XML-based Web Service for Collaborative Product Data Management

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Abstract

This article considers the strategy of using a new generation of web technology to support product data management during the traditional development process. An approach to the data exchange and sharing by defining the infrastructure of XML-based web service for collaborative product development is proposed. The outline of the theoretical background of products information modelling and relationships with the entities of the STEP PDM Scheme is presented. Benefits of STEP/XML integration as a base concept of the proposed solution is discussed. The overview of the web services technology is given. The architecture of the web service for collaborative product data management built by using Java2™ Enterprise Edition (J2EE) platform is described.

Keywords

Product data management, product structuring, product information modelling and representation, STEP, XML, web service

1 Introduction

This article considers the strategy for using a new generation of web technology to support product data management and information exchange in traditional product development process. All aspects of the product development process – design, development, manufacturing and product support – are performed more or less collaborated and concurrently. Proceeding of such process demands a product development environment for capturing the product data, within a digital model that can be viewed, modified and managed simultaneously. In order to support inter-organisational requirements in the new industries of the 21st century, an infrastructure of XML-based web service for collaborative product data management in SME-s is proposed. The web service in literature is defined as: "A collection of functions that are packaged as a single entity and published to the network for use by other applications" [Glass 2000.]. In other words, web services are building blocks for creating open distributed systems, offering companies and individuals relative simple and cheap tools for make their digital assets available worldwide. Described research was aimed to investigate the possibilities of using a new technology of web services for supporting engineering development cycle. To enable and realize such service two main goals have to be achieved:

- The informational infrastructure for knowledge formalization and modelling of engineering product data has to be defined.
- The computer platform for using and management product data, based on proposed informational infrastructure has to be developed.

The conceptual and implementation issues of above research goals are described in the following sections. In the second chapter a brief outline of the theoretical background of products information modelling, including an overview of the STEP PDM Scheme entities is presented. The third chapter considers benefits of STEP/XML integration as a base concept of the proposed web service. Finally, the architecture of the web service built by using Java™2 Enterprise Edition (J2EE™) platform are described and further research is addressed.

2 Research background

2.1 Theoretical basis

Striving to discover the main problems of collaborative product data management, the theoretical foundations in the particular research area were analysed, and the interviews with members of the design departments of SME-s were performed [Tichem, et all 1997.], [Tichem, Storm, Andreasen, 1998.], [Marjanovic, et all 2000.], [Storga, Pavlic, Marjanovic 2001.]. Driven by such collected findings, the main elements of the products data informational metamodel, that present a base for building informational infrastructure [Figure 1], were determined:

- *Information binding product data carriers*

  As the main product data carriers in engineering development process, the products physical components and structured documents were identified. A document file can could have a further internal structure as well as physical assembly. *Hierarchical breakdown structure* is a fundamental property of product data carriers, which describes how the product is divided into components, which are in turn divided into subcomponents, and illustrates the relationships between constituents. Further important property of product data carriers is *versioning*. Versions are mainly used for two base concepts. Firstly, version can represent the evolution of product data carrier through successive stage – *revisions*, or represent a number of parallel alternatives – *variant*s. The third main property of product data carriers that have been considered is data *status*. In design environment, the information, which is stable, consolidated and proven, is treaty differently from information that is tentative, untested and possibly incorrect.

- *Information binding subjects that create, own and manipulate product data*

  The subjects' information as a main part of presented metamodel, are describing users (project leaders, designers, administrators, etc.) and defining organization of development teams within design tasks (projects).

- *Information binding activities coordinated by subjects, in which the product data are consumed*

  The main activities in product development process described by informational metamodel are: product components' and documents' hierarchical structure management, engineering change management, approval and authorisation procedures, design process documentation and history, design tasks assignment and product configuration processes.

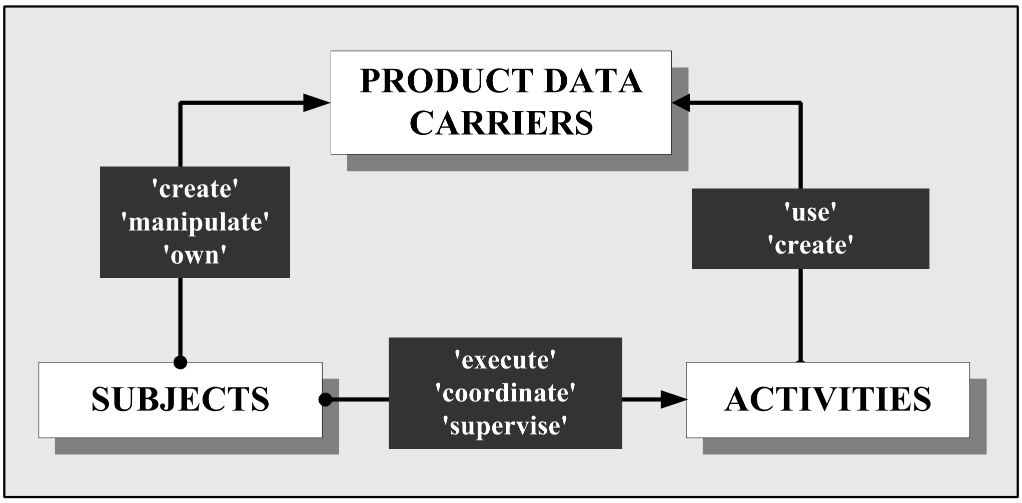

Figure 1: The main elements of the product data informational metamodel

2.2 STEP PDM Schema

Previously described metamodel was used for correct understanding, interpretation and implementation of informational model for the product data exchange, defined by the ISO 10303 STEP standard. The STEP PDM Schema is a harmonized data model capable to supporting a central, common subset of the data typically managed within PDM system. Its scope was developed as the harmonize intersection of requirements and data structures from range of STEP Application protocols all generally within the domains of development of discrete electro/mechanical parts and assemblies [ProSTEP GmbH & PDES Inc 2000.]. That is why, the elements of previously described metamodel, were used as a guide line for implementing the STEP PDM Schema entities [Figure 2] in particular case of the product data management for design phase of mechanical products in SME-s.

