

## Service-based Interoperability – Leveraging Web Services for Implementing Industry Standards

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### Abstract

With deeper levels of external process integration and a growing number of electronic business relationships, enterprises strive for becoming more interoperable with their business partners. Although B2B standards are supposed to ensure scalable B2B integration and m:n connectivity, enterprises face the challenge of ambiguous interpretations of standards when it comes to their implementation. This paper develops a conceptual model for service-based B2B interoperability which leverages web service technologies for implementing industry standards. The authors instantiate the conceptual model in a concrete B2B scenario in the automotive industry where a consortium of automotive manufacturers and suppliers are currently redesigning their inter-organizational Engineering change Management (ECM) processes. From the evaluation, they conclude that it is not sufficient to specify that standards are used related to pragmatics, semantics and syntax. In order to ensure interoperability, additional design rules are needed which define how industry standards are mapped to a web service design.

**Keywords:** B2B standardization, web services, SOA, interoperability

## 1 Introduction

Boundaries of organizations are becoming more fluid than they used to be. For enterprises which wish to establish a growing number of electronic relationships, interoperability becomes a critical factor. Being “interoperable” refers to the ability to integrate business processes with business partners, understand and process exchanged data, seamlessly integrate it into internal ICT systems and enable its beneficial use (Yang and Papazoglou 2000, Legner and Wende 2006). In order to establish interoperability between enterprises, a huge number of standardization bodies – among them RosettaNet, GS1, UN/CEFACT and others – are developing and promoting standards for collecting, presenting and transferring information between organizations. Although diffusion and adoption of B2B standards has been subject of recent publications (Angeles et al. 2001, Löwer 2005, Reimers and Li 2005), much less attention has been paid to the quality of standards so far. One

of the key issues in the adoption of B2B standards is their ambiguous interpretation when it comes to implementation. This can be explained by the large number of ex-ante agreements which are required before automation of business processes across companies boundaries can take place (Reimers 2001, McAfee 2005b).

In the last years, web services and service-oriented architectures (SOA) have emerged as an enhanced concept for systems integration in heterogeneous environments (Erl 2005, W3C 2004, Papazoglou and Georgakopoulos 2003). In the context of B2B collaboration, an enterprise could simply expose application functionality as a web service and thereby realize machine-to-machine process integration with its business partners (Feuerlicht 2005, Zimmermann et al. 2005). This paper takes on this argumentation and investigates the contribution of web services to achieve interoperability. More specifically, it investigates the following research questions:

- Does the implementation of an industry standard using web services reduce the need for bilateral agreements and thereby increase interoperability?
- How can existing industry standards leverage web services interoperability?
- Which conclusions can be drawn for future B2B standardization?

For this purpose, our research is based on a design science research approach and closely follows the guidelines outlined by (Hevner et al. 2004): Our research results are viable artifacts in the form of constructs and a conceptual model for service-based B2B interoperability (“Design as an artifact”). We applied rigorous methods in the construction of the model which we deduced from prior research on B2B integration, standardization and web service concepts, as well as in its evaluation (“Research rigor”). Utility, quality and efficacy of our model is demonstrated by an experimental design evaluation method (“Design evaluation”). By conducting a field study, we were able to instantiate the conceptual model in a real-world scenario and evaluate it based on a pilot implementation. This was done for the scenario of inter-organizational Engineering Change Management (ECM) in the automotive industry where a consortium of automotive manufacturers and suppliers are currently redesigning their inter-organizational processes based on the recent VDA recommendation 4965 (Association of German Automobile Manufacturers (VDA) 2005). The instantiation revealed some deficiencies of our conceptual model which we addressed by developing additional design rules for the relationships between the constructs. Thus, our design process was iterative and implied a generate/test cycle (“Design as a search process”).

The remainder of this paper is structured as follows: Section 2 summarizes prior research related to B2B integration, standardization and service-oriented architecture. Based on this review, section 3 develops a conceptual model for service-based B2B interoperability. Section 4 describes how this model was applied to a concrete B2B scenario in the automotive industry. The paper concludes with a discussion of the findings related to the conceptual model for service-based interoperability and the implications for future B2B standardization.

