A Comparison of XML Interchange Formats for Business Process Modelling[1]

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ABSTRACT

This paper addresses heterogeneity of business process metamodels and related interchange formats. We present different approaches towards interchange format design and effects of interchange format specification first. Moreover, we derive the superset of metamodel concepts from 15 currently available XML-based specifications for business process modelling. These concepts are used as a framework for comparing the 15 specifications.

1. INTRODUCTION

Heterogeneity of Business Process Modelling (BPM) techniques is a notorious problem for business process management. Although standardization has been discussed for more than ten years, the lack of a commonly accepted interchange format is still the main encumbrance to business process management [Delphi 2003]. The reason why interchange is still a problem can be attributed not at least to the different perspective of business analysts and system engineers on business processes [MR 2004].

Recently, various new specifications for Web Service based BPM, Web Service composition, and Web Service choreography have been proposed. At least in the short run, they contribute to a further increase of heterogeneity of XML interchange formats for business process modelling. Yet, the interrelation of these formats is too little understood. This paper tries to identify the superset of concepts covered in metamodels of the various proposals. We propose to use this set of concepts as a framework for the comparison of BPM interchange formats. It might serve as a first step towards a reference model for BPM that unifies the different perspectives on BPM.

The rest of the chapter is structured as follows. Section 2 gives an overview on interchange formats, their rationale, and general design criteria. Section 3 introduces a framework for comparison of different XML interchange formats for BPM based on concepts derive from the metamodels of 15 BPM specifications. In Section 4 these specifications are compared to the frame-

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work and briefly described. In Section 5 related work is discussed before Section 6 concludes the chapter with an outlook on future research.

2. INTERCHANGE FORMAT SPECIFICATION

The specification and standardization of interchange formats is a widespread strategy in order to achieve inter-operability of applications (see e.g. [Koegel 1992]). In essence, an interchange format defines the structure of a file via a grammar or a schema that represents data relevant for a certain application domain. Independent software components can then consume data files that other applications produce. As a consequence, a standardized interchange format provides for a simple integration of applications (see e.g. [HW 2004]).

According to a survey on experience reports of interchange format design projects, three general effects of interchange format standardization can be distinguished: a pragmatic effect, an economic effect, and an effect of conceptual consolidation [Mendling 2004].

- The *pragmatic effect* establishes inter-operability between heterogeneous applications of the same or related domains. This simplifies collaboration between people that work with different applications. An agreed upon interchange format avoids discontinuity of media. Furthermore, the interchange format can be used as an intermediary format for translations between multiple applications reducing the number of translation programs from $O(n^2)$ to $O(n)$ [WHB 2002].
- The *economic effect* refers to positive network effects. These network effects caused by the standardization of an interchange format might leverage competition between software vendors, because interchangeability of application data reduces vendor lock-in. It becomes cheaper to change the vendor or to buy complementary software that uses the same interchange format [Crawford 1984]. This might motivate the development of new tools. Moreover, the specification of an interchange format might even create a market: multimedia applications are a good example for this case (cf. e.g. [Koegel 1992]).
- The *effect of conceptual consolidation* is triggered by the standardization process of an interchange format. In order to be successful the interchange format has to reflect at least the commonly used concepts of a certain domain. Accordingly, the specification of an interchange format may be regarded as a special kind of reference modelling that leverages the explication of concepts and consolidation of terminology of a given domain [OMGM 1998].

All these three effects may be regarded as beneficiary. Standardization bodies like the Workflow Management Coalition have established standardization procedures in order to make these benefits effective. For a discussion of standardization processes in practice see e.g. [MNS 2005].

The specification of interchange formats involves three interrelated aspects: metamodel, serial representation, and mappings between both (see Figure 1, grey area).

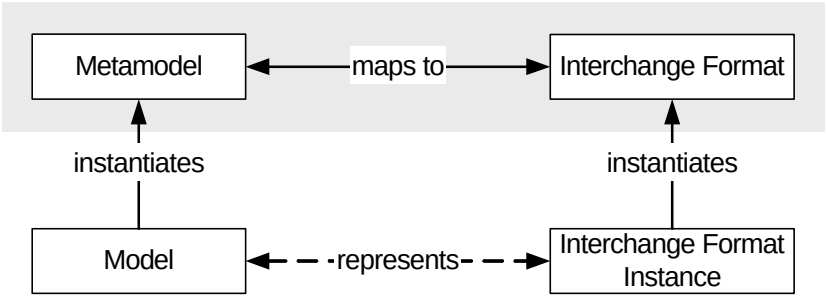

Figure 1: Relationship between Metamodels and Interchange Formats.

