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Cross-organizational processes in Public Administrations: Conceptual modeling and implementation with Web Service Protocols

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Abstract

An increasing level of cooperation between public administrations on regional and national levels requires methods to develop interoperable E-Government systems. It leads to the necessity of an efficient modeling of cross-organizational business processes and their subsequent implementation. This is a complex task, since it includes modeling of processes from various perspectives - modeling of internal and cross-organizational processes - and on various technical levels to enable both conceptual modeling and the execution of processes that comply with the conceptual models. In this paper a methodology is described for creating models of cross-organizational business processes based on Event-driven Process Chains (EPC). Building on this, it is described how these conceptual models can stepwise be transformed to technical process models in the form of Web Service protocols for implementing the cross-organizational processes. The methodology is motivated and explained on the basis of an E-Government reference model for the German Plan Approval Procedure.

1 Introduction

Due to the increasing heterogeneity and dynamics of the European Union, more and more public administrations within Europe are challenged to work together and to adapt continuously to rapid technological changes. New legal settings, strategic commitments, higher expectations for improved quality of service as well as rapid technological advances create a new dynamic
and complex administration environment, which requires transparency, flexibility and mobility from European public administrations. In order to improve the transparency of collaborative processes in public administrations, enterprise modeling is a promising approach. Enterprise models are easy to understand for various stakeholders of an organization and thus can help to get a joint understanding of processes, organizational structures and underlying IT-systems over organizational borders. After such cross-organizational process (CBPs) has been developed, the challenge is to ensure an implementation complying with this model. Thus, in this paper, a concept for collaborative modeling and a corresponding protocol based implementation will be introduced, which help organizations to define interactions on design-level and to transform them into a machine-readable protocol.

Web Service protocols enable public administrations to customize and implement CBPs in a decentralized and vendor-independent way. Due to the heterogeneity of IT-systems in public administrations and a relatively high resistance to changing underlying application systems, especially the last point recommends the use of the open Web Service standards in the E-Government. Interactions of public administrations comprise various groups, e.g. not only Government-to-Government (G2G) but also Government-to-Business (G2B) and Government-to-Citizen (G2C). Since citizens are not expected to explicitly model their business processes for preparing an electronic exchange of messages, this paper focuses on G2G and G2B scenarios.

After describing related research in section 2, in section 3 a method is presented that allows the creation of CBPs on a conceptual level. Here, the requirements and single steps of the collaborative modeling method are illustrated on the E-Government case study. In section 4 we change from design time to run time and describe how to implement the modeling approach presented before with Web Service protocols. Section 5 concludes with a summary and an outlook on future research.

2 Related Research

Various standards for promoting interactions have been developed especially for the public sector. The so called SAGA has been developed by the German government within the initiative „BundOnline 2005“ [KBS05]. SAGA defines standards and architectures for E-Government applications. This includes, for example, standards for data descriptions based on
XML, middleware technologies and protocols (e.g. J2EE, .Net, SOAP), or security standards like ISIS-MTT. The Online Services Computer Interface (OSCI) represents a protocol standard for the local authorities of Germany. It consists of a set of protocols like the OSCI transport protocol and the OSCI XÖV protocols. SAGA and OSCI allow public administrations to realize E-Government interactions, but do not support efficient modeling and implementation of cross-organizational business processes, nor do they comprise the implementation of CBPs with Web Service protocols as provided by the Business Process Execution Language for Web Services (BPEL, [ACDG03]).

With the rise of SOA and an increasing focus on coarse grained business functions than on fine grained technical modules, protocol standards - like BPEL - moved closer to conceptual business processes [ACKM04]. In the industrial field business protocols provide a widely-used approach for the message exchange between the involved partners of a collaboration as well as the design of application systems. The definition from [LeRo04] of a protocol focuses on the viewpoint of one partner: “a business protocol specifies the potential sequencing of messages exchanged by one particular partner with its other partners to achieve a business goal. I.e. a business protocol defines the ordering in which a particular partner sends messages to and expects messages from its partners based on actual business context”. Other authors use the term conversation protocol, which they define as “… a specification of a set containing all correct and acknowledged conversations”, where a conversation represents “sequences of operations (i.e., message exchanges) that could occur between a client and a service as part of the invocation of a Web service” [ACKM04]. The term protocol is closely related to the concept of Web Service Choreography, defined by as “… a multi-party contract that describes from a global view point the external observable behavior across multiple clients (which are generally Web Services but not exclusively so) in which external observable behavior is defined as the presence or absence of messages that are exchanged between a Web Service and it's clients” [ABPR04]. In this paper the term Web Service protocol is used for technically detailed descriptions of allowed interactions between Web Services, as provided for example by BPEL or the Web Service Choreography Description Language (WS-CDL, [KaBR04]).

