A Collaboration Framework for Cross-enterprise Business Process Management

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Abstract. New forms of cooperation like collaborative business scenarios require a deep but flexible integration of enterprises. In order to manage interorganizational business processes, existing concepts for business process management need to be adapted and extended. In this paper a framework is presented, that shows how cross-enterprise processes can be planned, implemented and controlled. The framework is based on the differentiation of global knowledge within the network and local knowledge of each participating company. Another important part of it is the process life-cycle model that serves as a guideline for the process-oriented setting-up and operation of cooperations. By the use of graphic representations of BPM-models and intuitive metaphor-based model-generation and -visualization tools a broad acceptance for the interorganizational BPM-effort can be achieved.

1 Innovation through business process interoperability

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 [1], [2]. Thus, enterprises have to react to the raised innovation pressure and facilitate flexible collaboration on a global scale by aligning their business processes. The borderless enterprise has been the subject of scientific discussion for years [3], [4] and the collaborative production of goods and services has been established as a crucial factor in the consciousness of economic entities. The opening of the organizations' borders is no longer regarded as a necessary evil, but rather as a chance with strategic importance. [3]

Current approaches that address solutions to specific problems of dynamically interacting organizations are summarized under the term "**Business Integration**"; the field of investigation is referred to as "**Collaborative Business (C-Business)**" [5]. C-Business describes the Internet-based interlinked collaboration of all participants in an

added-value network – from the raw material supplier to the end-consumer [6]. It allows a comprehensive information exchange not only between employees but also between departments and even between enterprises and encourages creative cooperations at all levels. As first case-studies show, the increase in added-value is out of proportion to the amount of participants in the network. Unlike former concepts, as e.g. E-Procurement, which focused only on small parts of the value chain, C-Business incorporates all stages of added value [7].

While the technological interoperability[8] on the one hand and the lifecycle of cooperation [9] on the other hand have already been intensively researched, too little consideration is given to the interconnecting business management concepts. A rethinking from the pure technology-driven implementation or profit-driven business model discussion to an integrated view that spans from the conceptual level to the system blueprint is needed. From a conceptual point of view business processes have proven to be the ideal design item in conjunction with the use of graphical methods. These models can then be transformed into Information and Communication Technology (ICT) -based specifications. With the use of open, standardized technologies, such as web services, they enable Business Process Automation, i.e. the automatic negotiation of process interfaces.

For these purposes a proposal for a Cross-enterprise Business Process Management Framework is developed in this paper, based on the findings the two overlapping research projects InfoCitizen and ArKoS, that are introduced later on.

2 The foundation of the Collaboration Framework

Compared to traditional business processes, the complexity of interorganizational processes has risen considerably as a result of the numerous possibilities of interaction as well as the strategic, structural and cultural differences between the partners [11]. The allocation of performances and resources of the business partners, the determination of responsibilities for material and financial exchange relationships as well as the information and data exchange over interfaces have to be planned, arranged and "lived" together. Thus the demands on Business Process Management (BPM) increase.

Existing BPM methods and phase models are used as a foundation in the architecture presented here, which had to be adapted to the specifications of collaborative scenarios. Especially because of its completeness of vision and its proven practicability, both in the scientific and the economic context, the "**ARIS House"** [12] is accepted as a generic framework for business process management and serves as a basis for further considerations. The ARIS House describes a business process, assigning equal importance to the questions of organization, functionality and the required documentation. First, it isolates these questions for separate treatment, in order to reduce the complexity of the field of description, but then all the relationships are restored using the Control View introduced for this purpose.

The **Cross-enterprise Business Process Management Architecture** is presented here in a three-tier framework that is connected through control loops, following the

concept of business process excellence of Scheer [13], which consists of a model to track a complete lifecycle model of business process management, including modeling, real-time control and monitoring of business processes. The first layer focuses on the **collaboration strategy**. In the centre of the second layer, **C-Business Process Engineering**, there are design, optimization and controlling of both enterprise spanning and internal processes. The third layer, **C-Business Execution**, deals with the (operational) implementation of business processes in value-added networks as well as their support through information and communication technologies. The structure of the layer model is clarified in Figure 1.