The metamodel is used to define the modelling language for a certain domain [KK 2002]. Various techniques are available for the definition of metamodels including ER-Diagrams [Chen 1976], UML Class Diagrams [OMG 2004], graphs [Winter 2002], or XML Schema [BLMM 2001, BM 2001]. In order to build the foundation of an interchange format a respective metamodel should meet certain design criteria. These design criteria include simplicity, completeness, generality, unambiguity, and extensibility [Mendling 2004].

- *Simplicity* refers to freedom of complexity [SDSK 2000] in order to provide a compact metamodel. This metamodel should be easy to understand for domain experts. In the context of XML this criterion might advocate not to use concepts like substitution groups.
- On the other hand, *completeness* demands that a sufficient set of concepts is included in order to provide the expressive power that is needed for representing all relevant aspects of the domain [Crawford 1984]. The representation of control flow is an example of a concept that a BPM metamodel has to include, among others, in order to be complete.
- *Generality* has to be offered by the interchange format in order to be applicable in all scenarios that are relevant to the domain (see e.g. [Crawford 1984]). Especially those concepts should be taken into account that are included in existing tools (see e.g. [Eurich 1986]). This implies that a general BPM metamodel should not be designed only with e.g. supply chain scenarios in mind.
- Moreover, the interchange format has to offer an *unambiguous* view on the domain. Precise terms need to be chosen and related semantics have to be defined formally. By this means an interchange format might prove valuable for the consolidation of terminology in the respective domain (see e.g. [OMGM 1998]). The Glossary of the Workflow Management Coalition illustrates the need for precise definition of terms [WfMC 1999].
- *Extensibility* belongs to the most prominent criteria of interchange formats (see e.g. [Crawford 1984, Koegel 1992, SDSK 2000]). It provides for the inclusion of additional information in a predefined way. This is especially desirable, because future developments, new requirements, and changing technology might motivate unanticipated revisions of the format in a priori unknown directions. Extensibility grants a smooth

integration of such new aspects. XPDL, for example, offers so-called ExtendedAttributes to capture additional information.

Models complying with the metamodel of an interchange format need to be expressed in a serial representation. Such a serial representation may follow e.g. a byte encoding, a plain text encoding, or XML [BPSM 2000]. The structure of the serial representation is defined via a schema. Furthermore, XML-based techniques like RDF [Beckett 2004], or GXL [Winter 2002] can be customized for business process modelling as well. A serial representation of an interchange format should also meet certain design criteria. These include readability, ease of implementation, platform independence, efficiency, free availability, and support of standards [Mendling 2004].

The identity of metamodel and serial representation is important in order to avoid loss of information [SDSK 2000]. Formally, this implies that isomorphic mappings between them must be available. There are different approaches to specify metamodel, interchange format, and respective mappings. These include the following:

- *Interchange Format Only:* Some interchange formats like BPEL4WS [ACDG 2003] provide only an XML Schema. This schema can be regarded as a metamodel. Thus, no mappings need to be defined between metamodel and interchange format.
- *Mappings Only:* Another approach is taken by XMI [OMG 2003b]. In order to offer an interchange format for UML models, the XMI specification defines production rules (mappings) from the Meta-Object Facility (MOF) [OMG 2002] meta²model of UML to XML and XML Schema representation. Actually, XMI does not define the interchange format for UML models, but the rules to derive an interchangeable representation of models. As a consequence, XMI implicitly defines a set of interchange formats that correspond to a set of UML (meta)models.
- *Joint Specification:* Frequently, the joint specification of a metamodel and a respective interchange format is given. For example, the Petri Net Markup Language (PNML) [BCHK 2003] defines a metamodel via a UML class diagram and an XML interchange format via a schema.

