

16th Bled eCommerce Conference

eTransformation

Bled, Slovenia, June 9 – 11, 2003

Does B2B Data Exchange tap the full Potential of XML Schema Languages?

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Abstract

B2B data exchange deals often not only with the representation of content in standardized data structures, but also with the transformation of relational data to XML-based data and vice versa. During the transformation process not only the data structures but also the power of the data modeling concepts of the respective document standards must be considered. Based on this knowledge the conversion could be made easier or partly automatically. This paper examines, to what extent real-world B2B data exchange standards make use of XML schema languages for formal specification and if they tap the full potential of these languages. For that purpose the relevant modeling concepts are viewed and applied to selected B2B standards. The result is a close look at the common practice of XML schema languages in B2B data exchange.

1. Introduction

Since the advent of XML as a universal language for describing data on the web, data exchange in business-to-business relationships has to answer the question how to close the gap between relational and hierarchical representation of the same information. One important aspect is the way in which we describe the syntax – and if possible – the semantics of the data. The transformation of data from a relational database into a standardized XML document and back into another relational database is essentially influenced by the formal specification of the data structures and its quality. While a relational database is described precisely by its conceptual schema, such a specification for XML documents depends mainly on the capabilities of the selected schema language.

The transfer of electronic product catalogs using e-business standards belongs to the first and most common applications of XML in B2B e-commerce [1]. Hence it is well suited for doing research in B2B data exchange. Suppliers create electronic catalogs in standardized formats and transfer them to their customers. Eventually the receiving enterprises import the data into e-market places and e-procurement systems. In both cases a transformation of relational data structures to XML documents (or in reverse) is necessary. Contrary to B2C, catalog data of the catalog-creating

enterprise has to be imported into an information system (target system) of the catalog-receiving enterprise. On the supplier side, catalog data is managed by and stored in operational information systems, which are often closely coupled to ERP (enterprise resource planning) systems. The foundations of these information systems are relational databases. In contrast to this the exchange of catalog data is normally based on XML e-business standards. Thus the main tasks of a supplier's catalog data management are the extraction of catalog data from different relational IS, the transformation of this data according to catalog standards, and the transfer to the customers. Catalog data management on the buy-side has to import the incoming XML data into relational databases. In view of this processes the integration of XML and relational databases is a core task.

2. Paper Organization and Related Work

This paper aims at analyzing how XML-based B2B document standards apply different schema languages. The empirical analysis can help answering the question to what extent a B2B document standard supports the task of integrating XML data in a relational database. To do so, our paper is structured as follows: First we will examine the current state of B2B document exchange in the specific area of electronic catalog (Section 2) to identify faults and starting points for an improvement. In the second step we will look at data modeling concepts for XML documents (Section 3). These concepts will serve as the foundation for our analysis of five industrial XML catalog standards. The standards, selected and characterized briefly in Section 4, will be examined, which concepts they implement and to what extent they are able to support the transformation and validation of documents (Section 5). Finally, we will evaluate the current state of these standards and formulate some future requirements.

Relevant research literature comes from two different areas. The first area deals with the loss-free storage of XML documents into relational databases. Many approaches for an automated transformation have been developed. A common goal is to map an XML document together with all its constraints into a relational schema. These constraints are contained in the document specifications. Thereby the semantic quality of the transformation depends on the semantic content of the schema definition used [2]. While early work was mainly based on the simple XML schema language DTD (e.g., [3]), recent work includes newer and richer schema languages like XSD (e.g., [4] and [5]). Most of this work is rooted in the database community. Research work on syntactical and semantic aspects of B2B standardization forms a second area. It is characterized by domain-specific issues, for example exchange protocols [6], reference data models [7], document integration [8] and semantic translation [9].

The main contribution of this paper lies in adopting and modifying a set of criteria that describes the modeling concepts of XML schema languages for an extensive analysis of selected B2B document standards. The results can help to evaluate the methodical quality of these standards.

3. Exchanging and Processing XML Catalog Data

Differently than data e.g., of controlling or sales, catalog data does not remain within the boundaries of an enterprise, but is supplied to and used by customers. This is contrary to most data stored in operational information systems. In B2B e-commerce more and more goods and services are procured using buy-side systems or e-markets. Buy-side systems are e-procurement systems, which are operated by large buying enterprises in order to optimize their own purchasing processes. E-markets bring several suppliers and customers together. In addition, catalog data exchange is not limited to the relationship supplier – customer. In many industries catalog data is exchanged along the entire supply-chain, e.g., manufacturer – wholesale – industry. On the other hand sell-side systems, typically e-shops, which provide only the assortment of one supplier, lose importance [10].