Literature on protocols and business processes usually focuses on modeling the exchange of fine grained, technical objects, like [MASN06], where state charts are used to display protocols, and disregards interaction descriptions stemming from the business level. This goes also for working on protocol engineering from agent related research, e.g. [ViHu03], [AFLS05].
Another example is [DeSi04], who claim to take into account business process models for development of protocols, but only provide models on a technical level represented with state charts, disregarding the organizational perspective in CBP development.

Recently the development of CBP on the business level for preparation of a CBP implementation was investigated, e.g. in [GLKZ06]. Also in that context, [ZDHB06] described a graphical language to describe service interactions, concentrating on global models. However, this language focuses on ensuring technically correct models, and the global models displayed by it are inadequate for illustrating complex CBPs to non-technicians.

The approach described in this paper focuses on transforming conceptual process models in form of EPC into executable protocols (abstract BPEL processes), and thus is comparable to OMGs MDA [JiJo03] approach. But in difference to that approach, our approach is based on a notation developed for business analysts and provides a specific methodology of how to derive the necessary models in different organizational contexts.

Extending former ATHENA results regarding the conceptual modeling of CBPs, we describe a way of how to prepare and develop Web Service protocols in an eGovernment environment. Thus, following the aim of the R4eGov project, the problem field of interoperability in the E-Government is tackled.

3 Conceptual Modeling of Cross-organizational Business Processes

In order to model the entire enterprise and its interfaces, different modeling dimension are necessary. Modeling frameworks which previously have been applied for enterprise modeling include, for example, the “Framework for Information Systems Architecture” (Zachman Framework) [Zach87] and the “Architecture of Integrated Information Systems” (ARIS) [Sche99]. Both frameworks offer modeling support for various dimensions of an enterprise. Although both frameworks combine different user perspectives and allow modeling on different levels of abstraction, they lack methods which allow modeling of cross-organizational collaborations, as a creation of an external view on the organization is not supported.

The modeling methodology described in this paper aims at developing easy-to-understand business process models that are transformable to Web Service protocols. For modeling conceptual CBPs the EPC was chosen. The EPC has been established for business process management for more then one decade and represents business processes by sequences of
events and functions put in logical and timely order; a further description can be found in [KeNS92]. The concepts for collaborative modeling and protocol based implementation will be described and evaluated on the basis of a scenario introduced in the following chapter.

3.1 A Cross-organizational Process in Public Administration: The Plan Approval Procedure

A Plan Approval Procedure (PAP) is a special, formal administrative procedure, whose single regulations are described in detail in the §§ 72 et seqq. of the Administrative Procedures Law (VwVfG). The aim of the PAP is to achieve the obligatory official approval of a plan (OAP) by a so called Plan Approval Decision. An OAP enables the matching of a number of public and private interests, which are addressed by a plan. Thus, it represents a substitution of necessary official decisions like for example administrative decisions or permissions by only one administrative act and at the same time eliminates possible further claims for omission [Beck05]. An OAP also determines exactly where the construction will be located later on. The regulations of VwVfG apply only if there is no prescription in a more specific law. These specific laws also determine for which procedures a PAP is necessary. An OAP is, for example, necessary for the construction of streets (according to the Federal Street Law (FStrG)) or the construction of airports (according to the Air-Traffic Law (LuftVG)) [HoSB01]. A PAP can roughly be divided into two main steps: a “hearing procedure” and a “decision procedure”. Because a PAP is required for most of the construction projects and involves various partners like public administrations, businesses as well as citizens, it is a suitable procedure to illustrate the conceptual modeling and implementation of a cross-organizational business process in the public sector.

Fig. 1 gives a general overview about the PAP. At the beginning of the process the project agency (e.g. a manufacturer) submits the plan for the construction project to the hearing agency. This plan is then checked and published by the hearing agency. After the plan has been published, the parties involved (e.g. the citizens and the retailer) have the right to have a look at the plan and, if necessary, raise objections. The hearing agency checks these objections and decides, in consultation with the parties involved, whether the plan has to be revised or not. In case of a necessary revision, the plan has to be revised by the project agency (e.g. the manufacturer). Afterwards, the revised plan is submitted to the hearing agency again, which
then forwards the plan to the approval agency. The Plan approval agency has the assignment to check the procedure according to the rules, to accept the plan and to announce it.