Although an interchange format should be isomorphic to the metamodel, actual software applications and tools use a proprietary internal model. This is frequently similar, but not identical to the standardized metamodel. Accordingly, the import and export of interchange format compliant files would be a homomorphic mapping to and from the proprietary model. Therefore, it is important for a metamodel and the related interchange format to meet the design criteria of completeness. An interchange format is more likely to gain acceptance when a complete set of modelling concepts is supported. The following section aims to identify the superset of concepts used in various metamodels of BPM interchange formats which is then used as a framework for comparing the different approaches.

3. METAMODEL CONCEPTS OF BUSINESS PROCESS MODELLING PROPOSALS

Recently, Business Process Modelling has become subject of various specification and standardization efforts. Different consortia including Object Management Group (OMG), Organization for the Advancement of Structured Information Standards (OASIS), Business Process Management Initiative (BPMI), United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT), World Wide Web Consortium (W3C), and Workflow Management Coalition (WfMC), as well as individual software vendors and academic groups have propose metamodels and related interchange formats for Business Process Modelling. From the analysis of 15 specifications we gathered a list of 13 high-level concepts that are included in these metamodels. These include the following:

- *Task I/O:* In this paper we use the term task to refer to basic units of work whose temporal and logical relationships are modelled in a process. The input and output (I/O) of these tasks may be modelled using simple or XML complex types.
- *Task Address:* The address specifies where or how a service can be located to perform a task. The address can be modelled directly via a URI reference of a service or indirectly via a query that identifies a service address.
- *Quality Attributes:* When a set of potential services is generated via a query, quality attributes may be used to identify the “best” service.
- *Task Protocol:* The protocol defines a set of conventions to control interaction with a service performing a task. Web Services use SOAP as a protocol.
- *Control Flow:* The control flow defines the temporal and logical relationships between different tasks. Control flow can be specified via directed graphs, block-oriented nesting of control instructions, or process algebra.
- *Data Handling:* Data handling specifies which variables are used in a process instance and how the actual values of these variables are calculated.
- *Instance Identity:* This concept addresses how a process instance and related messages are identified. Correlation uses a set of message elements that are unique for a process instance in order to route messages to process instances. The generation of a unique identifier which is included in the message exchange is an alternative approach.
- *Roles:* Roles provide for an abstraction of participants in a process. Roles are assigned to tasks and users to roles. A staff resolution mechanism can then allocate tasks of a process instance to users.
- *Events:* Events represent real-world changes. Respective event handlers provide the means to respond to them in a predefined way.
- *Exceptions:* Exceptions or faults describe errors during the execution of a process. In case of exceptions dedicated exception handlers undo unsuccessful tasks or terminate the process instance.

- *Transactions:* ACID transactions define a short-run set of operations that have all-or-nothing semantics. They have to be rolled back when one partial operation fails. Business transactions represent long-running transactions. In case of failure the effects of a business transaction are erased by a compensation process.
- *Graphic Position:* The graphical presentation of a business process model contributes to its comprehensibility. The attachment of graphical position information can be an explicit part of the metamodel.
- *Statistical Data:* Performance analysis of a business process builds on statistical data such as costs or duration of tasks.

This list of concepts can be used to compare different BPM specifications. In the subsequent section we will use it to benchmark 15 BPM interchange formats for their completeness.

4. A COMPARISON OF BUSINESS PROCESS MODELLING PROPOSALS

The 13 metamodel concepts gathered in the previous section are now considered for comparing the completeness of the 15 BPM interchange format proposals. The interchange formats are used in at least four different areas of application:

- *Composition:* Composition refers to the definition of the internal implementation of executable business processes. Web Service composition defines executable business processes that are built from a set of Web Services.
- *Choreography:* Choreography defines externally observable behavior of a business process. Web Service choreography refers to the correct content and order of messages that two parties exchange in a business process.
- *Business Analysis:* Business analysis refers to the presentation of business processes to managers. It builds on visualization of processes and annotation with statistics.
- *Formal Analysis:* This application refers to the verification of different formal quality criteria. These include e.g. soundness [van der Aalst 2000].