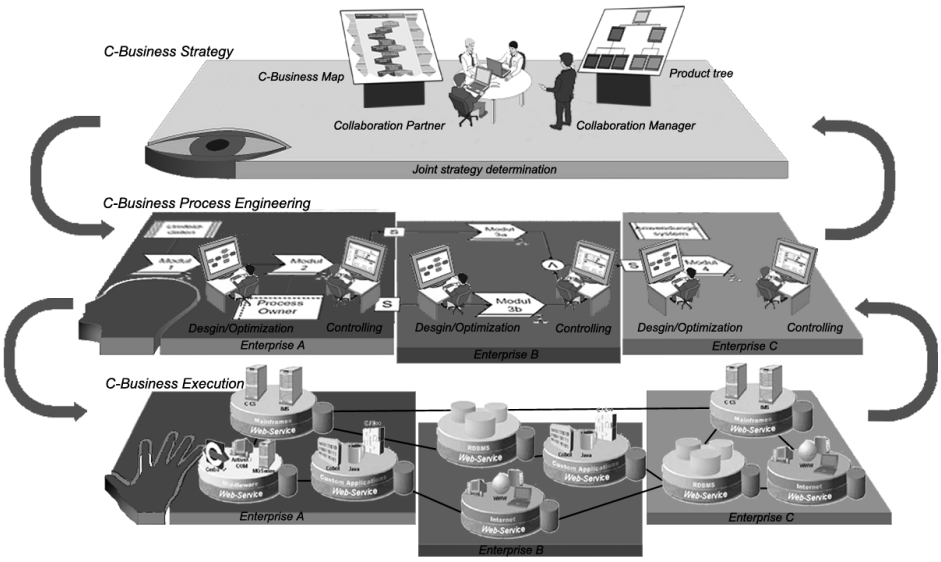

Fig. 1. Architecture for Collaborative Business Process Management

2.1 Views on Business Process Models

As described above, the framework is based on the ARIS House and divides it into a vertical axis of global knowledge of all collaboration partners and a horizontal axis of local knowledge of the single participants (cf. Fig. 2). The organisation view and the output view are global knowledge because a goal-oriented collaboration is impossible without them.

At the time the interaction occurs between two partners, local knowledge is shared (bilaterally) between the partners, i.e. additional information, like data structures and semantics, are exchanged. Updates of the local knowledge do not influence the network as network knowledge has to be available for all partners. This information is stored in the description of interfaces between the process modules of the partners (cf. section 2.3). Changes in the global network knowledge and as a consequence changes in the output and organization view have to be accessible to all partners immediately,

for example if a company leaves the network or if a product or service is no longer available within the network.

Global and local knowledge merge gradually in the step-by-step development of C-Business process engineering. Following the distinction between global and local knowledge, a language is needed for the exchange of these knowledge fragments. Because the necessary detail functions and data schemes of the respective enterprise are determined in the data and the function view, these are treated from a micro perspective. They are characterized by an intensive internal interdependence, whereas externally a standardized encapsulation has to be provided. Interfaces of the data and function views to other network participants become visible in the process view in form of attribute correlations to process modules and concern the technological field of the cooperation during the realisation much more intensely than the conceptual one.

This technique enables the generation of **public** (visible to network partners) and **private** (enterprise-internal) **views** and levels of detail for management, process owner and IT-experts out of a C-Business model.