3.2 Modeling Private, View and Cross-organizational Processes with EPCs

In a first step the scenario was analyzed concerning the requirements of the different partners. The analysis resulted in the following requirements for CBP models: First, the internal business processes of each partner have to be linked into a CBP without revealing confidential information. Second, the CBP models should only capture collaboration essentials, e.g. the collaborating parties only have to be interested in that part of a process which determines the interaction behavior; additional information could be confusing. Third, a simplified process adoption has to be achieved, e.g. a Hearing Agency interacting with different citizens and business partners should not require different private processes for each collaboration it is involved in. Fourth, internal process should still be flexible, e.g. although the interaction is fixed, the private processes behind the view processes have to remain flexible.

In order to realize the scenario requirements, it was necessary to introduce another abstraction layer which allows the externalization of information, which is necessary for the interaction with external partners. In the following, internal processes are defined as Private Processes (PP) which are only known to their owning organization and not exposed to the outside world. The abstraction of information is achieved by the introduction of Process Views as an additional abstraction layer between the PPs and the CBP model as proposed by Schulz [Schu02], [ScOr04]. Process views provide a process-oriented interface towards business partners. Process views are an abstraction of the private processes, containing information that needs to be
published for the purpose of an interaction. Several tasks of a private process can be combined to one view task. This leads to the following definition: A View Process (VP) abstracts information from one or more PPs and thus enables companies to hide critical information from unauthorized partners. It is an interface to the outside world which extracts only information, which is necessary for the interaction with one or more potential partners. Thus, a VP can be seen as a general interaction description of one or more PPs from the perspective of one partner.

Figure 2: First part of the Plan approval Procedure – Global process

While a VP describes valid interactions from the perspective of one partner, a CBP describes these interactions from a neutral perspective, capturing all allowed interactions between all partners. Since a VP can contain interactions with different partners, in special cases a VP can
capture all information contained in a CBP even in multi-party collaborations, when the collaboration activities consist only of those interactions between the partners and an organization that are described in the VP, offered by this organization.

While more technical definitions of view processes reduce them to descriptions of digital message exchanges (cp. [Buss02]), on the conceptual level also partner interactions regarding money (“Payment received”) or material (e.g. “Deliver Container”) can be described in a view process. In the following, the CBP-concept will be shown on the basis of the scenario. In fig. 2
the overall CBP is illustrated as a global process, fig. 3 shows two corresponding view processes.

The disassembly of the global process to view processes was guided by the following principles: First, the view process has to show the other party in which sequence which messages are exchanged. Nonetheless, since the global process is public anyway, no information hiding must be involved in developing the view processes, e.g. all information shown in the global process can be also shown in the view processes. For the sake of reducing complexity, these functions might be left out of the view process. On the other hand, even if functions are not directly involved in interactions, they might provide the collaboration partner with a better understanding of the process and also allow their own party to adapt its private processes better to the view process. The function “Execute preliminary check” of the government view process is an example of such a function.

Second, to constrain complexity, the view processes show only interactions on the level of the global process. Interactions happening below that level are displayed in sub-protocols. For example, the function of “Counseling” of the government contains a communication with the function “participate in counseling” of the project agency. The symbol of the messages lying on each other indicates a finer grained exchange of messages. The corresponding sub protocols are displayed in sub view processes. Thus fig. 4 illustrates the sub view process representing the

Figure 4: Sub View Processes to agree on a Meeting Date between Government and Project Agency
interactions between the functions “execute counseling” and “participate in counseling” of the view process shown in fig. 3. Note, that view processes on this level of granularity often display standard situations which are applicable in various contexts and thus can be seen as re-usable interaction patterns.

Third, since the global process indicates the organizational units responsible for functions, the view process functions should be derived accordingly: Each function of a global process that is annotated with organization A must appear in the view process of organization A. If more parties have an organizational unit attached to this function, it has to be decided how this function has to be split up. Normally, an exchange of messages between the parties must take place. An example is splitting of the function “Perform counseling before Application” from the global process to the two functions “Execute Counseling” and “Participate in Counseling” from the view processes of government and project agency.

