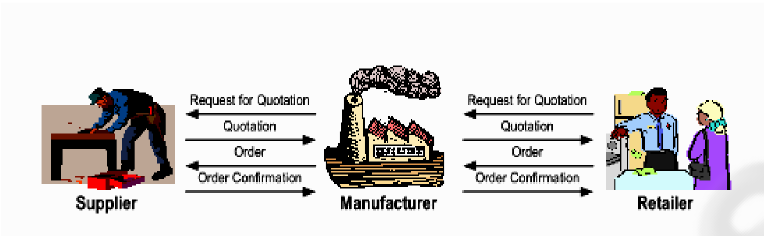

Fig. 1. Furniture eProcurement Scenario.

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 the three partners.
The scenario consists of two parts, 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. The process of the manufacturer 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.
During order processing (creating Bill of Material and Production) the manufacturer has to order material in case the warehouse is under stocked. This triggers the manufacturer-supplier collaboration (left part of the figure). The procurement department prepares and sends an RfQ to the appropriate supplier .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 modeling 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 modeling framework should support different graphical modeling languages meeting the needs of all involved stakeholders. To avoid re-modeling and to facilitate an execution of the processes defined on business level transformation concepts between the levels should be offered.
- The internal business processes of each partner have to be linked into a CBP without revealing private information. The extent to which information contained in internal processes is exposed to business partners should be easily adaptable. For instance, the manufacturer might provide a long known retailer with information about his private process that has be hidden from a new retailer. E.g. the process description for the new retailer might not reveal internal discount politics.
- Simplified process adoption has to be achieved. E.g. a supplier interacting with different manufacturers should not require different private processes for each collaboration it 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 [2] 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.

Related Work. Different modeling frameworks have previously been defined for business process or enterprise modeling. These include the ‘Framework for Information Systems Architecture’ (Zachman Framework) [3] and the ‘Architecture of Integrated Information Systems’ (ARIS) [4]. Both frameworks offer modeling 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 modeling on different levels of abstraction, the focus of these frameworks is on internal process modeling. They lack methods which allow modeling of cross-organizational collaborations as a creation of an external view on the organization (as required for CBPs) is not supported.

The UN/CEFACT Modeling Methodology (UMM) is specifically designed to provide a modeling procedure for specifying CBPs, in a technology neutral, implementation independent manner [5]. However, there is no notion of process abstraction and no support for linking up internal processes to CBPs without revealing confidential information.

3 A Framework for the Design and Implementation of CBPs

The framework consists of two dimensions:

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

The first dimension of the modeling framework deals with the requirement of different modeling users and stakeholders involved in the business process. These levels are similar to the different types of models used in model-driven architectures [6]. However, as the focus is specifically on modeling cross-organizational business processes, different names are chosen for the three levels to distinguish the more MDI related approach as described in [7] 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 allow 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 various means of execution.

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 [8], [9]. 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. A similar approach is proposed by Weske, Aalst called P2P approach (public to private) [10]. However, this approach only allows for an outside-in modeling where the internal process is defined based on an inheritance principle from the public process. It is the goal of the modeling framework proposed within this paper to support an outside-in, inside-out and mixed approach as required in a specific modeling context.

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 organization and are the type of processes that have been generally called workflow 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.

The framework structure incorporates (Fig. 2):

- Different user groups and modelers are involved in modeling cross-organizational business processes.
- 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 modeled.
Models can be distinguished between mandatory and optional models for the CBP implementation (Fig.2). On 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.

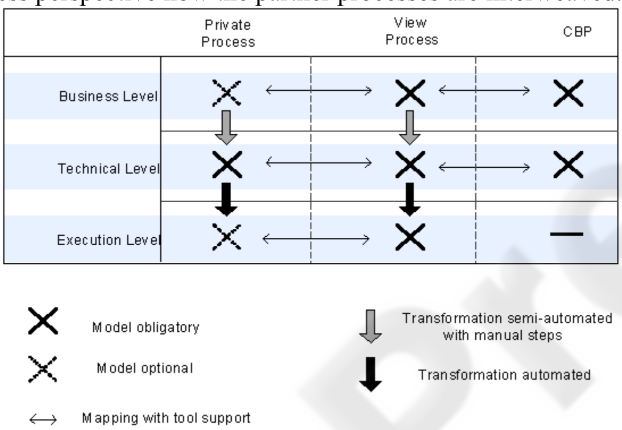

Fig. 2. Modeling Framework.

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 [9], 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 [9]. Therefore it is mandatory that both models are specified on the technical level. The framework allows creating various views on the same internal processes when interacting in a different context. It is the intent that a process modeler can leave a private process unchanged and create a special view process which can be adapted to satisfy specific business requirements.