## **2 Related Research**

### **2.1 B2B Integration**

Despite the rapid diffusion of the internet, the most frequent form of machine-to-machine integration supporting B2B relationships to date has been Electronic Data Interchange (EDI). From the adoption of EDI which was not as wide-spread

## Related Research

as originally hoped, researches have gained important insights related to the electronic integration of business processes. Due to the semiotic structure of communication (Kubicek 1992), a large number of agreements on different levels need to be made explicit and to be formalized in order to allow IS-mediated interaction (McAfee 2005b, Reimers 2001): At the lowest level, information systems have to share agreements about how data is to be transported over a network. Once agreements at this basic transport level, e.g. through standard internet protocols such as HTTP, are in place, human-to-human and human-to-machine interactions can take place. Since information systems are not as flexible as humans in interpreting documents, further ex ante agreements have been made for human-to-machine or machine-to-machine-interactions. The latter include data definitions and document syntax defining the contents and structure of messages, semantic annotations describing the meaning and purpose of messages in the business context as well as process-level information detailing the flow of process interaction.

(Kubicek 1992)	(Reimers 2001)	(McAfee 2005b, McAfee 2005a)
<i>Pragmatics</i> Action-reaction patterns	<i>Pragmatics</i> Purpose of the business document, resulting action (often requiring legally binding commitments of the involved parties)	<i>Level 3 – Process</i> Parameters of business process(es) making use of inter-machine messages
<i>Semantics</i> Common data keys	<i>Semantics</i> Meaning of the words in a business document, e.g. possible instances which may be described by the means of dictionaries	<i>Level 2 – Payload</i> Contents and structures of B2B messages
<i>Syntax</i> Types of messages and their formal structure	<i>Syntax</i> Rules for combining basic data elements into larger units and designing business documents	
<i>Communication</i> Internationally standardized message-handling system service	N/A	<i>Level 1 – Transport</i> Link / network used to transmit messages between machines
<i>Transport</i> Standards for unspecified data transmission (protocol adaptation, transport systems)		

**Table 1: Levels of Agreement related to Machine-to-Machine B2B Integration**

## 2.2 B2B Standardization

In their early study, (Benjamin et al. 1990) reported that insufficient availability of standards has been the most important barrier to inter-organizational integration. In the meantime, a large number of standards have emerged, but still many standards do fail to reach a broader dissemination. This has led to a continuing debate about the way standards are created and adopted (Angeles et al. 2001, Löwer 2005, Reimers and Li 2005). Although standards claim to ensure m:n connectivity, little attention has been paid so far to their contribution to achieving interoperability. Up to date, standardization has been successful regarding communication services and on the syntactical level (Bussler 2003, McAfee 2005b). One of the

examples is the eXtensible Markup Language (XML), which is a ‘tagging’ language for defining the syntax for creating business vocabularies and exchanging business information. Various initiatives have been launched to extend XML-based standards to comprise the semantic level. Among them are specifications of business documents by industrial associations, e.g. ChemXML as part of CIDX in the chemical industry, as well as harmonization efforts by standardization bodies, such as the ISO specifications for Currency and Country Codes or the UN/CEFACT Core Component Library. Standardization has not yet coped with issues on the pragmatic level. RosettaNet Partner Interface Protocols (PIPs) pursue this direction by defining interaction patterns in the high-tech industry (RosettaNet 2001). The difficulties to solve semantic and pragmatic issues in existing standards have been referred to as the “organizational gap” (Kubicek 1992).

