Process Interoperability - From the Idea to Execution

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Abstract

Interoperability is one of the keys to the future global market. With respect to the technological leadership claimed by Germany, it can not be sufficient to passively follow the evolution or adopt other stakeholders' technologies. It is required to be active and ahead of the interoperability related research, in order to have a leading position in the upcoming world market. Consequently, the fundamentals have to be developed, which can serve as a basis for new concepts and applications in the field of interoperability. It targets at enabling companies to actively provide interoperability instead of being forced by other market players. In this paper a technological framework is presented supporting independent actors to cooperate in creating their business model on a management level, designing and simulating their common business process, creating the technical implementation within the workflows and deriving the models for the execution. In each of these tasks optimisation on performance indicators might be necessary. Therefore an extension of this existing framework with simulation on business aspects and on technical aspects will be demonstrated.

1 Initial Situation

The importance to tackle interoperability between organisations increases since the globalisation became one of the most relevant business and economical issues. The European Commission has invested in several projects related to interoperability in the sixth framework program (FP6) over the last years such as in the integrated project ATHENA (http://www.athena-ip.org) and the network of excellence INTEROP-NoE (http://www.interop-noe.org). In ATHENA a framework for designing and implementing cross-organisational business processes (CBP) has been developed which covers the business concept in an enterprise model, the technical aspects in a technical model and finally leads to process execution. The framework also includes different transformations between models taking into account parameters, process sequences, annotations and correlation aspects. The CBP framework has been used to demonstrate the feasibility of an automated transfer of information from the business to the execution level. This helps to ensure that all different stakeholders involved in designing and implementing interoperability solutions can be addressed appropriately. For instance, business

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stakeholders (manager, board members, etc.) have little interest in the technical aspects and sometimes ask why these models are needed. On the other hand the IT stakeholders are not interested in the enterprise models coming from the business side. A further aspect to be considered when implementing process interoperability is the necessity to optimize the cross-organisational processes before actual deployment. This can be supported by simulation on the business and technical level. Therefore, the CBP framework has been extended with simulation capabilities to reengineer and optimize processes before deployment.

1.1 Enterprise Collaboration Demand

Global supply chains are established. Companies engaged in this cross regional supply have to handle costs, quality, trust, transactions, etc. Consequently, they have to manage technical and business aspects in an efficient way to be competitive and attractive for possible collaboration partners. Concepts have been developed to support and standardise the description and analysis of such collaborations. An example for supply chains is the supply chain operation reference (SCOR) which provides processes as well as performance indicators. It is designed for the effective communication among supply chain partners [Supply Chain Council 2002]. SCOR addresses business relations between enterprises in supply chain processes but the technical realisation of workflows is not tackled. Other activities, e.g. around the business process execution language (BPEL), address mostly the technical aspects of message and document transfer between business processes as well as the interlinking of services.

A demand is to lower the cost of integration and save the time of designers and developers. Consequently, the business and execution level needs to be interrelated to have a smooth transmission between these levels. This should result in a simultaneous realisation and optimisation of the organisational and technical structures for enterprise collaborations. Therefore, modelling on the business and technical level (providing more details than the business level but abstracting from execution platform details) as well as the analysis and simulation of these models has to be supported.

In this context enterprise modelling is used on business level to create a common understanding of the business processes as well as for their optimisation. Within supply chain approaches SCOR is a good source for the modelling and analysis on business level [Rab05]. Models with more technical details are needed to realize co-operations and implement interoperable processes. Therefore it is important to establish the link between enterprise modelling and modelling of the technical processes.

This faces some challenges. In the past quite often the process execution in the IT world conflicted with the real working processes (additional work needed to support the IT, insufficient dialog systems, etc). Therefore, the acceptance of process management systems is sometimes low. Furthermore, critical or mandatory information on the business level is not directly accessible by the IT systems because it might be generated by non-IT-executed processes (e.g. approval of an order change done by people). Also processes executed by IT in one company might be executed manually in another company. These facts have to be considered when generating process models on the technical level, or the models on the technical level should be derived from the business level models, directly.