3.3 Modeling Procedure

In section 3.2 we introduced concepts which support users in designing collaborative processes in public administration. But, providing methods to externalize internal information is just one challenge in supporting interoperable organizations. At least as important as the appropriate method is a procedure model which supports organizations in planning and designing CBPs. Thus, a procedure is required that describes in which order models have to be created to make best use of the approach. Concerning the creation of views and CBPs, three possible procedures can be identified. The procedure that was used in chapter 3.2 was a top-down procedure. In a top-down approach, the partners start identifying a common picture of the collaborative scenario in terms of a CBP model. This contains the definition of the whole interaction of all partners. Afterwards, each partner has to create his 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).

Within a bottom-up approach each organization starts with the speciation and modeling of their private processes. The next step contains the creation of process views which represent the necessary interaction of the PP (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 modeling activities (dashed
arrows 3). The third scenario is a middle-out procedure. It starts with one partner specifying and modeling its private processes and offering 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.

![Diagram](image)

**Figure 5: Modeling procedures: Top-down vs. bottom-up**

# 4 Deriving Business Protocols from View Processes

## 4.1 Business Protocols based on Web Services

Various standards exist to describe protocols, including the Business Process Specification Schema (BPSS) of ebXML [CCKH01], the Partner Interface Processes (PIPs) of RosettaNet (http://rosettanet.org), WS-CDL and the abstract processes of BPEL, which are also called BPEL protocols [ACDG03]. To establish an E-Business conversation, several components are necessary: interfaces published in a network, interaction descriptions and partner roles, a standard vocabulary and an environment of security and trust [Masu03]. RosettaNet, being a prominent example for E-Business protocols, contains all of the components listed above, but comprises only a predefined list of interaction patterns (called PIP) described with UML activity diagrams, text tables and XML documents. To provide more specific and technical process descriptions, [Masu03] and [Khal05] propose to transform PIPs, which represent proven well established reference models for CBPs, to BPEL processes. Though the methodology described in this paper also aims on generating BPEL processes, it does not focus on pre-established interaction patterns (like PIPs do), but allows the development of individual CBPs. Since Web Service standards provide interface descriptions (WSDL) and interaction...
descriptions (e.g. abstract BPEL processes), they can seen as complementary to established E-Business protocol standards like RosettaNet.

Similar to the different ways of describing conceptual CBPs, different methods exist to specify protocols: the first describes the interactions of all partners with the help of global models; the second only describes interactions of one partner with a so called abstract process (also called process skeleton, process stub or public process). Abstract Processes describe interactions from the viewpoint of one partner, thus they can only describe the interactions between this partner and one or more of its partners but not the interactions between his partners, where this partner is not directly involved. In comparison to abstract processes, global models allow for better use of model checking techniques (cp. [FuBJ03]). WS-CDL seems to be the only Web Service based standard for describing global processes, but only a few prototypical tools are supporting this standard. While global models are valuable in the design and analysis of CBPs, for implementing them in general, abstract processes are to be preferred: They comply with organizations demands of a de-centralized process execution (e.g. no central engine is required) and show as little process information as possible and only to immediate collaboration partners. BPEL abstract processes can either be used during design-time to ensure that private BPEL processes of the collaborating partners are complementary, they also might be used on run-time as input to an protocol engines as described in [MASN06].

4.2 Relating Conceptual CBPs to Business Protocols

In order to execute collaborations between two or more partners apart from a modeling method for CBPs a method is needed which allows companies to execute CBPs. Therefore, the concepts of Private Process, View Process and CBP described above for the aim of modeling CBPs on a conceptual level, can be matched to the more technical, Web Service and protocol related terms of abstract process and global model to enable their execution by IT systems. The interactions between various parties (e.g. CBPs respectively global models) can be described with WS-CDL, interactions of one service with its partner services (e.g. view processes respectively abstract processes) can be described by BPEL. How private EPC processes can be transformed to executable BPEL processes is described in (cp. [ZiMe05]).
Since the interactions realized by protocols should be controlled by business analysis, we propose an EPC based design of the (BPEL) protocols. As fig. 6 illustrates, we propose a two step transformation from the EPC level to the Web Service level. On the upper level, private and view processes are modeled by business analysts as described in section 3. Afterwards, these EPCs are enriched with Web Service specific information and shaped according to conventions for compliance with BPEL processes. These models contain the Web Service invocations (also describing the message exchanged between collaborating administrations) and all control flow information relevant to specify the sequence of interactions. Note, that this type of EPC processes can also be used as a visualization of BPEL processes. In the second step these technical EPC processes are further enriched by BPEL programmers, e.g. with variables used in a BPEL process to realize the control flow specified by the technical EPC process, and annotated in XML.