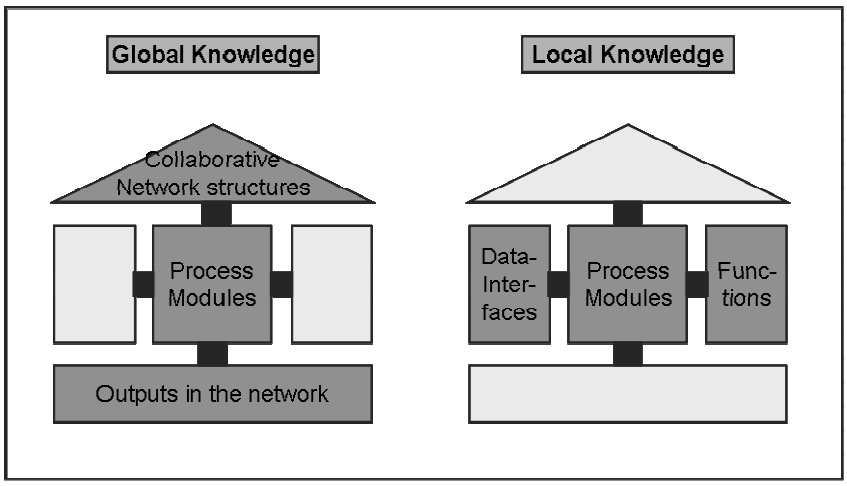

Fig. 2. Global and local knowledge in value-added networks

2.2 C-Business Strategy

Enterprise spanning business processes are not planned in detail at the strategic level, but are designed as concentrated, high-level process modules. Thus, they combine the public knowledge about the collaborative processes that is shared by all participants. C-Business scenario-diagrams that are used e. g. by SAP Ltd. for the description of my-SAP.com collaboration scenarios, aim at the representation of the cooperation of different enterprises and participants by means of an easily understandable method and the documentation of the value-added potentials resulting from it [14]. The responsibility for each process step, indicated by swimlanes, is of central importance to the determination of the scenario. This method is integrated into the ARIS concept and

combined with methods of (classical) business process and data modeling used at the C-Business Process Engineering layer.

The question of core competences in the enterprises is directly associated with the question which processes remain in the enterprise and which are supposed to be assigned to partner enterprises or collaboratively operated [15].

2.3 C-Business Process Engineering

On this layer each partner considers their part in the inter-enterprise process. Each party models its own internal processes. The event-driven process chain (EPC), that has been developed for the last 15 years at the Institute for Information Systems,[12] is used for the design of the process flow within an enterprise (**local view**). A possibility to reduce complexity and to focus on special aspects is the use of different views like data, organizational, function or output view.

The **global view** on the collaborative process is generated in order to manage the common processes and to reduce the complexity of integrating the participating organizational units into one virtual unit. In doing so it is important that the partners provide access to all relevant information described as global knowledge beforehand and at the same are able to hide their business secrets. Both aims are achieved by enhancing the EPC with a new construct, the **process module** [16]. It serves as an abstraction for more detailed sub-processes that contain the local knowledge and thus encapsulates crucial process information. Additionally the object-type **interface** is introduced. The interface contains relevant information about data and input/output structures in order to match and interconnect process modules.

The view concept presented in section 2.1 allows generating different views on the collaborative process depending on the degree of collaboration. In some cases closely interlinked collaboration partners allow each other inspection of their internal EPC models or parts thereof. By consolidating the processes at their interfaces a detailed collaborative process that can be used for further optimization and implementation emerges. More often the partners expose only parts of their individual processes to the partners because of the reasons above-mentioned. Thus, they grant access to their process knowledge at the process module level. A high-level public view of the collaborative process consisting of process modules and their interfaces is created. The information whether the detailed EPC or the high-level process module should be disclosed in a certain public view is stored as an attribute in each process module object.

The collaboration partners have to continuously compare the result of the implementation with their goals and adjust deviations. Hitherto the management has obtained its knowledge about the company's success from figures of the past, e.g. cashflow, trading volume or profit made. The causes for fluctuations, requiring immediate counter measures, were not discernible. Until the problem was recognized, valuable time has elapsed. Therefore new measurement categories, which allow a reliable and contemporary evaluation of process efficiency, are required. The information needed cannot be extracted from the record and transaction oriented applications alone. **Key performance-indicators** must be defined based on records, logfiles, time stamps etc.

These can be measured and analysed by means of intelligent tools [15]. The controlling function is a must when there is a high degree of uncertainty as with C-Business projects. The management can permanently control the implementation of the strategic collaboration configuration and promptly evaluate whether the expected added-value potentials have been reached.