The motivation for the different types of models is that the different stakeholders require different support for their specific view. An example might be UML which is not seen as an adequate modelling technique on the business level. Furthermore, the point of interest regarding evaluation and optimisation are different. On the business level costs and throughput times are relevant. In contrast, on the technical level the message flow is in the focus with the analysis of response times, bottlenecks etc.

1.2 CBP Framework

In the ATHENA research project a framework to model cross-organisational business processes (CBP) has been developed that provides modelling support on business and technical level as well as the transformation to executable models [Gre06a]. In the following a brief sketch of the framework is presented as the basis for further discussions. The CBP framework incorporates two dimensions (Figure 1):

1. Different modelling levels from business over technical to execution related models of the CBP addressing different stakeholders involved.
2. Aggregation and filtering of information through an additional abstraction layer: This allows for selectively hiding company-internal information while offering a mechanism to expose CBP relevant information to partners.

The first dimension incorporates three modelling levels:

- **Business level:** This level represents the business view on the cooperation and describes the interaction of the partners in their cross-organizational business process. The CBPs modelled 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 including message exchange. We distinguish different task types, those which are executable by IT systems and those that are executed manually. However, the control flow and the message exchange are specified independently of a concrete execution platform.
- **Execution level:** On this level the CBP is modelled in the modelling 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 concept of process views as an additional abstraction layer between the private processes and the CBP model as proposed by [Sch04]. The different types of processes in the modelling framework are defined as follows:

- **Cross-Organizational Business Process (CBP):** A CBP defines the interactions among two or more business entities. These interactions can take place inside one company or also span multiple companies. An interaction is defined as a valid sequence of message and/or other material input/output exchanges.
- **Private Process (PP):** PPs describe the internal processes of a company. They can contain parts that are not to be published to the partners.
- **View Process (VP):** A VP abstracts one ore more PPs to a process interface that a partner provides in collaboration. It enables companies to hide critical information from unauthorized partners.

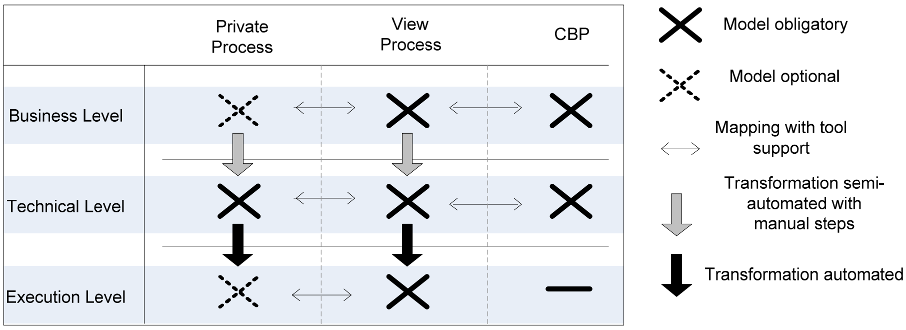

Figure 1: Cross-organisational Business Process (CBP) Framework

Figure 1 illustrates the CBP framework. 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. The framework also specifies how models can be transformed between the modelling levels (see [Gre06b]).

1.3 CBP Framework in the Context of Simulation

Simulation is an important step between modelling of processes and their execution in an operational infrastructure. Thus, it is necessary that the simulation capabilities are aligned with the different model types in the framework. The CBP framework so far did not directly address the aspects of process optimisation. Such aspects are handled separately e.g. for supply chains on the business level such as in SCOR or for feasibility studies on the technical level.