Catalog data possesses a substantial meaning for suppliers. They describe their assortments and are an instrument for differentiation between competitors. To that extent high-quality catalog data can

be regarded as a valuable economical good, which contains bundled know-how about products. This shows up in the wholesale, which function is to provide its customers an aggregated and complete assortment, and therefore bundles the catalogs of many suppliers. The wholesale does not only aggregate catalog data, but “ennobles” this data by completing missing contents and normalizing data. At the same time catalog data represents a legally relevant offer. Insufficient or incorrect catalog data can lead to economic disadvantages.

In order to fulfill the task of creating catalog data often the introduction of new or the extension of existing information systems is necessary. A reason is that catalog data is a mixture of technical and business data stored in different and distributed operational information systems. Likewise the relevant data is managed by different organizational units of the enterprise. Often established concepts and enterprise-wide data models for the catalog data management are missing.

Enterprises that receive catalog data on their buy-side must be able to import any XML catalog documents into their information systems. Especially for e-markets, which process hundreds of supplier catalogs, the catalog import is a key task; particularly since it cannot be assumed that all catalogs use the same format and their quality is evenly high [11].

Aggravating is the size of the data that must be transmitted and processed. Extensive catalogs with up to hundred thousand products and attached multimedia objects can be, not least because of the XML tags, several hundred MB large [12]. Parsing and importing large XML document is a time-consuming task. Hence the need for valid catalog gains a special importance. Errors and faults regarding syntax, semantic and complexity of a catalog delay these import processes and make a new extraction, transformation and validation necessary [6].

Therefore the import has to apply two concepts: The first is based on the reuse of profiles, which define for each catalog standard (and if necessary supplier catalog), how the received catalog data has to be processed. Associated is a mapping or transformation of import data elements to the internal structure as well as the specification, which data of the supplier is required and which data from the standard cannot or should not be processed. Secondly, each catalog passes a staging process that covers different technical and content wise checks, operations and release steps. The final result is a checked catalog that is ready for the use in operational systems.

The mapping of catalog data appears both on supplier side (catalog creation) and on customer side (catalog import). Data mapping defines statements, which bring data in relationship to each other. The complexity reaches from simple direct mappings to rule definitions for different cases. However, the handling of differences in representation requires extended mapping concepts, which lead to data manipulations. The manipulations are described by one or more rules. The mapping needs not only knowledge of the syntax, but likewise of the meaning of the data [13]. This is a problem if the format is documented little or not and an exact specification of the intended semantics is missing.

If instructions for the export and import of catalog data are once specified, then it is not already guaranteed that the created catalogs are completely correct. Concerning this a general statement can be made only in dependence on the formal specification of the exchange format. As far as individual standards have degrees of freedom or inaccuracies, errors can occur during the catalog import. This aspect is of special importance, since thereby the exchange processes must be intervened manually. This contradicts the automation paradigm of e-business. With consideration of the import errors catalog creation and catalog import must be repeated, until the catalog is regarded by the target system as valid. As a consequence the exchange processes are little automated and costing as well as time-intensively.

The described situation shows a set of weak points, which are causally determined by the used specification languages. A promising approach is to bring the specification of the catalog document types on a higher level by the use of formal XML schema languages in order to minimize degrees of freedom and interpretation spaces. Thus it is both possible to supply necessary information for the definition of mappings and transformations into relational representations and to improve the validation of documents effectively.

4. XML Data Modeling Concepts

In this section we describe the formal schema languages for the specification of XML data or documents. The languages provide a set of modeling concepts, which are used to a greater or lesser extent by catalog standards. Eventually the developed analysis schema is applied for an empirical analysis of industrial standards. Before specification languages can be selected, we have to ask, which issues of data modeling have to be considered. A comparative analysis of six XML schema languages is presented in [14]. We adopt the criteria introduced there and form seven examination areas: specification structure, datatypes, XML attributes, elements, inheritance, being unique or key and other features.