### **2.3 Web Services and Service-Oriented Architecture (SOA)**

The World Wide Web Consortium (W3C 2004) defines web services as “a software application identified by a URI, whose interfaces and bindings are capable of being defined, described, and discovered as XML artifacts. A web service supports direct interaction with other software agents using XML-based messages exchanged via Internet protocols.” Web services expose the functionality of an information system and make it available through standard Web technologies. They build on a number of standards, in particular XML to tag data, SOAP to transfer data and WSDL for describing the services available. Web services are considered a major enabler of the service-oriented architecture (SOA) which has been advocated for many years and is supposed to facilitate internal and external integration across different platforms. The term SOA describes a paradigm for the structured design of multi-level, distributed integration architectures based on services (Erl 2005, W3C 2004, Papazoglou and Georgakopoulos 2003). Services provide distinct functions of application systems over a network and adhere to the following design principles (Newcomer and Lomow 2004, Erl 2005):

- *Interface orientation.* Services are stable interfaces that provide a complete technical and functional service description and abstract from the service implementation details.
- *Interoperability.* Services are interoperable, i.e. they adhere to certain technical and functional industry standards in order to allow cross-platform and cross-organizational integration.
- *Autonomy and Modularity.* Services encapsulate functions with a high level of interdependencies (cohesion) and are at the same time highly independent from other services (loose coupling).
- *Business Suitability.* The granularity of services ideally reflects business concepts.

## **3 Conceptual Model for Service-based Interoperability**

### **3.1 Foundation**

#### **3.1.1 Levels of Agreements Related to Machine-to-Machine Integration**

Based on the existing literature and following the semiotic structure of communication (Kubicek 1992), interoperability requires agreements to be in place on four levels: (1) Transport and communication layer, (2) syntax, (3) semantics and (4)

### Conceptual Model for Service-based Interoperability

pragmatics. We deduce that interoperability can be increased if standards are defined for all of these levels. Whereas web service standards cover the transport, communication and syntax level, they do not specify any domain-specific business processes and documents. Consequently, the semantics and pragmatics need to be covered by industry standardization.

#### 3.1.2 Inter-Organizational Business Process Design

In order to address the “organizational gap” outlined by (Kubicek 1992), our conceptual model relies on constructs which have been suggested by prior research related to inter-organizational business process design (Theling et al. 2005, Legner and Wende 2007, van der Aalst and Weske 2001): They comprise a process model describing the inter-organizational or public process, an organizational model defining roles and responsibilities, an information model specifying the relevant information entities and an interface model which refines the organizational interface and details the information flow. Due to the inherent complexity of B2B collaboration, mechanisms for de-coupling inter-organizational process design from the individual process design of business partners are required. From prior work related to distributed business processes (Liu and Shen 2003) as well as B2B standardization (OMG 2006, RosettaNet 2001), we adopt the distinction between the public (or external) and the private (or internal) view. The public process establishes stable interfaces for the electronic interaction with external partners. It needs to be aligned and reflected by the (private) process design of the individual organizations in order to ensure for interoperability.

## 3.2 Conceptual Model

### 3.2.1 Overview

The conceptual model for service-based interoperability comprises a defined set of “public” constructs which business partners have to agree on in inter-organizational relationships. Table 2 summarizes the conceptual model and depicts the contribution of web service concepts, including the open internet protocols they are based on, as well as industry standardization.

Levels of Agreement	“Public” Constructs	Standardization
Pragmatics	Organizational and Role Model Public Process Model	Industry standards
Semantics	Information Model Interface Model / Messages	
Syntax	Service interface definition (WSDL) Business documents as input and output parameters (XML)	Web service standards (+ internet protocols)
Communication and Transport	Communication protocol (SOAP) Transport protocol (http, TCP/IP)	

**Table 2: Conceptual Model for Service-Based Interoperability**

### 3.2.2 Industry Standards (Pragmatic and Semantic Level)

Vertical standards are supposed to define the semantics and pragmatics of the B2B relationship. Regarding the pragmatics, our conceptual model defines the following constructs:

- The *organizational or role model* describes the different roles involved in the cooperation on the organizational and position level. It describes their specific responsibilities and functions.
- The *public process model* is the central element of the framework for modeling inter-organizational processes. It describes the activity flow and the interaction between external organization units. The public process represents a view of the entire inter-organizational processes which conceals details in the private processes of the individual partners by using abstraction concepts.