2.3.1 Tool-based, intuitive generation of process models

Discussing business processes means discussing abstract and mental formations as well. When the process-owner has to communicate the process to co-workers or even to partners within the network, the notional construct has to be visualized. This task is called **process visualization**; an effort to refine the mental representation of a process by using available media like images, texts or animations.

The main concern of process visualization is to achieve a common understanding of collaborative processes among all persons involved in the business process. Additionally, in collaborative environments the use of views as described above is supported effectively by a visualization system. An innovative approach to this is to record the process while reenacting it. This can be achieved with the aid of tools, e.g. the INTERACTIVE Process Modeler^{VR} from Interactive Software Solutions. The tool provides an intuitive Internet-based communication platform to record business processes interactively and in a decentralized way. In particular functionally responsible employees describe the business processes by playing them through within a virtual environment (cf. Fig. 3).

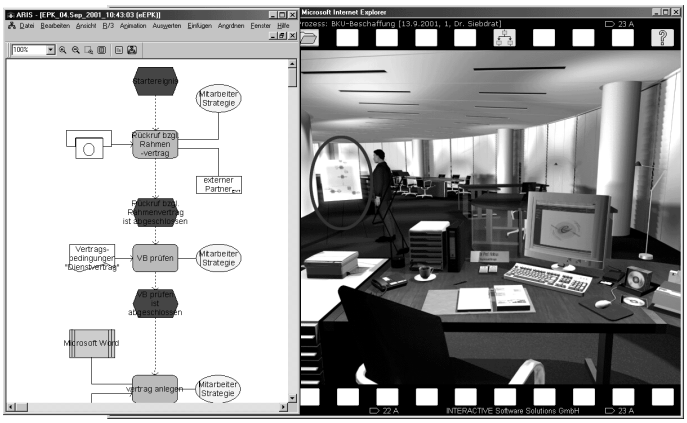

Fig. 3. Automatic generation of a process model

The recording of the employee's activities in the virtual working environment is transformed into a semi-formal process models needed for the analysis and evaluation. The automatically provided process models are based on the method EPC and can be handed over to a process modeling repository, for example the one of the ARIS Toolset, to process the models. By doing so information loss due to communication errors between knowledge carriers and method experts is reduced to a minimum. In addition, modeling errors can be recognized and eliminated easier and faster on a much broader

basis and errors resulting from formalisation of the surveyed process by method experts are avoided. Furthermore, expensive method training courses and the use of modelling experts can be reduced to a large extent.

2.3.2 Tool-based communication of process models

Within the process execution phase the implementation of target processes, the evaluation of the existing processes and the permanent optimization of processes require an adequate visualization of the processes in order to establish a common understanding of the processes among all persons involved. Otherwise, specialized divisions´ employees with knowledge of the operations often take a rather passive role. This holds especially true for interorganizational processes.

In order to achieve the demanded participation by employees in validation and discussion of the process concepts produced in reorganization projects the business processes are visualized close-to-reality. By the intuitive representation weak points and opportunities for improvements can be identified and used for the construction of optimized target processes.The new form of business process visualization can serve to reach a quality improvement of conventional semi-formal business process modeling methods.

When the optimization should go across corporate frontiers the challenge gets more demanding, because of the higher complexity, as described in section 2. The distributed modeling approach, combined with the use of close-to-reality metaphors can cause an immense boost for the success of business process management within distributed modeling environments.

2.4 C-Business Process Execution

Instead of closed systems that have been used so far, C-Business requires the integration of different applications. Component based architectures that are process-driven and rely on fully developed standards and interfaces can be seen as a state-of-the-art approach to overcome these problems [17]. The term “process-driven” emphasizes the importance of the process models created on the preliminary layer. On the execution layer these models are used e. g. for the orchestration of web services. Orchestration in this context describes the composition of business objects in a process flow. In detail it defines the complex interaction between business objects, including the business logic and execution order of the interactions and the exchange of messages between them.

3 Collaborative Business Process Management Lifecycle

The lifecycle -model presented in this section serves as a manual for the process-oriented setting-up and operation of cooperations. Using a consistent phase model and standardized modeling methods increases transparency and structuring of cooperations and creates a basis for communication between participants, including management

that lays down strategies, process-owners in the departments and IT-experts that integrate the different application systems.

