A Reference Model for Seamless Cross-Organizational Collaboration in the Public Sector

Christoph Schroth

University of St. Gallen, MCM Institute
SAP Research CEC St. Gallen
Blumenbergplatz 9, 9000 St. Gallen, Switzerland
christoph.schroth@sap.com

Abstract: Today, electronic cross-company collaboration is about to gain significant momentum, but still shows weaknesses with respect to productivity, flexibility and quality: A lack of standardized supporting e-Business solutions, unclear terminology and unstructured business processes prevent from seamless interoperability and the fast development of a globally networked service economy. A novel approach is now required which facilitate a comprehensive industrialization of related concepts and methodologies. In this work, we present the St. Gallen Media Reference Model (MRM) and extend it to fulfill the specific needs of electronic, cross-organizational collaboration. Based on the three components "Organizational" (structural as well as process-oriented organization of interaction between agents), "Logical" (common language between agents) and "Physical" (the physical infrastructure enabling interaction), we amend the reference model by introducing key principles which improved the performance of computer programming during the past decades. To show its real-world applicability and potential for performance enhancement, we apply this extended MRM to the specific case of governmental administration in Switzerland.

1 Introduction

Due to the relentless march of improvements in the cost-performance ratio of information technology, electronic cross-company collaboration is about to gain significant momentum and facilitates the emergence of a globally networked service economy [Sc07b, Po01]. However, significant challenges must still be coped with to successfully deploy and operate proper e-Business solutions: Substantially different standards prevent from a common understanding of both business processes and exchanged data, while high cost and complexity of existing solutions impede a fast adoption by potential users. Besides of technological hurdles, managerial issues have to be considered as well. The structural as well as process-oriented organization of cross-organizational collaboration mostly does not build upon solid guidelines and design principles. New concepts are therefore required to facilitate a comprehensive industrialization of the provision and consumption of electronic information-intensive services across corporate boundaries [Sc07a].

In this work, we present the **St. Gallen Media Reference Model (MRM)** [SKL99] which serves to formally structure and analyze various kinds of media and comprises the three major components Physical Component (physical basis of the medium), Logical Component (logical sphere between agents) and Organizational Component (social interaction organization). The St. Gallen MRM comprises a dedicated layer and phase model which builds upon these three components and allows for systematically modeling, understanding and reorganizing media. In this work, we extend this reference model to meet the specific requirements of electronic, cross-organizational collaboration and thereby leverage central principles which proved to improve productivity, quality and flexibility of computer programming. We apply this reference model to the specific case of **governmental administration in Switzerland**, which represents a cross-organizational service industry with significant potential for performance enhancement.

2 HERA: A novel Framework for Seamless Cross-Organizational Collaboration

2.1 The collaborative process of creating tax declarations in Switzerland

In this section, we elaborate on a case study that has been conducted in the course of the Swiss government-funded project HERA [He07] which aims at an improvement of the tax declaration procedure in Switzerland. It serves as example for the interaction of certain stakeholders who collaborate to achieve a common goal: As depicted in Figure 1, there are mainly four stakeholders involved in the cross-organizational process of creating a tax declaration. First, a company itself aims at submitting a tax declaration that complies with laws, is consistent with the forms issued by the various cantons (Swiss states) and is optimized with respect to the resulting tax load in an as efficient way as possible. Accountants can either be represented as company-internal departments or external service providers. They create comprehensive financial statements and also provide consulting services with respect to profit appropriation strategies. Auditors have to be organizationally separated from accountants (by law) to ensure their independency. They examine and verify compliance of financial statements and profit appropriations. Finally, the cantons (states) receive the completed tax declaration and initiate the assessment/ enactment process. Municipalities play a certain role within the tax declaration process in some of the Swiss cantons, but are left out in this work due to space constraints. Also, the visualized, cross-organizational business process represents a cutout (which is valid in the canton of St. Gallen) of the full process with all its canton-specific deviations. During this procedure of creating a tax computation, the division of labor among the players induces the need for coordination and information exchange between them which follows certain process choreographies. As a consequence, numerous documents (as visualized in the graphic) are passed from one stakeholder to the other and are thereby processed in different ways until they reach the end of their respective “lifecycles”. Today, all stakeholders depicted in Figure 1 interact with each other via different communication channels. Some information is exchanged in paper format; other documents are transferred via e-Mail or proprietary electronic interfaces.