The set of criteria mentioned is reduced by those criteria (12), which are determined implicitly by the schema language used for the specification and therefore are not dependent on the modeling of the respective XML standard. This means that not the power of the schema languages is compared, but to what extent B2B catalog standards make use of the provided modeling concepts. For example for our analysis it is not relevant whether the vocabulary of a schema language is based on XML or not, since this question is already being answered by the selection of the language (for DTD: no; for all other languages: yes). Additionally, such criteria are not adopted, which are not relevant for the regarded schema languages, since the appropriate concepts do not appear in any schema language (e.g., attribute choice).

We introduce ten new criteria; among them are a more exact differentiation of datatypes and the structure of the specification documents. This structure shows how the instruments of modularization and reuse are applied. In the following we describe the seven examination areas for our analysis of catalog standard specifications briefly.

- First, general modeling characteristics are examined. Here we have to ask in particular, how the concepts of modularity and change management are supported by distributing the specification content on several files.
- In the area of datatypes we look which modeling concepts are used, in order to model datatypes in XML catalogs. An important question is whether user-defined datatypes are used and how domains are specified. How the specification of user-defined datatypes takes place, is examined in the area of attributes and elements. Regarding the domains we refine the criterion proposed in [14], since it is not only examined, whether domains are limited or not, but also how (enumerations, patterns, restrictions of base types e.g., field lengths or precision).
- The next examination area deals with the specification of attributes. Similarly to datatypes we analyze how domains are defined. Beyond that it is checked whether attributes have to be used and whether default values for attributes have to be set.
- Within the following area element structures are examined, i.e. it is analyzed how the concepts of sequence and selection are used and which cardinality qualifies the occurrence of an element.
- Similarly to object-oriented modeling some XML schema languages implement the concept of inheritance. There is the possibility of either extending or limiting the upper type by inheritance. To what extent this concept is used to specify the selected catalog standards, is subject of the fifth area.
- In relational models primary keys and foreign keys are defined. A similar concept exists also in XML schema languages. This area examines, to what extent this concept is used for modeling attributes and other structures in e-catalog standards.
- Finally, we compare in the remaining area whether the catalog standards use the possibility for integrated documentation and whether the schema offers the embedding of HTML code into the XML document.

While in [14] six XML schema languages are compared concerning their modeling concepts, in our analysis we confine to those schema languages, which are used by the selected XML catalog standards. The four relevant XML schema languages are briefly introduced in the following.

At present a common language for the definition of business documents is the Document Type Definition (DTD) [15]. It was already published by the W3C at the beginning of 1998. The DTD specifies XML documents by means of an own language in a document-oriented view, which forms hierarchical structures. However, the modeling concepts in XML DTD are rudimentary compared to other XML schema languages. In particular the absence of datatypes for the definition of domains limits the specification possibilities strongly.

In order to solve the type problems of DTD and to define a XML schema language, which is itself an XML document, W3C published XML-Data in 1998 [16]; it was adapted by Microsoft in the form of XML-Data Reduced (XDR) [17] and integrated into the BizTalk framework. Another advancement of XML DTD was developed by CommerceOne. Compared with XDR, the schema for Object-Oriented XML (SOX) integrates additionally object-oriented concepts such as inheritance [18]. Because of a strong support in terms of software tools and applications, and the long development phase before the publication of XML Schema (XSD), XDR and SOX found a large dissemination for the specification of XML e-business standards. After a long development and evaluation, started in 1999, the language XML Schema (XSD) reached its final state and became a W3C Recommendation in May 2001 [19]. The XSD language is the official successor to XML DTD and extends its capabilities by the concepts already introduced by the other schema languages, for example syntax in XML, a data-oriented view, an extended set of datatypes, name spaces as well as object orientation. XSD offers even relational concepts, e.g., keys and foreign keys to guarantee referential integrity.

5. XML Catalog Standards

For the exchange of catalog data a number of XML-based standards are available. Before particular standards can be examined, catalog standards have to be seen in the context of B2B standardization. On the basis of a level model, standardization can be partitioned [20]. Often the levels framework, processes, documents, vocabulary and datatypes are formed. Catalog standards define catalog documents, which consist of a vocabulary. The vocabulary contains the elementary data objects, which are specified up to the datatype level. The highest level "processes" is only partially covered by catalog standards. A process is an admissible sequence of documents, e.g., order, order confirmation, delivery notice, invoice. Therefore a catalog process could cover: catalog request, catalog, and catalog update. Finally the level "framework" contains definitions regarding transmission and communication protocols.