Despite the increased complexity of network processes in comparison to internal processes, those involved have to adapt to constantly occurring changes in a fast and flexible way. The model is a fusion of classic phase-models with lifecycle -models of virtual enterprises [18]. The resulting dynamic model is consistent with the structure-oriented Cross-enterprise Business Process Management Architecture (cf. section 2) and represents a cyclical approach.

Protecting internal know-how is of paramount importance to the network participants, even though the business process knowledge has to be used jointly. Following the view concept presented in paragraph 2.1, this implies that the lifecycle alternates between phases that focus on global and on local issues in order to reach a coherent solution (cf. Fig. 4).

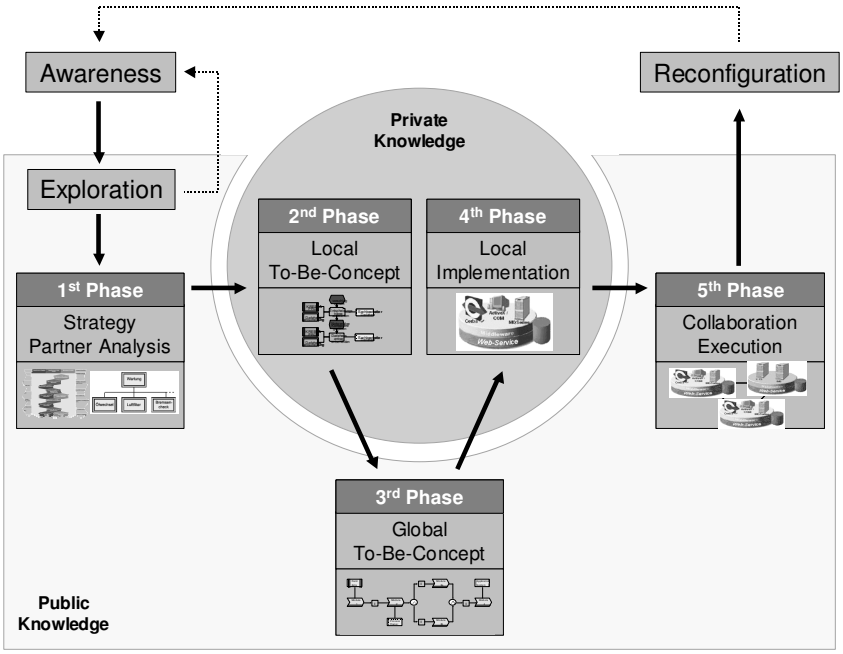

Fig. 4. Collaborative Business Process Management Lifecycle

3.1 Pre-phase and reconfiguration

Prior to the use of the architecture is the **awareness** of one or more enterprises that they can profit by collaboration with complementary core competence partners. The decision if and with which enterprises a C-Business scenario should be implemented is taken by every single enterprise individually and rationally; for this reason it depends

highly on the expected economical profit of the individual partner. In this model, it is assumed, that a set of potential network participants is given.

After conducting the cooperation the companies regroup or split and **reconfigurate** themselves. The lifecycle returns to its starting position “awareness”.

3.2 Main-phases

In the first phase **Strategy Partner Analysis** or formation phase, also referred to as initiation and agreement of the enterprise network, the collaboration partners are determined by the shared goals of the collaboration and the aspired win-win situation of all partners. The joint aims of the collaboration have to be defined as synthesis of the individual aims.

To facilitate the collaborative service or product delivery, graphical methods, like product models, are used in this stage for the determination of a common service or product bundle. They simplify and put the often implicit objectives into concrete terms. In addition to the characteristic features of a service or a product over its entire lifecycle , the organizational units participating in the production are contained in a product model [19]. By means of product trees enterprises can conceal detailed service descriptions in an internal view that puts special focus on the organizational aspects of the product offered by the partners. In an external view they just provide the information required for the configuration of the common service bundle in form of product bundle models [20].