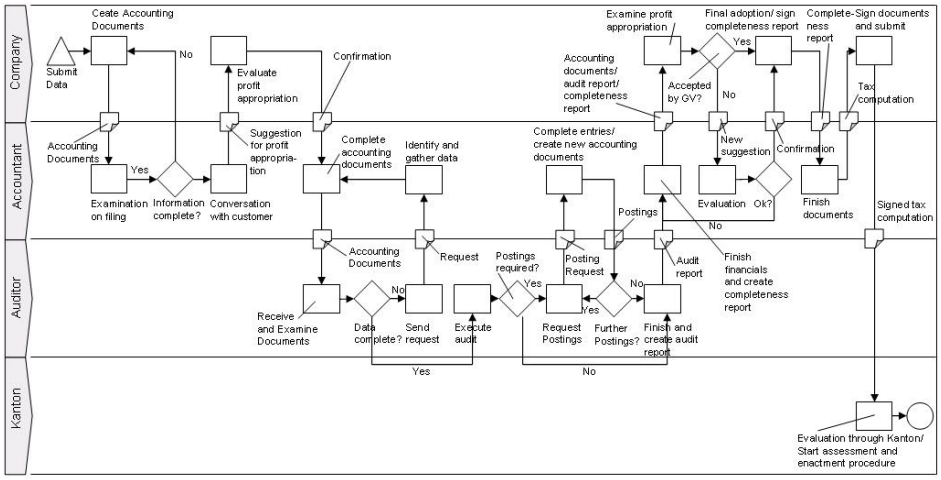

Figure 1: Cross-organizational tax declaration process in Switzerland

Resulting media breaks, the lack of standardized interfaces and the strong involvement of humans into information processing induces high transaction costs and increases the risk of errors, thereby limiting service quality. Also, services are only rarely subject to quantifiable performance metrics. The study has shown that especially non-functional properties of services such as delivered quality or exact time required for completion are usually not provided in a clear, formal and quantifiable way. Also, the cross-organizational process varies from canton to canton as the individual states determine the boundary conditions of the tax declaration procedure. The heterogeneity prevents from standardization with respect to terminology, processes, pieces of information and therefore deteriorates the productivity of seamless collaboration across the stakeholders' boundaries. Frequently, decisions have been found to be made on the basis of best practices instead of formalized rule sets.

2.2 The extended St. Gallen Media Reference Model

This section is devoted to showing a reference framework which enables to analyze, design, implement and change electronic media for cross-organizational collaboration. According to Schmid [SKL99, SS04], **media** can basically be defined as enablers of interaction, i.e. they allow for exchange between agents. Such interaction enablers can be structured into three main components: First, a **physical component** (**C-Component**) allows for the actual interaction of physical agents. This component can also be referred to as carrier medium or channel system. Second, a **logical component** (**L-Component**) comprises a common "language", i.e. symbols used for the communication between agents and their semantics. Without such a common understanding, the exchange of data is possible (with the help of the C-Component), but not the exchange of knowledge. Third, an **organizational component** (**O-Component**) defines a structural organization of agents, their roles, rules which impact the agents' behavior as well as the process-oriented organization of agents' interactions. Together, these basic three components have been identified to constitute various kinds of media. Among others, it is appropriate to describe electronic media such as those deployed to support cross-organizational

collaboration. Based on these components which already represent a first, scientific approach to modeling, understanding and reorganizing media, a layer/ phase reference model has been introduced as well. The **Media Reference Model** (MRM) (Figure 2) comprises four different layers (which all represent views on media) and structures the use of media into four sequential phases.