With reference to the level model the following groups of applicable standards can be formed:

The group of genuine catalog standards contains those standards, whose origin is situated in the specification of catalog documents for e-procurement. To this group belong e.g., BMEcat and cXML. Meanwhile cXML has expanded its scope to further business messages; BMEcat is supplemented by the transaction standard openTRANS. Transaction standards go a step further in standardizing a multiplicity of business messages; catalog documents are just a part of it. Prominent members of this group are EAN.UCC, OAGIS and xCBL. The third group consists of e-business frameworks (e.g., ebXML and RosettaNet), which standardize a complete data and communication infrastructure.

From the groups mentioned now those catalog standards are selected, which have a relevant spreading in practice on the one hand and cover a wide range of formal specification languages in e-business on the other hand. Anyhow ebXML is not covered, since it does not provide own catalog specifications but will integrate the document level from OAGIS in the near future, as well as RosettaNet, which is a vertical framework and thus limited to a specific branch of industry.

- BMEcat is a catalog standard, which was developed in Germany by a trade association, 20 large companies and research institutes. According to own statements it is the leading catalog standard in Europe. The specification takes place via DTD and XML Schema [21].
- cXML is the standard data exchange format used by the e-procurement solutions of Ariba, a provider of market places and desktop purchasing systems. The focus is not on

the complete modeling of catalog data, but on giving a set of formats for catalog-based order processes. The specification takes place via DTD only [22].

- EAN.UCC is a transaction standard that was published by the Uniform Code Council (UCC) and EAN International, which are also responsible for the development of EDIFACT in Europe. Among all standards EAN.UCC is the newest approach and it uses XML Schema exclusively [23].
- OAGIS is developed by an international consortium of most diverse enterprises and enclosures over 200 XML transactions for business documents today, which are called Business Object Documents (BOD). Specification languages are DTD, XML Schema and XDR [24].
- xCBL (XML Common Business Library) is alike cXML developed by a large e-business software company, CommerceOne. The designation "library" shows that xCBL is an extensive collection of XML business documents. DTD, XSD, XDR and SOX are used [25].

Table 1 summarizes the results of our analysis according to the criteria described in Section 4. An entry "-" means that this criterion has not to be considered, since this feature is not provided by the respective schema language. In case of the selected standards all available catalog document specifications were analyzed, which make use of an XML schema language.

We discovered that DTD is no longer the language with the highest spreading, since EAN.UCC, which is the newest approach, uses XSD only, and OAGIS does not support DTD in its newest Version 8.0 anymore. Four out of five standards use XSD for defining catalog documents and two standards also support other schema languages as well. But the use of these schema languages like DTD, SOX or XDR is reduced step by step. This observation is confirmed by the new standard UBL (Universal Business Language, publication determined for early 2003), that is based completely and exclusively on XML Schema [26]. Only xCBL provides both XDR and SOX definitions.

If we narrow the comparison to those modeling concepts, which can be implemented both by DTD and newer XML schema languages, then it is obvious that the specifications of catalog standards based on newer XML schema languages are more detailed and conceptually richer than specifications using DTD. For example some catalog standards model externally defined data structures, like order units, countries and currencies in their XSD, XDR or SOX version. The respective DTDs do not model this despite it is possible.

A drawback of DTD is the limited number of datatypes. Hence standards define own basic datatypes (e.g., STRING, NUMBER, BOOLEAN). These are defined as ENTITIES, which are mapped on #PCDATA. They are used during the definition of the elements to describe which datatypes are expected in the XML files. But they can not be used for a formal verification and can only help to create the XML files or build software by providing some additional information for the developers [27].

A closer look at the definition of domains shows that all catalog standards use enumerations in order to limit these domains. However, the mapping of XML schemas to relational schemas could be difficult, since FACETs are used for detailing the base datatype only partially in the catalog specification. The application of complex datatypes is forced by some modeling weaknesses in the content model of XML schemas, though it is handled quite different. While some catalog standards get along almost without any complex datatypes, others define nearly all elements with the help of complex types (e.g., xCBL vs. EAN.UCC).