Having completed the strategy finding, in the second phase, **Local To-Be-Concept**, an existing or a new (local) as-is model and the (global) to-be concepts are compared. According to predefined conditions about collective product creation, intra-organizational business processes can be derived. Each partner considers their part in the inter-enterprise process. Starting with process modelling and optimisation over process controlling up to implementation, the processes involved are aligned with the requirements of the collaborative scenario agreed on in the former phase.

In the third phase **Global To-Be-Concept** coordinated public parts are allocated over the network, establishing a collective to-be concept. Every partner is able to connect their own private model with every other public process model. Every partner gains their partial view of the collaborative process or in other words a virtual process chain of the whole collaboration is designed. The Business Process Modeling Language (BPML) can be considered as an appropriate exchange-language. Global knowledge is described in a public interface, which can be provided by a BPMN representation. The public processes as well as the message formats and contents can be formally defined by B2B protocols like RosettaNet or ebXML. Furthermore the semantic combination of models of the different partners is necessary. As long as ontology-based approaches don’t reach a productive state this combination process is a manual action.

The integrated collaborative business process model enables all partners to configure their application systems locally in a fourth phase called **Local Implementation**. Reference systems for interfaces are provided by interface definitions of the collective to-be concept.

Now every partner is prepared for the execution of interactions within the collaborative framework. That is the transition to the fifth phase **Collaboration Execution**. Based on bilateral bases interacting information systems are able to communicate by using the standardized protocols and interfaces. The transactions are arranged and executed. The aim of this phase is to support collaboration through the appropriate use of ICT. That requires primarily the configuration of interfaces and the implementation of interorganizational workflows; at the same time the permanent monitoring and adaption of the collaboration, based on business ratio defined in the conception phase, must be assured. [6]

In order to automate inter-organizational processes the conceptual models are transformed into formal models that are used as configuration data for the orchestration of business objects. The applications of the partners have to communicate bilaterally to negotiate the interface specifications based on the formal models, defined in the repository. The local knowledge is generated by this negotiation for a certain situation. After this collaboration task has ended no updates of configuration changes etc. are reported to any other party except at the time when a new direct interaction occurs. In this context multiagent systems offer a solution to achieve an automated or at least semi-automated interface-configuration [21], [22].

With the use of XML the technological basis for interoperability has been established, the interoperability between the semantic business process definitions however is still missing. Efforts like BPMI's Business Process Modeling Notation (BPMN) promise standardization for the management of inter-organizational business processes that involve different applications, departments and business partners [10]. Therefore a mapping mechanism has been developed allocating EPC-elements to BPMN constructs. Besides, a wide acceptance of the Business Process Execution Language for Web Services (BPEL4WS) by BEA, IBM, and Microsoft as well as the newly finalized specification of the Web Services Choreography Interface (WSCI) mainly driven by BEA, Intalio, SAP and Sun show the importance of a second standardization level for interoperability [23]. While BPMN is more focused on the conceptual level, the latter two focus on the transformation into the system-level by orchestrating web services.

4 Towards an Intuitive Cross-enterprise Business Process Management

In this paper a framework and a lifecycle model were developed, that provide a generic solution concept, which transfers business recommendations into ICT-solutions based on a holistic business process management approach and supported by intuitive tools. The greatest demand for further research can be seen in the formulation of transformation methods especially in a methodologically sound transfer of process models into ICT-configurations. Another aspect that requires further research is the use of supporting tools that ease the task of exchanging process models between different enterprises and to distinguish between private and public knowledge. User-specific views on the business process models will enable new user groups to use BP-models,

as the example of intuitive metaphor based process modeling points out. Moreover ICT can support actively business process management by checking, verifying or even automatically negotiating consistency and interoperability of models.

The described conceptual design of inter-enterprise business processes and the open research questions are currently elaborated in the research project "Architecture for Collaborative Scenarios (ArKoS)"[24], funded by the German Federal Ministry of Education and Research (BMBF). As a proof of concept the presented distributed process enactment was implemented in a agent-based software prototype and evaluated in a four countries showcase by the EU-funded project "InfoCitizen"[25].

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