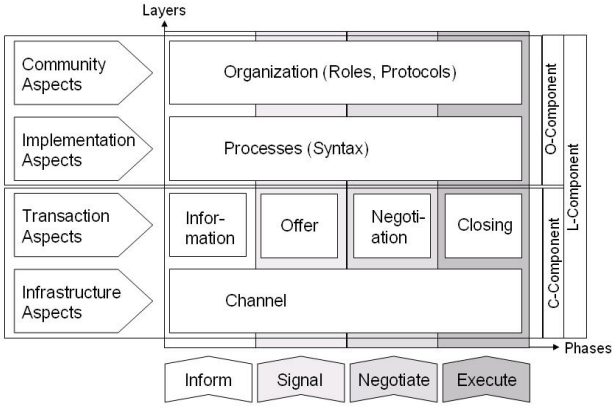

Figure 2: Schmid's Media Reference Model [Skl99]

The **Community View** (first layer) accounts for the set and structure of interacting agents, the organization of the given agents' population, i.e. the specific roles of involved stakeholders, the situations in which they act as well as the objects with which they deal. The **Process View** (Implementation Aspects) deals with the modeling of the process-oriented organization of agents and can also be referred to as "Interaction Programming" [SS04]. It is also called implementation view as it connects the needs of the community with the means provided by the carrier medium and thus implements the "community-plot" on the basis of the carrier medium. The **Service View** (Transaction View) models the services provided by the carrier medium which can be used in the different interaction steps to reach the respective interactions' goals. The **Infrastructure View** models the production system, which creates the services provided by the service view, i.e. in the case of electronic media the actual underlying information technology. The above discussed three major components can seamlessly be integrated into the MRM: The upper two views represent the organizational component (O-Component) which accounts for the structural as well as process-oriented organization. The lower two layers are mapped to the physical component (C-Component) which focuses on the creation and provision of services. Last, the logical component (L-Component) concerns all four layers as it ensures that interaction of agents is based on a common understanding of exchanged symbols. The four phases promoted by the MRM are not in the focus of this work and therefore shall not be further discussed.

2.2.1 The Managerial View (O-Component)

We will now focus on the upper two layers of the MRM and discuss how both the **structural** and the process-oriented **organization** of agents' interaction can be improved through transferring major software programming and engineering principles, in particular the essential paradigms of modularization [Pa72] and service-orientation

[ACK04, Mc07] to the context of human organizations. As a first step in the process of engineering a (distributed) organization is *to identify the overall tasks* which have to be accomplished. In the public sector context, tasks are mostly defined by law; in the business context, they are derived from general strategy. The identified tasks shall then be structured and decomposed into subtasks (which we refer to as services) according to the criteria proposed by Parnas [Pa72] in the software programming context: First, rather than starting with a process or workflow and determining subtasks/ services as sequential parts of this process, organizational engineers are supposed to encapsulate those *design decisions which are difficult or likely to be subject to change* in the future: "We have tried to demonstrate by examples that it is almost always incorrect to begin the decomposition of a system into modules on the basis of a flowchart. We propose instead that one begins with a list of difficult design decisions or design decisions which are likely to change. Each module is then designed to hide such a decision from the others. Since, in most cases, design decisions transcend time of execution, modules will not correspond to steps in the processing."[Pa72] Second, organizational services need to *hide as much proprietary information as possible*. By shielding information and complexity from the outside world, services are quickly exchangeable and their specialization is facilitated. In this way, service managers may change and optimize service-internal operations over time if required without affecting other services' functionality. As a third important criterion which we transfer from software engineering to the organizational context, *hierarchies need to be adopted* where appropriate: Tasks are first of all broken down into subtasks/ services which reside on a first level. Similar to composite Web Services [ACK04], such services than can often be composed out of other, more basis and focused services: "The partial ordering gives us two additional benefits. First, parts of the system are benefited (simplified) because they use the service of lower levels. Second, we are able to cut off the upper levels and still have a usable and useful product." [Pa72]