Figure 2 illustrates the first dimension of the CBP framework (business, technical and execution level) together with the modelling concerns and application aspects of the models on each level. The second dimension of the CBP framework (CBP, VP, PP) is not explicitly presented because the model application in terms of usage and simulation can take place on the CBP as well as on the PP level. For the realisation of the simulation the

High Level Architecture (HLA) concepts [IEE00] as well as extensions developed for example in MISSION [Rab03a] could be helpful. Here the simulation model for the Private Processes can be developed independently in each enterprise and the CBP could be realised as an HLA federation. This requires the synchronisation of the models not only in the execution of the simulation but also during the modelling process at least on the business level. Concepts have been applied in projects such as SPIDER-WIN [Rab06a]. INTEROP currently develops general support mechanism to secure the model connectivity between independent enterprise models [INT05, Jae05].

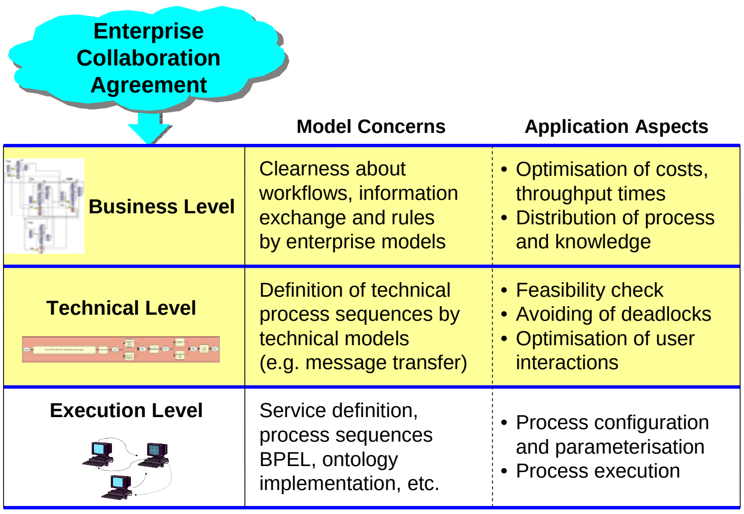

Figure 2: Application differences on business and technical level

Starting with business agreements the processes for the business level need to be defined. As one example, SCOR provides here the required terminologies and process definition if a supply chain is targeted by the collaboration. It also provides performance indicators to monitor and optimise the business. This allows the analysis and optimisation of the processes according given targets of cost, time, quality etc. and the distribution of the process knowledge related to collaboration rules (e.g. access rights). But SCOR provides only little support for the technical and execution level. Therefore, the model will be transmitted to the technical level which provides mechanisms that are closer to the execution of IT systems such as definition and monitoring of messages. This enables feasibility studies of the required system functionality, identification of deadlocks and optimisation of response times. After the enrichment and optimisation on the technical level (which might have implications on the business level) the technical model will be transmitted to the execution level. This could be a BPEL model which might be finalised and enriched at the execution level.

The procedure above illustrates the complexity and the high number of interfaces. The tool support of the framework has the following general options:

1. The development of one complex system which incorporates all aspects
2. The elaboration of smooth (standard) interfaces allowing the cooperation of different systems
3. The definition of services and their composition

The first option would create difficulties in maintenance and evolution of the system. The second option allows different tool vendors to provide their solutions and is easier to maintain in terms of flexibility. It is also a step into more openness and interoperability between the different levels. But this approach requires the establishment of standards for model annotation and transformation. The third point would open the possibility to combine functionality of different vendors on demand. In the following the second option is prioritised because modelling and simulation systems already exist and they should be usable within the framework. Standardisation approaches such as Business Process Definition Model (BPDM), XMI and BPEL have already been considered [ATH05a, ATH05b] but further investigations are needed e.g. for the aspects of annotation and correlation. Similar ideas regarding interoperability and simulation can be found in the work done around distributed simulation [Tay03].

2 Supporting Tools and Interfaces

The target of the CBP framework and its extension related to simulation is to support the achievement of conceptual, organisational and technical interoperability between enterprises [INT06]. The conceptual aspect is related to syntax and semantic which is addressed within the interfaces but also within the enrichment of models at the business level to allow a better transformation to the technical level. Organisational aspects are related to human issues e.g. responsibilities and organisational structures which is addressed on the business level.