Figure 2 gives an overview of the findings. A plus sign indicates that the concept mentioned on the left hand side of the row is included in the metamodel of the proposal mentioned at the top of the column. A minus sign denotes that the concept is not included. The figure shows that none of the specifications addresses all of the 13 concepts. BPEL4WS, BPMN, and WSFL yield the good results each lacking only three concepts. BPDM which is still in progress of specification achieves the best score missing only two concepts. In this context it is important to mention that plus signs for a concept do not imply that the languages offer similar primitives to capture a high-level concept. Although control flow is the only concept supported by all specifications, there may be huge differences in the set of control flow primitives available in different language (see [AHKB 2003]). We will now discuss each proposal in detail.

	BPDM	BPEL4WS	BPML	BPMN	BPSS	EPML	OWL-S	PNML	UML Act.D.	WS-CDL	WSCI	WSCL	WSFL	XLANG	XPDL
Task I/O	+	+	+	+	+	-	+	-	+	+	+	+	+	+	+
Task Address	+	+	+	+	-	-	+	-	-	+	+	+	+	+	+
Quality Attributes	-	-	-	-	+	-	+	-	-	-	-	-	+	-	-
Protocol	+	+	-	+	-	-	+	-	-	+	+	+	+	+	-
Control Flow	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Data Handling	+	+	+	+	-	-	-	-	+	+	-	-	+	-	+
Instance Identity	+	+	+	-	-	-	-	-	-	-	+	-	+	+	-
Roles	+	+	+	+	+	-	+	-	+	+	+	-	+	+	+
Events	+	+	+	+	-	+	-	-	-	-	-	-	+	+	+
Exceptions	+	+	+	+	+	-	-	-	+	+	+	-	+	+	+
Transactions	+	+	+	+	+	-	-	-	-	+	+	-	-	+	-
Graphic Position	-	-	-	+	-	+	-	+	+	-	-	-	-	-	-
Statistical Data	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+

Figure 2: Overview of BPM Interchange Formats

- *BPDM:* OMG's Business Process Definition Metamodel (BPDM) is still in progress of standardization. BPDM will be MOF compliant. As a consequence, the respective BPDM interchange format will rely on XMI production rules. According to the Request for Proposals [OMG 2003a] the BPDM is expected to support implementational aspects like task input and out, address, protocol. Furthermore, BPDM will include procedural and rule-based control flow concepts. Data handling, instance identification, and roles are also supported as well as events, excpetions, and transaction compensation. The inclusion of audit information is also requirement. Yet, graphic position information of objects in a visual model is not mentioned.
- *BPEL4WS:* Business Process Execution Language for Web Services (BPEL4WS or BPEL) [ACDG 2003] has moved from a consortium of major software vendors to OASIS. BPEL is specified as an interchange format only via an XML Schema. BPEL models tasks as calls to Web Services whose input and output are specified by messages and whose address is identified via Uniform Resource Identifiers (URI) of WSDL port types. SOAP is used as the communication protocol. Control flow of BPEL can be modelled block-oriented or graph-oriented, data handling is expressed via variables and related operations. The identification of process instances is achieved via correlation sets. Roles of process participants are defined via so-called partner link types. Furthermore, BPEL supports handling of events and faults as well as compensation of transactions.

BPEL can be used to describe executable Web Service composition as well as Web Service choreography.