This set of constructs is complemented by two artifacts specifying the semantics:

- The *information model* creates a common business vocabulary for the different parties involved in the B2B collaboration. It describes the main information entities by defining attributes and their values as well as associations between entities.
- The *interface model* details the process interfaces between the involved organization units. In doing so, messages are explicitly modeled with the associated business information entities as defined in the information model.

### 3.2.3 Web Services Standards (Syntax, Communication and Transport Level)

Web services standards build on open internet standards, i.e. http and TCP/IP to ensure the transport based on internet protocols, and the eXtensible Markup Language (XML) as syntax for exchanging business information. Web services add to these internet standards by defining how service providers and users interact (Alonso et al. 2003):

- On the syntax layer, WSDL defines the description of service interfaces. The abstract part of a WSDL service specification defines data types, messages, service operations and port types, whereas the concrete part describes protocol binding and other information. Service operations require XML messages (business documents) as input and output parameters.
- On the communication layer, SOAP specifies communication services for exchanging XML messages between a service provider and a user.

If an industry standard has been defined by the constructs mentioned in 3.2.2, it can be systematically translated into a public web service interface by applying the following design and mapping rules (c.f. Figure 1):

- Every interaction between business partners which is defined in the public process has to be supported by a service operation (relation 1 in Figure 1).
- The input and output parameters of the service operation are business documents (or messages) which are specified by the interface model of the industry standard (relation 2 in Figure 1).
- Business documents are composed of different data types which represent the business information entities (relation 3 in Figure 1).

Once the public web service interface has been implemented by different organizations, business partners achieve m:n connectivity and can flexibly establish electronic process integration.

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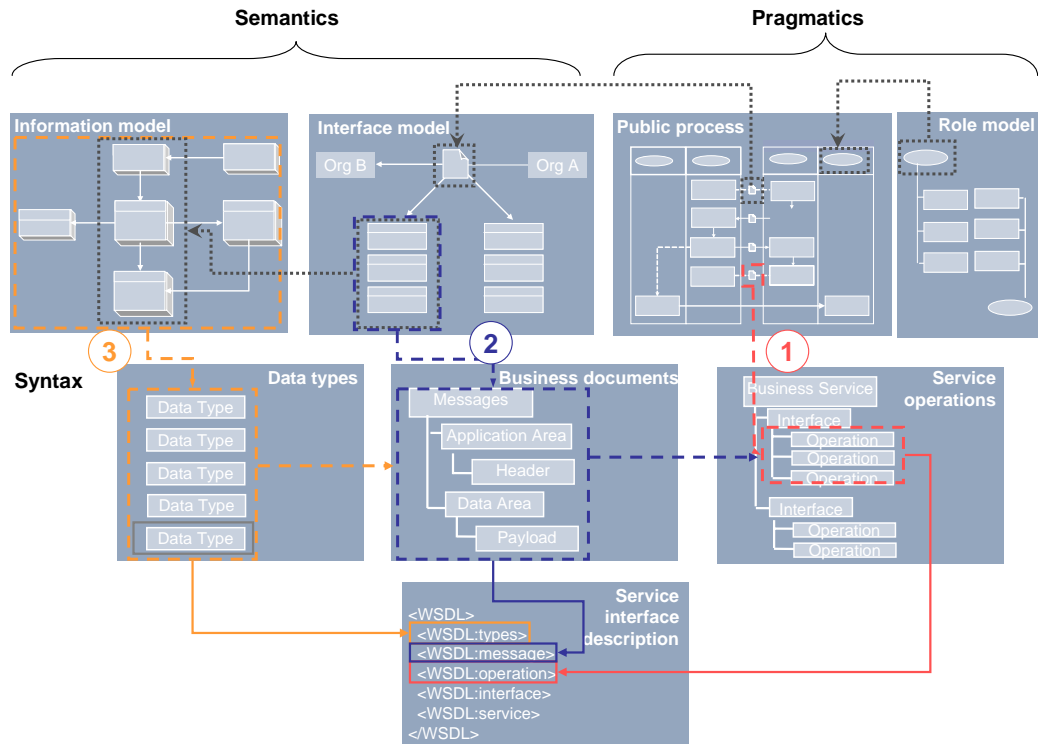