After these decomposition rules which mainly concern the structural organization ("community aspects" according to our MRM), the **process-oriented organization** must be dealt with: Business processes are realized by orchestrating the above discussed services (on possibly different hierarchy levels) appropriately (again, similar to the orchestration of Web Services). In the programming context, there are two basic elements for organizing the procedural execution of an algorithm. First, certain logic underlies any algorithm which represents "what" it is supposed to be achieved. As opposed to the "what", there is a control element which describes "how" the respective goal shall be achieved. In the course of programming evolution, two different classes of languages have emerged: *Declarative* languages "allow the programmers to concentrate on the logic of an algorithm (declarative languages are goal driven, control is not the concern of the programmer), while *imperative* languages require the programmer to focus on both the logic and control of an algorithm" [Co07]. This means that imperative languages "describe computable relationships in terms of sequences of operations", whereas declarative languages "are made up of sets of definitions or equations describing relations which specify what is to be computed (not how it is to be computed), e.g. Prolog" [Co07]. Similarly, in an organizational context, the collaboration of agents (across corporate boundaries) can be organized by prescribing the logic and the control (adhering to an imperative style) or by only pre-determining the logic (i.e. "what" has to be accomplished). The choice for an imperative or rather declarative process-oriented organization depends on certain external requirements. In

case stable, standardized processes determine the interaction of agents, an imperative organization is appropriate. In cases where the actual interaction of stakeholders depends on various situational, unforeseeable factors, context-sensitive parameters or individual preferences and restrictions which vary over time, a process-oriented organization which prescribes both logic and control elements is not adequate. In such environments, more declarative "interaction programming" is needed which is merely based on specifications of "what" has to be achieved during the interaction rather than "how" (e.g. in which exact order).

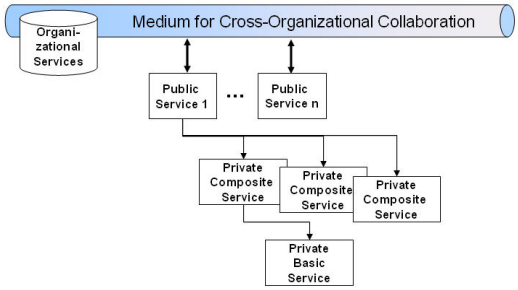

Figure 3: Service Taxonomy for Cross-Organizational Collaboration

Figure 3 shows a simplified view on the upper two layers (**Community Aspects and Implementation Aspects**) of the extended MRM for cross-organizational collaboration: The blue bar symbolizes a medium which is shared by a number of various agents who intend to provide or consume "public" services with its help. So called "Organizational Services" first of all account for both the structural and the process-oriented organization of these services. The stakeholders as well as the operations they offer are encapsulated as "Public Services" which act in different roles (roles formally describe sets of obligations and rights [SKL99]). Complying with the requirements stated in [SKL99], organizational services also should comprise a registry of the different involved stakeholders which allows to easily retrieving interaction partners including their individual attributes such as functional restrictions, preferences and track records. Also, (either declarative or imperative) interaction programs (describing the process-oriented organization between the various agents and their services) are stored and maintained as part of this O-Component. Finally, certain elements which ensure a common understanding between the different stakeholders (L-Component) are installed as part of the organizational services as well: Common standards with respect to structure as well as semantics of exchanged messages which represent the objects dealt with by the agents [SS04] (to ensure seamless cross-organizational interoperability), uniformly defined role models for the connected services, common addressing schemes and process logic and control descriptions represent some of the most important elements of the L-Component within the upper two layers of our extended MRM.

2.2.1 The Infrastructural View (C-Component)

Besides Community and Implementation Aspects of seamless cross-organizational collaboration which focus on the O-Component as well as organization-related elements of the L-Component, **Transaction and Infrastructure Aspects** play a critical role as well.

These lower two layers of our extended MRM mainly focus on the provision of services via "Service Access Points" [SS04, p.46] and their actual creation through "encapsulated" agents [SS04, p.46]. In this context, it is important to mention that services provided as part of the medium can be created by arbitrary stakeholders. The operators of the medium, external participants or other parties may be in charge of offering and maintaining them. The languages and logic required to describe these services constitute the service-part of the above discussed L-Component. It provides adequate means to semantically describe the services and the related information objects. Also, the formal means for the description of interfaces as well as the rules for their consumption are part of the service-related L-Component.