- *BPML:* The Business Process Modeling Language [Arkin 2002] proposed by BPMI is very similar to BPEL [MM 2003]. As the main difference BPML allows to specify multiple processes in one XML document and related communication between those processes. Furthermore, BPML is not tied to WSDL. Accordingly, the communication protocol is left to a BPML compliant implementation.
- *BPMN:* The Business Process Modeling Notation [White 2004] also developed by BPMI wants to unify the different graphical notations for business processes. The specification also provides a mapping to BPEL. Therefore, its metamodel reflects most of BPEL's concepts except message correlation. Additional specifications will define a BPMN metamodel based on MOF. This will permit serialization with XMI production rules for XML interchange.
- *BPSS:* The Business Process Specification Schema [CCKH 2001] is part of OASIS and UN/CEFACT's work on ebXML. It includes a metamodel and XML Schema for Web Service choreography. Accordingly, it does not address implementational aspects like data handling or process instance identification. It supports the definition of roles, exceptions, and transactions in an inter-organizational message exchange.
- *EPML:* The Event-Driven Process Chain (EPC) Markup Language (EPML) [MN 2004] is an academic proposal. It captures the control flow elements of EPCs. Further aspects can be defined via extensions. As EPML aims to facilitate graphical model interchange it includes graphical position information for each EPC model object.
- *OWL-S:* OWL-Services (OWL-S) [APSS 2003] is an academic proposal for a service metamodel represented in OWL. OWL-S builds on an (input-output-preconditions-effects) quadruple to describe services. It also allows the definition of resources that we categorized as roles in Figure 2. OWL permits the definition of so-called groundings which is similar to a WSDL binding to a protocol and related endpoints.
- *PNML:* The Petri Net Markup Language [BCHK 2003] is an academic proposal for an XML interchange format for Petri Net models. It supports the basic Petri Net syntax elements and can be extended to represent arbitrary Petri Net types. The eXchangeable Routing Language (XRL) [Norta 03] is based on PNML and can be executed on a dedicated infrastructure.
- *UML 2 Activity Diagram:* Activity Diagrams of the Unified Modeling Language (UML) [OMG 2004] can be exchanged using XMI. Their metamodel includes concepts to model input and output of tasks, control flow, data handling, roles, exceptions, and graphical information.
- *WS-CDL:* W3C's Web Service Choreography Description Language [KBRY 2004] is up to now only available as a last call working draft. It builds on WSDL and SOAP and provides different algebraic control flow primitives.

It also supports data handling, role definition, as well as exception and transaction modelling.

- *WSCI:* W3C's Web Service Choreography Interface [AAFK 2002] provides a set of extensions to WSDL in order to describe process behavior of message exchanges. Beyond input and output message types, WSDL bindings, and correlation WSCI also supports roles, exception handling, and transactions.
- *WSCL:* Hewlett-Packard's Web Service Choreography Language [BBBC 2002] defines a minimal set of concepts in order to describe Web Service choreographies including message types, protocol, and service location. The specification contains a meta-model and a related XML Schema.
- *WSFL:* IBM's Web Services Flow Language [Leymann 2001] is one of the predecessors of BPEL. It includes most of the concepts despite transaction support, graphical position information, and statistical data. Control flow in WSFL is modelled via directed graphs.
- *XLANG:* Microsoft's XLANG [Thatte 2001] is the second predecessor of BPEL. It defines WSDL extensions to describe process behavior of a Web Service similar to WSCI. Additionally, it provides means for defining message correlation, roles, event and exception handling as well as transaction declaration.
- *XPDL:* XML Process Definition Language [WfMC 2002] is a standardized interchange format for business process models proposed by WfMC. It includes various concepts like task input/output and address, control flow, data handling, roles, events, and exceptions. It is also the only specification that addresses process statistics like durations and costs.

5. RELATED WORK

A lot of work on business process model interchange formats and related metamodels is dedicated to the comparison of only two or three proposals. Examples include comparisons of BPEL and BPML [MM 2003]; DAML-S (predecessor of OWL-S) and BPEL [MM 2002]; and XPDL, BPEL, and BPML [Shapiro 2002]. Other approaches define metamodels or lists and use them as a framework for comparison (see e.g. [BKKR 2003], [SAJG 2002], [RG 2002], or [zur Muehlen 2004]). Our approach complements this work by providing a list of concepts that are extracted from actual specifications. To our best knowledge our list of XML-based business process modelling specifications is exhaustive at the time this paper is written. It extends the list of proposals gathered at the XML4BPM workshop [NM 2004] or those listed on Cover Pages [Cover 2003]. Another approach is taken by [AHKB 2003] who identify workflow patterns for control flow semantics. A similar approach seems to be well suited for each of the high-level metamodel concepts identified in this paper in order to build the foundation of a reference model for business process management. This will be subject to future research.

6. CONCLUSION AND FUTURE WORK

In this chapter we discussed interchange format specification in the context of BPM. Furthermore, we presented a framework for comparing XML-based business process modeling specifications that builds on the superset of concepts extracted from the metamodels of 15 BPM specifications. Moreover, we applied this framework to compare the 15 BPM specifications. With our work we aim to contribute to a better comparison of heterogenous approaches towards BPM. This may finally result in a BPM reference metamodel and a related general interchange format for BPM. Yet, the high-level metamodel concepts identified in this paper need further in-depth analysis similar to the workflow pattern analysis reported in [AHKB 2003]. Such analysis will be subject to future research.

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