Figure 1: Translating an Industry Standard into a Public Web Service Design

## 4 Application to the Automotive Industry

### 4.1 Background

This section applies and instantiates the conceptual model to collaborative engineering change management between automotive manufacturers and their suppliers. We chose this particular scenario due to the following reasons: (1) The automotive industry has a broad experience related to B2B integration due to its long history in EDI-based supplier relationships. (2) Automotive manufacturers and suppliers can be considered “IT-savy” and open to migrate to web services which made it possible to implement the conceptual model and run a pilot. (3) Engineering change management has been subject to a recent industry standardization initiative by the Association of German Automotive Manufacturers (VDA). This initiative resulted in the VDA Recommendation 4965 which represents a well documented and comprehensive industry standard. (4) In the light of the experience gained from the first pilots, which range from EDI-based implementation to rich client applications accessing multiple PLM systems, automotive manufacturers and suppliers decided to pursue standardization in the area of IT implementation as well, with the ultimate aim of ensuring the interoperability of approaches and solutions. They felt that a service-oriented approach could offer significant improvements in the design of expandable and scalable architecture by making services available via both, interactive portals for human users and standardized interfaces for automated processing.

The translation of the industry standard into a web service design was outside the scope of the VDA standardization initiative. It was performed by the authors together with six European automotive companies which were striving for more interoperability in implementing industry standards by leveraging SOA and web ser-

vice concepts. Over a period of 15 months, from October 2005 to February 2007, these companies worked together in order to translate VDA Recommendation 4965 into a web service design and test interoperability of the approach by realizing a pilot implementation.

## 4.2 Industry Standard

Developed in a joint effort by suppliers, manufactures and software vendors and issued by Association of German Automobile Manufacturers (VDA), the VDA Recommendation 4965 creates a common understanding of engineering change management, in particular the processing of engineering change requests (ECR). Engineering change management is typically performed interactively between the automotive manufacturers and suppliers. Its purpose is the evaluation of change requests and the subsequent real-time propagation of engineering changes in development, planning and manufacturing processes. Possible triggers for changes include amongst others modification in product design, quality or safety problems. As a pure business standard, VDA Recommendation 4965 describes role, process and data models without defining the implementation of the standard.

The *organizational model* comprises two roles at the organizational level as well as nine roles at the functional level. The organization which assumes the coordinator role is the overall responsible for processing the engineering change request, whereas the so-called participant assists in commenting and evaluating the change. Roles at functional level include the engineering change manager, one or more comment performers (including external parties) and the approver.

The *reference process* as defined by VDA Recommendation 4965 includes an informal process description (including phases, milestones and so-called synchronization points) as well as UML activity diagrams. It describes in detail how an engineering change request should be processed once a need for change has been detected and possible solution alternatives have been described. Engineering change requests must then be analyzed for effectiveness and feasibility. This is followed by a comprehensive economic and technical evaluation which provides the basis for a decision on the change request and its rollout to production.

Related to the semantics, the VDA recommendation contains a *data dictionary* and a *data model* on that base messages are defined. The data model which is formulated in Express-G can be considered a comprehensive information model of an engineering change request. It comprises the basic description of an ECR (in the `ECR_header` class), classification and status information (e.g. `ECR_classification`, `ECR_status`, `ECR_acceptance`) as well as the documentation of further analyses which are performed during ECR processing. So far, process interface descriptions are restricted to message definitions and do not include any further specifications, e.g. service-level agreements. These interfaces are defined by linking each message type to the optional or mandatory classes which can or should be contained in the message.