4 Application of the Modeling Framework

The implemented prototype of the modeling framework includes the following modeling languages and tools (Fig. 3):

- On the business level the ARIS Toolset [4] and MO²GO [11]. The two modeling tools are chosen to illustrate the capability to follow the CBP concept in different tools and methodologies. ARIS supports EPC (Event-driven Process Chain) [12] and MO²GO supports the Integrated Enterprise Modeling (IEM) [13], [14]. 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 [15].
- On the technical level Maestro [16].
- On the execution level BPEL4WS [17].

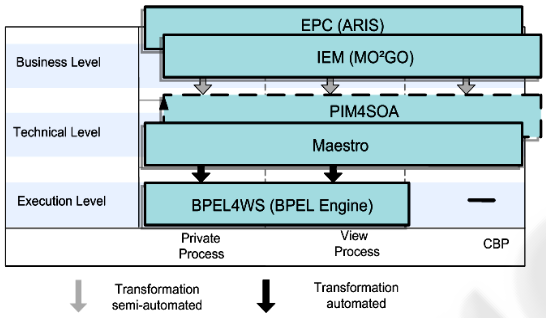

Fig. 3. Modeling tools and languages in framework prototype.

In this paper we will illustrate the abstraction of information on a business level (horizontal dimension of the framework) based on an EPC-example whereas the vertical dimension of the framework will be exemplified by the transformation from IEM to PIM4SOA [15] (transformation from a business to a technical level).

4.1 Modeling CBPs on a Business Level with ARIS

In order to enrich an EPC with functionalities required to model CBPs, new constructs have been implemented. In order 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. 4. In this figure the private process of the furniture manufacturer's order processing is on the left side. As described in section 2, the process contains an area to check the solvency and an area to calculate a possible discount for the retailer. Thus the manufacturer creates two different views of the same internal process for two classes of retailers by subsuming the area labeled 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 organizational 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.

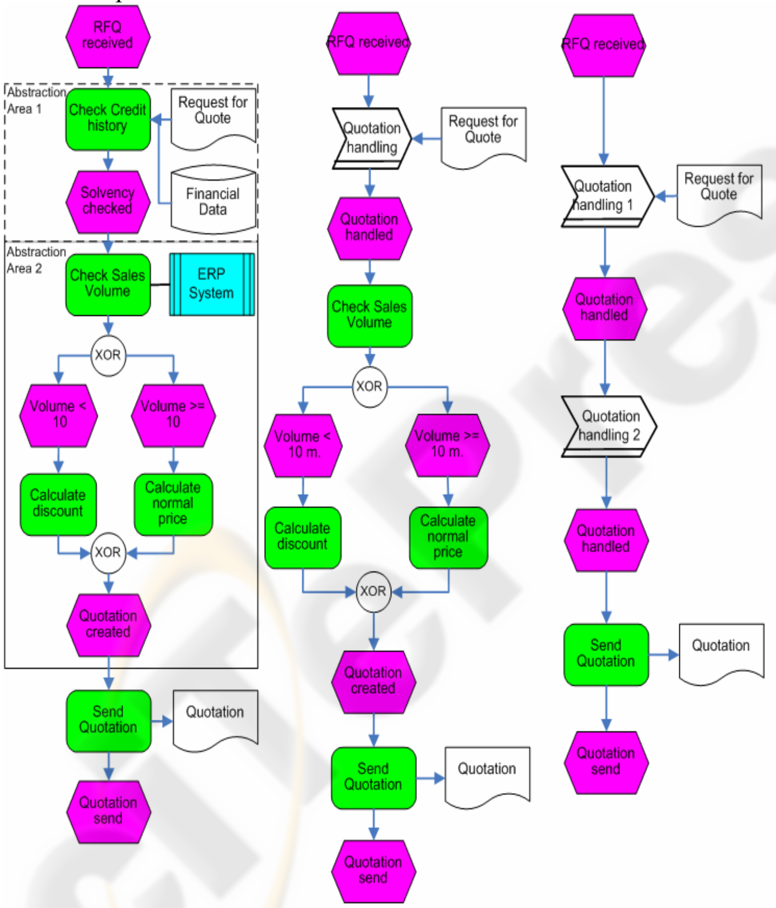

Fig. 4. Private Process of Manufacturer and derived View Processes for Retailers.

One way of dealing with this problem is describing the required 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 have been taken into account. An example is given in Fig. 5.
Further details of the concepts and its realization with IEM can be found in Deliverable A2.2 [18] of the ATHENA project.