Certain media services which **facilitate the interaction of agents** particularly in the context of electronic, information-intensive services which are provided and consumed across corporate boundaries have been identified in the course of research projects such as HERA [He07] and ATHENA [At07]. Services accounting for security of the information exchange, fault detection and removal, message format validation, tracing of message exchange histories represent some of these which all serve connected users and their need for reduced uncertainty inherent to their interactions. By fulfilling basic institutional services and by allowing for an improved degree of governance, media employed for the support of cross-organizational collaboration will be more attractive and experience better adoption rates than without such a value-adding offering.

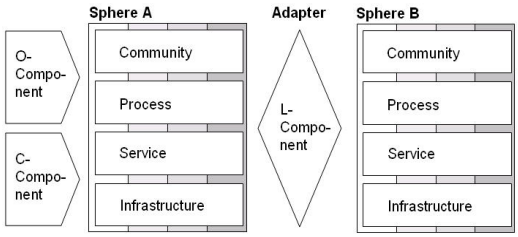

Figure 4: Adapting the L-Components of different Spheres (concerning both O- and C-Components)

So far, we have been discussing the organization (both structural and process-oriented) of collaboration via media as well as its realization based on services and certain infrastructure. The organizational and (in the field of electronic, cross-organizational collaboration) technological layers (Figure 4) are, as discussed above, amended by an L-Component. It ensures a common understanding of artifacts such as message structure, semantics, role models, service orchestration patterns (processes) and descriptions within the O-Component and service descriptions, interfaces and others within the C-Component. Since the L-Component, however, has been found to highly vary between different media used to support inter-organizational collaboration, another key element shall be introduced. To allow for the establishment of different semantic, logical spheres, we propose **adapters** as critical element into our extended Media Reference Model. In case two business ecosystems have already established specific organizational (O-Component-related) as well as technical (C-Component-related) standards, they are thus enabled to collaborate by leveraging an adapter which mediates between them.

In this way, for example, the already existing e-Business standards dilemma can be coped with: Over time, companies or whole industries have developed strongly varying formats and semantic representations of the same information, leading to a huge degree of confusion and uncertainty with respect to electronic information integration [Ma04, Mc04]. By employing adapters which automatically transform the different formats, this issue can be tackled adequately. Similar advantages can be realized with the mediation between different role models and descriptions, stakeholder registry formats and addressing schemes, process pattern semantics and many more.

The last step in the process of organizing and deploying cross-organizing collaboration is referred to as "**Design**" by Schmid's MRM [SKL99, SS04]. Design thereby represents the task of actually realizing the "ideas" of the community-and process-related layers in a tangible form. Briefly, the design process comprises the adequate transformation of O-Component elements to C-Component elements. The choice of a proper carrier medium (in our case the underlying information technologies) represents a significant challenge as it strides along with considerable implications (e.g. on user adoption). Due to space constraints, we will only very briefly discuss media design options which drive the industrialization of cross-organizational collaboration. For implementing the *structural organization* of the agents' interaction, registries containing relevant information about all stakeholders (their electronic services respectively) are required. Novel *registry* concepts and technologies [Sc07a, Sc07b] go beyond traditional UDDI-based approaches and offer rich means for searching, retrieving and binding electronic services in a very intuitive and efficient fashion. The above discussed *ancillary/assistant services* which facilitate the interaction of agents can be modeled and deployed as state-machines that are usually used in the product manufacturing context. Formalized *service descriptions* such as WSDL (belonging to the service-related part of the L-component) must be available to allow for their measurability, predictability and thus manageability. In the course of the HERA project, Web Services-based *software adapters* have been designed and implemented. For the process-oriented organization, imperative processes may be controlled by orchestration engines (e.g. based on BPEL), while a more declarative process-oriented organization can be deployed on the basis of fine-granular interaction-patterns [He07]. With regard to the physical message exchange infrastructure, different design alternatives exist as well. Besides of merely relying on the well-known SOAP-protocol, Event-Driven Architectures [Ch07] represent an alternative for shielding technical protocol details from connected stakeholders: By connecting to this bus via Web Service-based adapters, users may send (to any of the other users connected to the bus) and receive messages (also referred to as events) of certain, predefined formats. An address register (implemented as a separate module) encapsulates addressing schemes and acts as basis for the routing of messages from one service to the other over the bus.