Table 3 depicts the coverage related to the different levels as defined in Section 3.2. Since it addresses all relevant constructs for describing pragmatics and semantics, VDA recommendation 4965 can be considered a comprehensive industry standard. However, Table 3 also reveals that public processes and the interface model are not completely specified. Consequently, these gaps had to be filled by the companies prior to deriving the service design. In order to ensure interoperability, they had to agree on a more detailed model of the public process and additional specifications for interpreting the information model.

Levels of Agreement	Constructs	VDA Recommendation 4965	Specification
Pragmatics	Organizational and Role Model	Role model covering <ul style="list-style-type: none"> <li>organizational level: 2 roles (coordinator and participant)</li> <li>functional level: 9 roles (engineering change manager, comment performer, approver, ...)</li> </ul>	●
	Public Process	Process description consisting of <ul style="list-style-type: none"> <li>phase model (non-formal text description)</li> <li>sequence of activities (UML activity diagrams, descriptions)</li> </ul>	◐
Semantics	Information Model	Data model (in Express-G notation) <ul style="list-style-type: none"> <li>1 main business entity (engineering change request) composed of 12 classes (ECR_id, ECR_detail, ECR_header, ...)</li> </ul>	●
	Interface Model / Messages	Relation table with <ul style="list-style-type: none"> <li>11 message types linked to optional or mandatory classes</li> </ul>	◐
Syntax	Service interface definition Input / output parameters	<i>Not covered</i>	○
Communication and transport	Communication protocol Transport protocol		
Legend: ● - construct completely specified; ◐ - construct partly specified; ○ - construct not specified			

**Table 3: Coverage of VDA Recommendation 4965**

### 4.3 Public ECR Business Service

The translation of the VDA Recommendation into a web service design – the so-called ECR Business Service – was performed in an iterative process involving business and IT integration experts from the different companies in order to ensure as much interoperability in the service design as possible. The ECR Business Service leverages web service technology by defining platform-independent, document-oriented web services. The following section describes the most relevant aspects of the service design: (1) the messages which the service operations expects as input or output parameter, and the fundamental data objects they are composed of; (2) the service operations which characterize the service interface.

#### 4.3.1 Business Documents (XML Schema Definition)

Based on the information model and the messages which have been defined by the VDA Recommendation, business documents – as service input and output – have to be specified as XML schema representation. Although the data model exists, relatively high degrees of freedom exist when deriving the schema representation. They relate (1) to the mapping of certain constructs, e.g. inheritance or abstraction, which the original data model represents in Express-G notation, into UML and later XML schema representation; (2) to the general structure of the XML schema. In the case of the ECR Business Service, the XML message structure

follows the Naming and Design Rules of the OAGi for designing Business Object Documents (BODs).

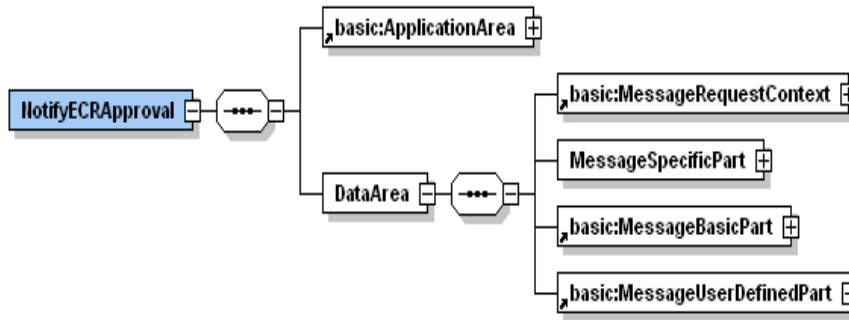


Figure 2: ECR Business Service - XML Schema Definition for Business Documents

### 4.3.2 Service Operations

The single operations of the ECR Business Service directly reflect the interactions which are defined by the reference process in the VDA Recommendation and the related 11 message types. For each of these messages a service operation is provided which expects the XML representation of the message as input parameter. The ECR Business Service merely returns a synchronous acknowledge message which signals correct receipt at the partner's end. In contrast, the business reply to the message is sent asynchronously as ECR processing constitutes a long running transaction.