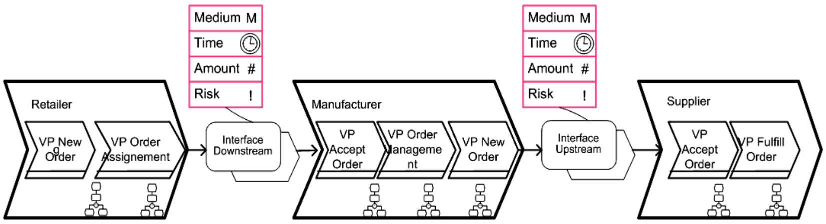

Fig. 5. CBP – Overall View.

4.2 From Business Level to Technical Level: AN IEM to PIM4SOA Transformation

The business level models created within MO²GO or the ARIS Toolset are transformed to the technical level using PIM4SOA models [15] as an intermediate format. In particular the view processes are transformed. In the following it is described how the transformation from process models on the business level to the technical level can be achieved using MO²GO. For the ARIS Toolset the transformation concept is described in the deliverable D.A2.4 [19].
The MO²GO tool is extended to export models to PIM4SOA using XMI 2.0 interface. The basis for this export is the conceptual mapping: IEM to PIM4SOA. Depending on the complexity of the mapping the following different mapping levels are defined:

1. *Generic Mapping*: The "generic mapping" is a one to one mapping of IEM meta-model constructs to PIM4SOA constructs. This mapping can easily be applied to any IEM model but maybe not the whole relevant PIM4SOA content of the model will be transformed into PIM4SOA format.
2. *Extended Mapping*: The term "extended mapping" is used to indicate a mapping based on an extension of the generic IEM constructs by a specific PIM4SOA class structure (meta-model). This allows defining and identifying more PIM4SOA relevant content within IEM models. Using the specific PIM4SOA –IEM metamodel the mapping is a one to one mapping and similar to the "generic mapping".
3. *Structure Mapping*: The term "structure mapping" is used to indicate that some information can only be mapped to PIM4SOA by model fragments. This mapping is complex and close to a graph pattern matching.

Related to the complexity of the different mappings the "generic mapping" and the "extended mapping" can be done automatically. The "structure mapping" is under consideration for "simple" patterns. Complex topologies have to be mapped, manually. Thus, the transformation of some complex PIM4SOA patterns of several elements can only be achieved by mapping patterns of several elements from IEM as a whole. An example is given in Fig. 6.

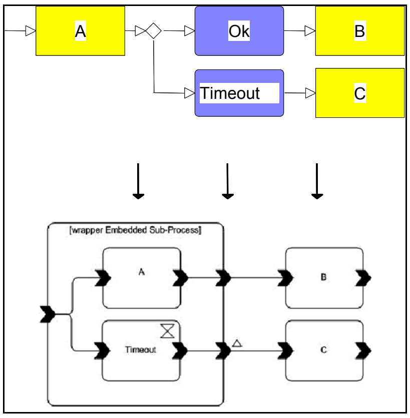

Fig. 6. Structure Mapping.

In the Example Action A is performed. After it has finished a decision is made to check if the Action finished due to a timeout (Order from Exception class) or it was "Ok". The corresponding PIM4SOA pattern might be only created if this IEM pattern is mapped as a whole. When performing a mapping on this level the information for all the elements connected to the element currently being mapped has to be checked for pattern matching. In the example when trying to map Action A all of the elements up to B and C have to be checked because they all match the PIM4SOA specific pattern. It may also require significant effort to manually prepare an existing IEM model for this level of mapping in case the model was not created using exactly the same predefined IEM patterns. This increases the complexity of the structured mapping and makes it a resource-consuming process. An extension to a semi-automated approach is subject of further research. The IEM-PIM4SOA metamodel consists of classes and attributes corresponding to the classes defined in the PIM4SOA specification (see Fig. 7).

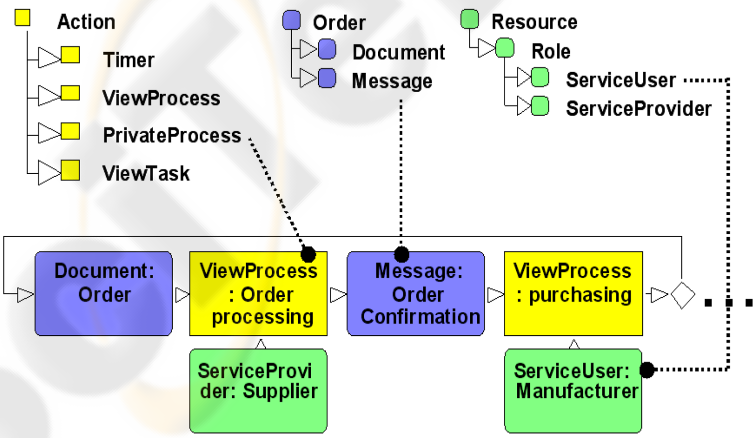

Fig. 7. Extension of IEM Action, Order, Resource by PIM4SOA concepts.