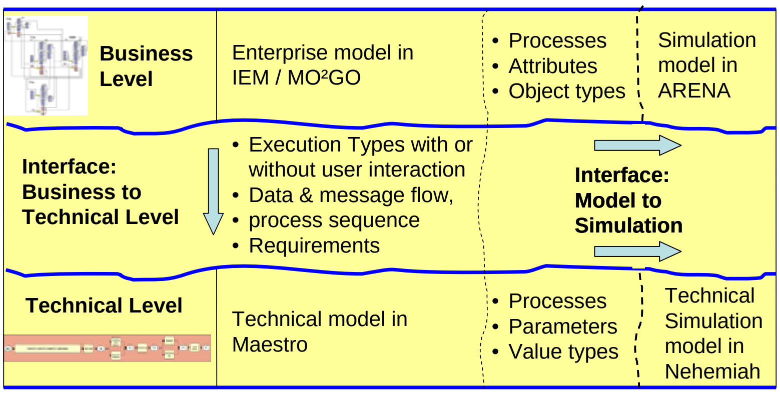

Figure 3: Interface concept and tool examples

The technical interoperability is defined on technical and execution level. Interoperability occurs in two facets within the presented approach:

1. The interoperability between the levels of the extended framework as well as between the conceptual models and the simulation.
2. The enterprise interoperability between different organisations supported by the framework.

The second facet will be addressed below in the chapter of a possible demonstrator. The first facet deals with the interoperability features required not only between the levels but also between the conceptual model and the simulation within the levels of the framework. The simulation focuses mostly on the business and technical level because on the execution level the simulation would be a test run of the implemented system and not a usual simulation. Examples for tools supporting the modelling and simulation on both levels are illustrated within Figure 3.

2.1 Business Level

Interoperability between collaborative and networked enterprises requires a consolidated and consistent understanding across all stakeholders. Enterprise Modelling (EM) provides concepts to achieve a common understanding between the stakeholders and to support the implementation and the evolution of enterprise networks on the business level. A number of tools are available on the market to realise enterprise models. During the development of the framework two tools MO²GO [MER06] and ARIS [SCH99] have been used as business level modelling tools. For these tools interfaces have already been implemented according to the framework. For example MO²GO provides an XMI interface (www.moogo.de) which supports an export of the process models to UML tools as well as to other technical level modelling tools such as Maestro [SAP06b]. The interface can transfer enhancements in the business process model such as:

- Annotations to indicate IT-executable, interactive and non-IT-executable processes
- Basic correlation between messages and processes to cover the routing
- Types of modelling elements such as receiver, sender, etc.

In MO²GO the annotations and the correlation are realised by attributes and their values. The types are realised by class definitions. The mechanism to feed the simulation of COTS simulation packages can be similar.

The use of HLA and the MISSION [Rab04] approach would be one of the most adequate concepts for the realisation of a simulation scenario according to the CBP framework. The private processes could be simulated as separate simulation models within the different enterprises. The view processes could provide the required information for the SOM (single object models) to define the federation in the CBP which would correlate with the FOM (federation object model). Afterwards the simulation could be distributed across organisations. An example for that is given with the supply chain demonstrator see [Rab06b].

In the following a first step into such approach is illustrated using the ARENA tool for the simulation. The interface between MO²GO and ARENA can benefit from the development of the transformation between the business and the technical level. The following information is available for the transfer to the simulation package for dynamic simulation:

- Process network
- Resources processing the process
- The routing of objects across the simulation model
- Types of processes and objects

This set of information is extended by parameters about costs, time and optimal other performance indicators. Even if a specific simulation package is used, the interface definition is general. It consists of generic descriptions of processes, connections, routings, objects, attributes and values. Afterwards, the models within the simulation package needs to be extended by the workload description and the definition of the simulation experiments.