Inheritance is used only for refining simple datatypes to enumerations. Thus the potentials of object orientation are hardly opened. Even less common is the application of relational concepts like keys and uniqueness. These modeling concepts are seen in the BMEcat standard only.

Catalog Standard	BMEcat 1.2		cXML 1.2.008	EAN. UCC 1.1	OAGIS 8.0	xCBL 3.5			
	DTD	XSD	DTD	XSD	XSD	DTD	XSD	XDR	SOX
Specification Structure									
include	-	Yes	-	Yes	No	-	Yes	-	Yes
import	-	No	-	Yes	Yes	-	Yes	-	No
external datatypes	No	Yes	No	No	Yes	No	Yes	Yes	Yes
one file per message	Yes	Yes	No	Yes	No	Yes	No	Yes	No
multiple files per message	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes
one file integrating all messages	No	No	Yes	No	No	No	Yes	No	Yes
Datatypes									
user-defined type	-	Yes	-	Yes	Yes	-	Yes	-	Yes
domain constraint: enumeration	-	Yes	-	Yes	Yes	-	Yes	-	Yes
domain constraint: pattern	-	Yes	-	Yes	Yes	-	No	-	-
domain constraint: facet	-	Yes	-	Yes	No	-	No	-	Yes
null	-	No	-	No	No	-	No	-	-
XML Attributes									
default value	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
optional vs. required	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
domain constraint: enumeration	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
domain constraint: pattern	-	Yes	-	Yes	Yes	-	No	-	-
domain constraint: facet	-	Yes	-	Yes	No	-	No	-	No
Elements									
default value	-	No	-	No	No	-	No	-	-
unordered sequence	-	No	-	No	No	-	No	No	-
choice	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
min & max occurrence	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Inheritance									
simple type by restriction	-	Yes	-	Yes	Yes	-	Yes	-	Yes
complex type by extension	-	No	-	Yes	Yes	-	No	-	No
complex type by restriction	-	Yes	-	Yes	No	-	No	-	-
Being unique or key									
uniqueness for attributes	No	Yes	Yes	No	No	Yes	No	Yes	No
uniqueness for elements	-	Yes	-	No	No	-	No	No	-
key for attributes	-	Yes	-	No	No	-	No	-	-
key for elements	-	Yes	-	No	No	-	No	-	-
foreign key for attributes	No	No	No	No	No	Yes	No	Yes	No
foreign key for elements	-	Yes	-	No	No	-	No	-	-
Miscellaneous									
documentation	-	No	-	No	Yes	-	No	-	Yes
embedded HTML	-	No	-	No	No	-	No	-	No

Table 1: Comparison of selected XML Catalog Standards

6. Conclusions

All B2B standards analyzed in this paper use the modeling concepts of XML schema languages only partially and not constantly. Especially the concepts of keys and uniqueness, which are important in reference to relational schemas, are used only by the XSD version of BMEcat. This

lack within the area of catalog standards makes the transformation of XML-based catalog documents into relational databases substantially difficult, since the designation of primary and foreign keys must be added manually. Therefore the full potential of rich specification languages is not tapped. This conclusion can be broadened to B2B document standards in general, since all of the five selected catalog standards are part of or form the core of standards offering a wide range of different business document types.

So far genuine XML database systems are hardly used for e-business applications; therefore the transformation of XML documents into relational databases (and in reverse) is still a main task in electronic data interchange between enterprises. A substantial reason is that e-business systems connect existing operational information systems, which are based almost exclusively on relational models and database systems. In order to keep XML documents in relational databases persistent, it is necessary to define a database schema that permits the representation of content and structures of XML files as loss-free as possible. Inlining methods point out that such a transformation of documents, which are specified in a XML schema language, is possible and thus storage in relational databases can be realized [3]. However, the quality of the transformation, especially regarding the implicit semantics, depends on the meta information that is formalized in the specification of the catalog standard. Newer XML schema languages can express more semantic information, e.g., datatypes and relational concepts, which facilitate the transformation process or even enable their loss-free execution [28].

Though XML Schema (due to its late publication in May 2001) is still a quite young XML schema language and therefore only few e-business software tools offer a complete and correct implementation of its concepts, we expect and observe that it is becoming the prime and therefore standard schema language in B2B document standardization. However, not all data modeling concepts are utilized so far and we still have to wait, whether newer specifications of XML B2B document standards actually use additional modeling concepts.

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