2.3 The extended MRM in the context of Swiss Public Administration

This section is devoted to showing that the extended MRM is applicable to the collaborative tax computation use-case presented above and allows for performance improvement:

Based on an analysis of the interaction of agents as depicted in Figure 1, the **structural organization (Community-Aspects)** has been defined according to the above discussed task decomposition principles. *Accounting-related services* (e.g., "create accounting documents", "execute postings"), *audit-related services* (e.g., "check for compliance", "check for completeness") as well as *processing-related services* (e.g., "execute enactment") have been identified and formally described. All agents connecting to the "HERA medium" have a registry available which provides information about other users (preferences, offered services, transaction conditions). Besides mere registry functionality, a role model (based on the Swiss federal authority registry[1]) is employed: Based on the roles which specific agents assume (e.g., "company", "auditor"), they are allowed to provide or consume only a subset of all the public services presented above (An agent with the role auditor must not provide accounting-related services). The **process-oriented organization (Implementation Aspects)** follows a declarative (rather than an imperative) approach:

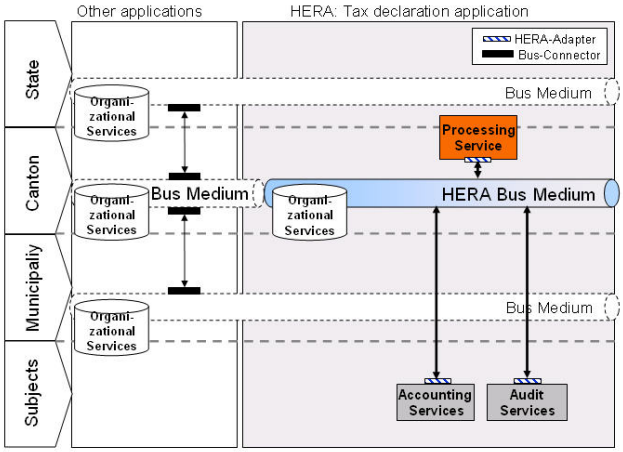

Figure 5: HERA Service-Oriented Reference Architecture

As argued above, the choreography representing the logic of the agents' interaction highly varies from canton to canton, also depends on the respective involved parties and their individual preferences and involves, for example, various unforeseeable additional claims for documents in case they are incomplete or error-prone. However, as opposed to collaboration scenarios without any process control, certain pre-and post-conditions must be accounted for when executing a specific service. Certain auditing-related services, for example, may only be called after accounting services have been completed successfully. To allow for such a rather declarative process-organization in the HERA context, we leverage so-called interaction patterns representing "atomic process pieces" which can then be assembled by the users in an ad-hoc fashion, though based on a process status control (which monitors the documents exchanged between the services and enforces compliance with a certain process).

[1] http://www.bk.admin.ch/

Agents may then call services at arbitrary points of time (as long as this is within previously agreed time limits), but thereby have to adhere to a certain interaction program logic (as opposed to a exactly prescribed process control). As a further important part of the O-Component, *information objects* (the objects agents deal with) are well defined in a business document catalogue and are also subject to a standard (issued by the Swiss eCH[2] institution) to also ensure a common understanding (L-Component) between the different agents.