For example any instance of the subclass of the ServiceProvider class in MO²GO will be exported as a PIM4SOA ServiceProvider element. Additionally, the processes in MO²GO can be annotated to indicate executable, non-executable processes or processes requiring user interactions. This information is used to transform only execution relevant processes. On the technical level the process models are then imported via XMI into the Maestro tool.
On the technical level the view processes are linked to existing technical 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 modeling 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 modeling 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 a modeling framework to support efficient design and implementation of CBPs. Business level models, e.g. enterprise models, illustrate the organizational 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 realization of the process interaction and represents the bridge to the process execution. Further work will address the realization of the (semi-)automated transformation from the technical to the execution level and the application in further business scenarios. Apart from BPEL4WS other standards for Web Service based execution of CBPs will be considered, e.g. the Web Service Choreography Description Language (WS-CDL) [20].

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References

1. Sydow, J.(1993). Strategische Netzwerke – Evolution und Organisation. 2. Nachdruck. Wiesbaden, Gabler
2. Lippe, S., Greiner, U., Barros, A.(2005). A Survey on State-of-the-Art to Facilitate Modelling of Cross-Organisational Business Processes. In Proc. of XML4BPM 2005, Karlsruhe
3. Zachman, J.A.(1987). A Framework for Information Systems Architecture. IBM Systems Journal 26, No. 3, pp. 276-292
4. Scheer A.-W.(1999). ARIS – Business Process Modeling, 2nd. ed. Berlin
5. UN/CEFACT Modeling Methodology User Guide. Available at http://www.ifs.univie.ac.at/untmg/artifacts/UMM_User_Guide_2003-09-22.pdf
6. OMG: Model Driven Architecture. Available at http://www.omg.org/mda/
7. Elvesater, B., Hahn, A., Berre, A., Neple, T.(2006). Towards an Interoperability Framework for the Model-Driven Development of Software Systems. In Konstantas, D., Bourrieres, J.-P., Leonard, M., Boudjlida, N.(ed). Interoperability of Enterprise Software and Applications. (INEROP-ESA'05)). London, Springer Verlag Limited, pp. 409-420
8. Schulz, K.(2002). Modelling and Architecting of Cross-Organisational Workflows. PhD thesis, The School of Information Technology and Electrical Engineering, The University of Queensland, Australia
9. Schulz, KA., Orlowska, ME.(2004). Facilitating cross-organisational workflows with a workflow view approach. Data & Knowledge Engineering 51(1), pp. 109-147
10. Aalst, v der W.; Weske, M. (2001). The (P2P) Approach to Interorganisational Workflows. In Proc. Of the 13th annual Conference on Advanced Information Systems Engineering (CAiSE01)
11. Mertins, K., Jaekel, F-W.(2006). MO²GO: User Oriented Enterprise Models for Organizational and IT Solutions. In Bernus, P., Mertins, K., Schmidt, G.(ed.). Handbook on Architectures of Information Systems. Second Edition. Heidelberg , Springer-Verlag, pp. 649-663
12. Klein, R.; Kupsch, F.; Scheer, A.-W. (2004). Modellierung inter-organisationaler Prozesse mit Ereignisgesteuerten Prozessketten. In Scheer, A.-W. (ed.): Veröffentlichungen des Instituts für Wirtschaftsinformatik, Nr. 178, Saarbrücken : Universität des Saarlandes
13. Spur, G., Mertins, K., Jochem, R.(1996). Integrated Enterprise Modelling, Berlin Wien Zürich, Beuth
14. Mertins, K., Jochem, R.(1999). Quality-Oriented Design of Business Processes. Boston, Kluwer Academic Publishers
15. ATHENA Consortium (2005a). PIM4SOA. http://www.athena-ip.org
16. SAP Research(2005). Maestro for BPM. Deliverable of the ATHENA project, http://www.athena-ip.org
17. Andrews, T. et al. (2003) Business Process Execution Language for Web Services, Version 1.1
18. ATHENA Consortium D.A2.2.(2005b): Specification of a Cross-Organisational Business Process Model – D.A2.2. ATHENA, Integrated Project - Contract n°:IST-507849, http://www.athena-ip.org
19. ATHENA Consortium D.A2.4.(2005c): Architecture for Enactment and Integration of Cross-Organizational Business Processes – D.A2.4. ATHENA, Integrated Project - Contract n°:IST-507849, http://www.athena-ip.org
20. Kavantzas, N., Burdett, D., Ritzinger, G. (2004): Web Services Choreography Description Language Version 1.0 - W3C Working Draft 27 April 2004, Http://www.w3.org/TR/2004/WD-ws-cdl-10-20040427/