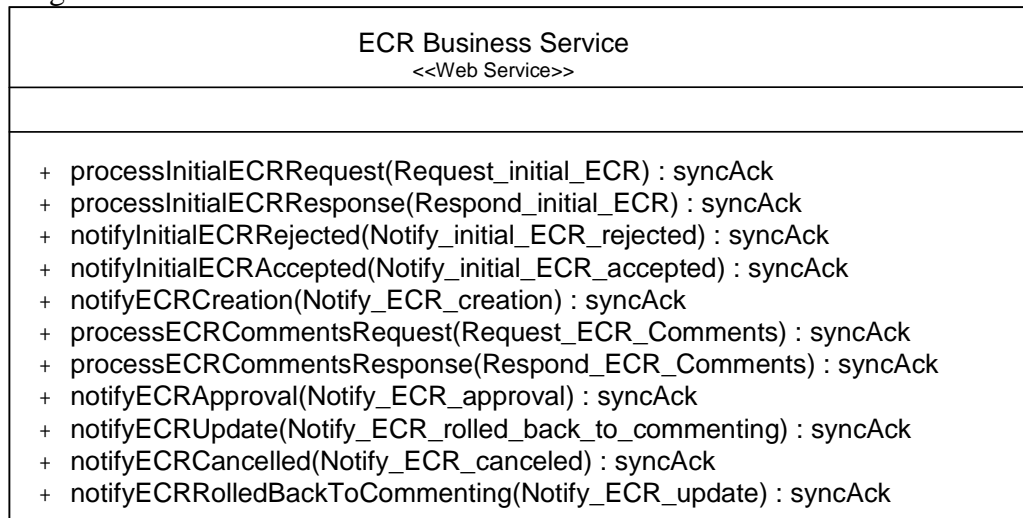


Figure 3: ECR Business Service – UML Class Diagram Representing Service Operations

## 4.4 Evaluation

### 4.4.1 Industry Standards Interoperability (Semantic and Pragmatic Level)

From the instantiation and the piloting, we found that the constructs outlined in the conceptual model, if they are fully specified, ensure interoperability at the semantic and pragmatic level. Although dealing with a relatively mature industry standard (e.g. compared to the recent VDA recommendation Quality Data Exchange which focuses exclusively on semantic and syntactic standardization of messages), we have been experiencing some shortcomings in the specification of the different constructs in the concrete scenario which generate the need for addi-

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tional bilateral agreements. As outlined in Table 3, these shortcomings relate to the insufficient specification of the public process and process interface model. Additional interoperability issues result from the complexity of the standard which encompasses a large number of process variants and abundant optional attributes (only 10% of the attributes are classified as mandatory). In the case of insufficient or ambiguous standardization, the constructs outlined in the conceptual model have been refined, e.g. by more detailed specifications and implementation guidelines.

#### 4.4.2 Web Service Interoperability (Syntax, Communication and Transport Level)

With regard to technical interoperability, the evaluation of the pilot implementation confirms that web services standards foster interoperability. The participating companies were able to implement the ECR Business Service on different platforms (e.g. SAP XI, IBM WebSphere, BEA Web Logic) and expose it to their business partners within a timeframe of 10-15 days. This is in particular due to the existence of so called “*profiles*” which are defined by WS-I and are implemented by most vendors. The ECR Business Service relies on WS-I Basic Profile (WS-I 2005) which has been supported by all SOA platforms.

#### 4.4.3 Vertical Transformation of the Different Levels of Agreement

The instantiation represents a “proof of concept” for translating an industry standard into a web service design. The pilot demonstrates that the conceptual model comprises all the relevant constructs to specify interoperable B2B relationships. However, there are multiple ways of translating the pragmatic and semantic specifications into a “public” web service design. This is underlined by the fact that recently a competing service design has been suggested for implementing VDA Recommendation 4965, the OMG PLM Services 2.0, which exposes a totally different service interface: Whereas the ECR Business Service derives 11 service operations from the interactions outlined in the reference process, OMG PLM Services leverage an existing generic service operation `write_messages` that was originally created for exchanging product data. Thus, little or no interoperability exists between companies which implement these different service designs.