In section 3 it was described how conceptual models are derived in a coherent way, ensuring that the view processes of collaborating parties are complementary. Following this model driven approach ensures that the implementation of the CBP is compliant to the conceptual model. Nonetheless, since the technical model contains further information (e.g. the name of Web Services to be invoked), the technical view process models have to be synchronized also.

4.3 Deriving Web Service Protocols for the Plan Approval Procedure

Based on the sub view processes shown in fig. 4, now technical EPC models are derived, that contain the BPEL syntax necessary to specify the interactions between both parties. Since BPEL can represent both a graph based and a block-oriented control flow (e.g. a containing a While Loop), all EPC control flow elements can be transformed to BPEL (cp. [ZiMe05]). If the EPC functions represent interactions (e.g. “receive message”, “send message” etc.), they can be
transformed to corresponding BPEL orders, if an EPC function represents activities not captured by the BPEL syntax (like “Evaluate proposal” in fig. 4) an individual Web Service has to be created that will be invoked by the BPEL process. In [ZiMe05] further details regarding the transformation of EPCs to BPEL are described. The result of the transformation from the EPCs in fig. 4 to the BPEL aligned EPCs is illustrated in fig. 7.

The whole interaction takes place between two Web Services, one offered by the Government ("GovService") and one by the Project Agency ("ProService"). The source and destination services are attached to the interaction activities, e.g. “Invoke propose Date” sends a message called “Date” to the Enterprise Service. The notation distinguishes between internal Web Services (e.g. “Receive initiate counseling” is invoked by a Web Service inside the public administration) and external Web Services, marked with the letters “ext”. The right side shows the abstract process of the Project Agency, which interacts with the abstract processes of the government. On the right of the government view process, the corresponding private process is shown, also. The abstract processes only contain the information necessary to describe the interaction with the other Web Service. Thus, the function “Evaluate Proposal” does not appear in the abstract process, though for illustrative reasons it was part of the conceptual view process. As the synchronous invocation of the “Create Date Proposal” function shows, these functions might be added again in the private processes. The private process also contains functions to interact with the top level process: It is called by its parent process and after the meeting is fixed, it replies the result to the parent process.
5 Summary and Outlook

We described how CBPs can be described by a combination of private, view and collaborative processes with EPCs. This concept was motivated and evaluated on the basis of an eGovernment reference model. In order to automate this collaborative process, we proposed a transformation to business protocols and described some forms of such protocols. Due to their close relationship to executable models of private process and the possibility to describe them in a machine readable format, the abstract processes of BPEL were chosen as the target protocol. Accordingly, we described a transformation of the EPC based concepts to model CBPs view processes to BPEL abstract processes and illustrated this transformation by the use case introduced before. For example, we described under what criteria conceptual view processes can be derived from conceptual global processes and showed how the use of sub protocols on the conceptual and technical level can reduce the complexity of CBPs in the E-Government.

One 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 the different model types used in CBPs. This tool could support actively business process management by checking, verifying or even automatically negotiating consistency of models. As fig. 6 shows, only taking in regard view process and private processes, numerous interdependencies exist between the different model types. This paper focused on a Top-Down approach; in future we will investigate further procedures to synchronize those models, e.g. taking private processes as the starting point of the CBP development.

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Einführung in den Track

Information Services in der Logistik

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Prof. Dr. Herbert Kopfer
Universität Bremen

Prof. Dr. Kai Furmans
Universität Karlsruhe

Dr. Dieter Pütz
Deutsche Post AG

Neben den modernen Informationstechnologien hat vor allem die Leistungsfähigkeit von Transport- und Umschlagsystemen einen erheblichen Einfluss auf die zukünftige Entwicklung der Arbeitsprozesse zwischen Industrie-, Handels- und Dienstleistungsunternehmen.

Der Track widmet sich daher Strategien, Modellen, Algorithmen und Softwaresystemen, die der Verbesserung der Güterflüsse in einer Supply Chain dienen. Im Fokus stehen hierbei die Planung und Konfiguration logistischer Netzwerke, die strategische Transportplanung, die operative Transportplanung und ihre Unterstützung durch Telematik und Verkehrsinformationssysteme, das Management von Terminals und intermodalen Hubs sowie Fragen der Gestaltung kooperativer Systeme und elektronischer Marktplätze für Logistikleistungen.
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