Figure 5 visualizes the basic structural organization of collaboration in the HERA project which is based on the service taxonomy depicted in Figure 3: Public services related to accounting, processing and auditing communicate via the shared medium ("HERA Bus Medium") and are registered as part of a set of organizational services (white database symbol). These organizational services comprise the above described role model, the stakeholder registry, the related elements of the L-Component (e.g., common semantics regarding exchanged documents) and the atomic interaction patterns which can be used by agents to manage their "interaction program". Adapters ensure seamless interoperability between L-Component-related elements of the different stakeholders. As argued above, these frequently vary significantly and require mediation: Descriptions of role models, information object semantics, addressing schemes, process patterns and service semantics need to be subject to a common understanding which is realized by L-Component adapters (symbolized as small striped rectangles).

Due to space constraints, the **infrastructural layer** shall be discussed only very briefly. In general, the physical HERA medium will fully build on the principles of Event-Driven Architectures (EDAs) [Ch07]. Agents connect to this medium via Web Services-based software adapters and may interact on the basis of atomic interaction patterns (following the restrictions imposed by declaratively formalized business rules). It is important to mention that the core part of the HERA-medium, the so-called "HERA-Bus" thereby follows the technical specification of the currently emerging **Event-Bus Switzerland (EBS)** [Mü06]: As already adumbrated in Figure 5, a number of "sub-buses" on all relevant political levels is expected to serve as loosely coupled media for supporting cross-organizational collaboration in Switzerland. Each sub-bus serves a certain amount of agents and their respective services (connected to their buses via adapters). Agents are enabled to interact with other agents connected to the same bus as well across an arbitrary number of other buses (which then act as mediators). In fact, each of the buses can be built and maintained by different stakeholders and can support various kinds of messages to be exchanged between connected services. A global routing table, together with some basic standards with respect to data envelopes and security mechanisms represent the only centralized element of this infrastructure. This modular setup of different buses of which each exactly reflects the needs of the connected services allows for a high degree of decentralization and individualization. Bus connectors (adapters) account for connecting the different buses (which are operated on a peer level) and ensure connectivity as well as interoperability (in case buses implement different message formats, these can be mapped forth and back by the adapters).

[2] http://www.ech.ch/

3 Revisiting Related Approaches

Different frameworks for the organization or reorganization of value creation already exist. Many of them rely on the rationalization of existing, traditional value chains and business processes. The Business Process Reengineering (BPR) methodology [Ha90, DS90], for example, challenges traditional processes within enterprises and focuses on improved exploitation of information technology for the integration of economically interrelated, company-internal business processes. However, as discussed above, prior to any process specification, services should be defined and organized properly. Also, business interrelationships which span across corporate boundaries need to be accounted for [Le95]. Krcmar and Wolf [KW07] provide a holistic framework which defines the different existing phases and spheres of interactions between companies and governmental bodies. By leveraging all spheres and by ensuring flexibility when introducing e-Government solutions, cross-entity collaboration can be improved considerably. In [LBS03], a generally applicable approach for organizing business and IT architecture levels is presented. It emphasizes the need to specify so-called service domains and map these to the cross-organizational business processes. Applications and infrastructure are defined as separate layers to shield complexity from upper layers and to simplify possible changes. This framework shows similarities to our approach; however, it corresponds to the engineering of merely IT rather than on organizations as in our case. The extended MRM leverages some of its principles and extends it towards a framework that explicitly addresses the needs of cross-company collaboration, prioritizes the organization of services rather than processes and finally comprises all relevant levels from tasks over the actual organization to the systems.

4 Conclusion

In this work, we elaborated on a novel reference framework which aims at supporting the organization of seamless cross-company collaboration. The extended St. Gallen Media Reference Model (MRM) follows a Service-Oriented paradigm which leverages major concepts that played a major role in the industrialization of computer programming. By structuring collaboration into tasks, breaking these down into services which can then be orchestrated according to certain processes, assigning these to resources and finally mapping them to physical media, the performance of cross-organizational collaboration can be improved considerably. We applied this framework to the case of governmental administration in Switzerland, which represents a cross-organizational service industry with significant potential for performance enhancement. The analysis showed that organizations in the public sector may improve productivity, quality and flexibility of their collaboration by adhering to the St. Gallen MRM which transfers programming principles to the context of human organizations.

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