2.2 Technical Level

On the technical level simulation allows to check and optimize the models of the technical processes before they are actually deployed in an operational environment. This includes for instance identifying bottlenecks, optimizing throughput times and message exchange between partners. The simulation operates on models that have been generated with technical level modelling tools such as UML tools or Maestro. We typically start from business level models that have been transformed by the interface between business and technical level in the CBP framework and enrich them with more technical details. Based on these enriched process models we start the simulation that can be executed for instance by process engines for CBPs that offer additional simulation functionality (e.g. the Nehemiah process engine developed in ATHENA [SAP06a]). In the following we describe the functionality that supports the simulation of technical level process models.

The user can either simulate from the perspective of the high level CBP or from the perspective of one involved organisation. Therefore, the engine supports the simulation of private processes as well as of cross-organisational business processes including the View Processes of all partners. When simulating a process, independent engines are started for each partner. This can be done on one machine or on separate machines, as desired. The latter allows simulating distributed scenarios with different people using different machines.

The engines run the simulation independently; i.e. there exists no central instance. The different process instances communicate over events that simulate the process flow. The user can change the state of activities manually to simulate the execution of the process. To simulate splits in a view process or in a private process the user can enter data that is necessary to decide which path to take. The execution status of each activity is indicated over different colours in the user interface. This allows the user to monitor the simulation state of the CBP.

3 Demonstrator

The described CBP approach extended with simulation facilities can bridge enterprise interoperability barriers for interoperability as described in INTEROP [INT06]. The organisational barrier between different companies is bridged by enterprise models supporting a cross organisational knowledge exchange about the relevant processes. However, the knowledge about the internal processes of the companies is still restricted in the network. The conceptual barrier is bridged by providing transformation capabilities between the different levels and with dynamic simulation. The technical barrier is bridged by the use of standards supporting the definition of executable processes. The CBP concept also supports the independency of each partner within an enterprise network.

To underline the necessity of a comprehensive simulation of cross-organisational business processes we use the following supply chain scenario (see Figure 4 for a simplified view) which correlates also with the supply chain demonstrator presented at the SimVis'06 [Rab06b]. A manufacturer (e.g. for furniture) cooperates with retailers that offer his products, as well as with suppliers that provide him with material and pre-fabricated parts. The cooperation processes are similar for both partners. They comprise the following steps: *Request for quotation – quotation – order – order confirmation – send goods* (the last step is not illustrated in the figure). On the manufacturer side two departments are involved in the process: the sales department for the interaction with the retailer and the procurement department for the interaction with the supplier. Both processes are linked when the manufacturer gets an order for furniture that requires purchasing of raw material to produce it. The manufacturer cannot send an order confirmation to the retailer before it has received an order confirmation from the supplier with date of delivery and price. The simple structure is used to briefly illustrate the CBP framework approach. It is expected that each company applies the CBP framework.

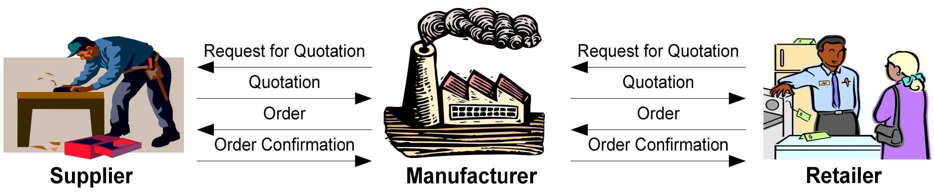

Figure 4: Demonstration scenario (simplified view)

In order to achieve interoperability between the partners and processes we first have to model the CBP including all three partners. This is done by the stakeholders introduced in the modelling framework above. After simulation on the business level and transformation to technical level models the simulation on the technical level starts. Figure 5 shows how the simulation on the technical level looks like for this scenario. In the screenshot you see the CBP for the scenario comprising the view processes from four different partners: the retailer (in green), the manufacturer (sales department in blue, procurement department in red), and the supplier (in grey). To simulate the CBP the retailer starts the execution and simulates the first steps manually by clicking on them in the user interface. When the process execution reaches the first send nodes, the simulation engine of Nehemiah starts a new simulation instance and triggers a new view process instance of the sales department of the manufacturer. The simulation then continues in this process instance until it reaches a send node and the event is sent to the next partner or back to the first one. In this way the simulation continues for the whole CBP. The colour coding of the activities visualizes the current execution state of the CBP. The colours have the following meaning:

- yellow activities are still to be executed and have not been activated yet
- light blue activities are activated and can be executed next (e.g. the "Create Quotation" activity in the supplier view process)
- dark blue activities are running (meaning that they have been started and are executed or waiting for input, e.g. the receiver nodes)
- green activities have been completed (the simulation has successfully been finalized)

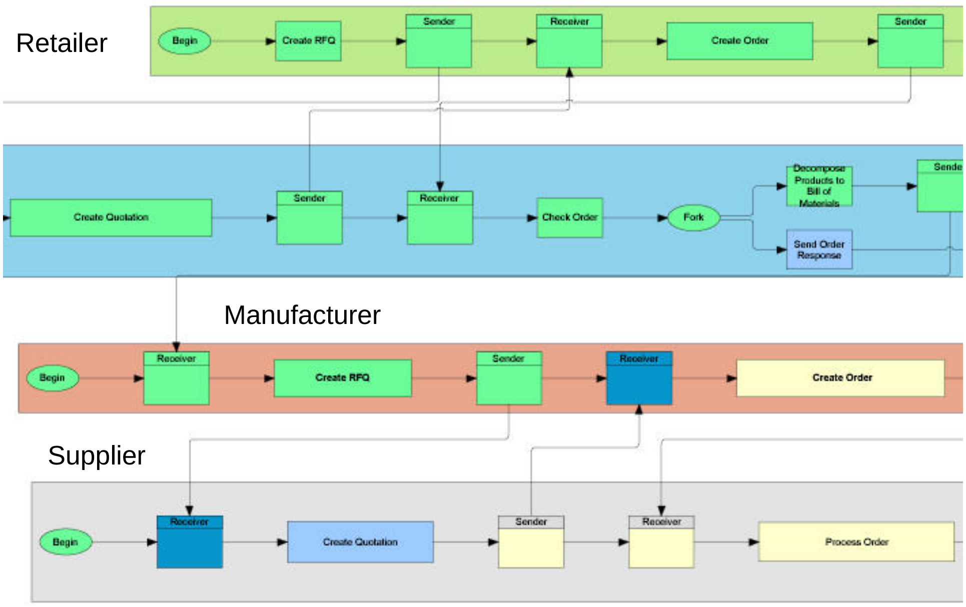

Figure 5: Simulation in Nehemiah

This simulation on the technical level helps to search and fix errors in the process and message exchange before actually deploying it in an operational environment. This saves time and costs as otherwise each partner would have to change the process models and re-implement the processes on his side. Using the simulation capabilities introduced above helps to identify errors before deployment and avoids changes on productive systems. Furthermore different aspects such as costs and message exchange can be considered separately on the different levels. This allows clarifying any uncertainties directly between the involved stakeholders.

4 Conclusion

The approach provides a holistic concept to overcome interoperability barriers covering the way from a business idea to cooperate to its implementation accompanied by optimisation via simulation.

The CBP framework and its extension in the context of simulation consist of a set of interface and annotation features which take into account the heterogeneous tool market. Therefore, the approach is open for different tool vendors to join such an implementation. However, the described approach needs further investigations in terms of:

- Interlinking of models at different locations:
  - ensuring consistency and potential demand of connectivity
  - monitoring and propagation of changes across the different models
  - realisation of the distributed evaluation of the models
- Reflecting changes in the executable level within the business level via a bi-directional interface. This ensures that each change is directly reflected in all other levels.
- Managing of different views on overlapping sets of processes because in one network the definition of an view process might be differ to another network in which the company is involved.

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