This demonstrates that specifying standards for all relevant levels of agreements does not necessarily lead to full interoperability in B2B relationships. In addition, mapping and design rules are needed for the vertical transformation of the pragmatic and semantic level constructs into a web service interface. Consequently, the conceptual model for service-based interoperability has to be complemented by a set of design rules which address the following issues:

- *Translating the information model and the interface model into a modular XML schema definition.* Naming and design rules as issued by the United Nations Center for Trade Facilitation and Electronic Business (UN/CEFACT 2006b) or OAGIS (OAGi 2006) as well as the use of semantic building blocks like Core Components Library (CCL) and the Core Component Technical Specification (CCTS) may help. However, these rules are neither complete, nor exhaustive today.
- *Deriving service operations.* A major design decision has to be taken whether to apply strongly typed versus generic operations (Zimmermann et al. 2003). While genericity may better cope with upcoming changes in the interface and information model than strongly typed interfaces, the loss

of semantics outweighs the advantage when it comes to maintainability of the interface and service orchestration in a fully-fledged SOA.

## 5 Summary and Outlook

From the existing work related to B2B integration, we have argued that the use of standards on all semiotic levels of agreement will increase interoperability in electronic B2B relationships. This paper provides a conceptual model for service-based interoperability which specifies constructs at the different levels and builds on web service concepts. Whereas industry standards are supposed to cover the pragmatics and the semantics, they should rely on web services and the underlying internet standards which ensure interoperability on the syntax, communication and transport layer. In a field study, the conceptual model has been instantiated and evaluated in the automotive industry. The instantiated model and its pilot implementation for engineering change management can be considered a “proof of concept” for service-based interoperability. It demonstrates that (1) the constructs outlined in the conceptual model are sufficient for specifying interoperable, service-based B2B relationships. It also demonstrates that (2) industry standards can be systematically translated into web service concepts if, as a prerequisite, they fully specify the relevant constructs representing the pragmatics – i.e. an organizational and a public process model – as well as the semantics – i.e. an information and interface model. However, the field study also reveals that (3) the pure definition of standards on every level of agreement is not sufficient to ensure interoperability. In fact, the same industry standard can easily lead to multiple service design proposals as demonstrated by the competing service design proposal PLM Services 2.0. With regard to the conceptual model for service-based interoperability, this underlines the importance of mapping rules and design principles which specify vertical transformation of pragmatic and semantic level constructs onto the web service interface.

As an implication from our study, researchers as well as practitioners and standardization bodies should (re-)discuss the role and focus of industry standardization as well as the methodology and approach for leveraging web services concepts. Thus, we support (Feuerlicht 2005) who calls for engineering principles in B2B standardization as well as recent UN/CEFACT efforts (UN/CEFACT 2006a). Our findings suggest that industry or vertical standardization should focus on specifying the set of constructs describing semantics and pragmatics. At the same time, industry standards should remain syntax independent and build on widely accepted service design principles. The latter have to be the result of a broader consensus covering multiple industry and functional domains.

With regard to the scope of B2B standardization, it is important to notice that today’s standards neither focus exclusively on the semantic and pragmatic layer nor comprehensively specify these constructs (Leser 2005). Our findings also recall that interoperability requires specifications to be even more precise than existing B2B standards are. As of today, companies often need to bilaterally agree on how they interpret and implement the standard. On the technical layer, this issue has been solved by so-called “*profiles*” which are defined by WS-I and are supported by most vendors. We conclude that profiling of industry standards in an analogy to the profile efforts by WS-I on the syntactical layer could be beneficial. Profiles would comprise detailed guidelines and specifications which ensure unambiguous interpretation of the corresponding business standard as well as conformance rules which allow for testing their organizational implementation.

## Summary and Outlook

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