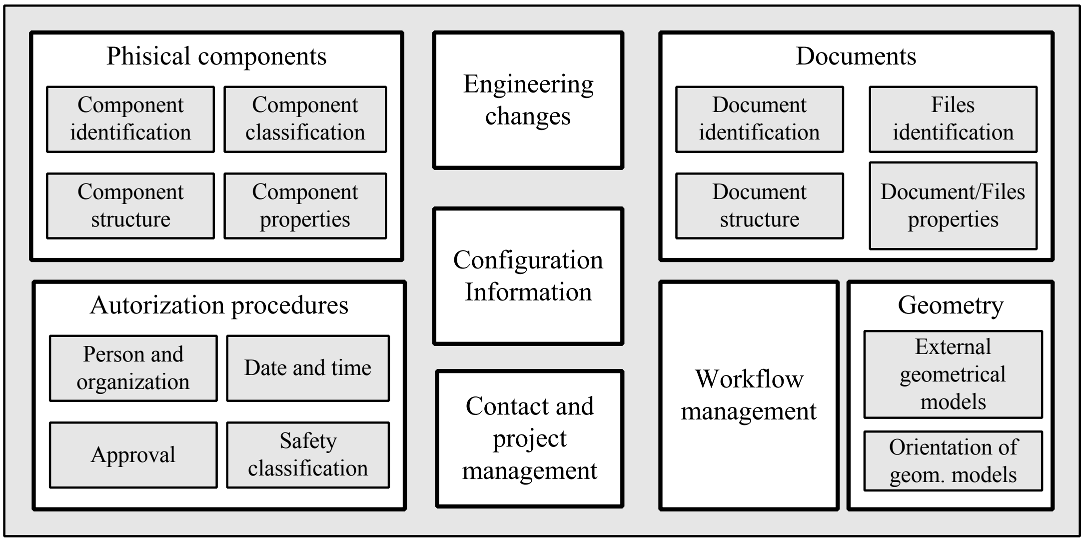

Figure 2: The main groups of the STEP PDM Schema entities

The main groups of the implemented entities of STEP PDM Scheme are as follows:

- *Entities for identification and classification of product data carriers* - identification and classification are achieved according to a fundamental STEP interpretation of 'Part as a Product'. The identified data carrier may represent part or assembly. In addition, a product may represent a managed document and be identified according to the 'Document as Product' interpretation.
- *Entities for describing the product data carriers' properties* – a property is the definition of a special quality and may reflect physics or arbitrary user defined measurement. There are also a number of pre-defined property type names, proposed for the use: recyclability property, mass property, quality property, cost property, duration property. A special case of data carriers properties is the component shape property – a representation of the geometrical shape model of the product components, but this topic is out of research scope described in this article and not included in final informational infrastructure of proposed web service.
- *Entities for defining the hierarchical structure and relationship between product data carriers* – explicit hierarchical structure represents complex components and the constituents of those components. Relationships between constituent definitions are the principle entities used to structure an explicit configuration of complex components (either physical parts of product or structured documents). In addition, relationships could characterize explicit alternates and substitutes for the each component.
- *Entities for identification and classification of external references* – external references represent external files. External file may identify a digital file or a physical, 'hardcopy'

file. As opposed to a managed 'Document as Product', an external file is not managed by the STEP PDM Schema entities – there is no capability for managed revision control or any document representation definitions for an external file.

- *Entities for user identification and responsibility assignments* – organisations and people in organisations perform functions related to product data and data relationships. Approving is accomplished by establish and approval entity and relating it to some construct. Approval may be representing as a single basic approval (used in concrete implementation for SME-s), or it may represent a more complex approval cycle involving multiple approvers, on different dates/times, and possibly different status values (useful for complex projects and organizations).
- *Entities for projects identification and organization* – project identification area contains construct to represent project, i.e. programs of work for which one or more organizations are responsible, and relation between projects. Events may be defined to specify when a project is planned to or actually start and/or ends.
- *Entities for describing engineering change and workflow management* – provides data structure for representation of the data used to manage the work being done during the engineering (release and change) process. The work management area contains the construct to describe initial part deign requirements and the change requirements and issues for revising part designs, as well as the directive for work and actions to proceed in the development of these initial or modified part designs.
- *Entities for supporting product and structured documents configuration* – configuration identification is the identification of product concepts and their associated configurations, the composition of which is to be managed. Configuration effectively is used to define the planned usage of components in the context of a particular product configuration. There are not supported concepts of configuration completeness conditions and configuration constraints as the main parts of configuration process.

The main deficiency of STEP PDM Schema is in insufficiently support to early phase of development process. There are not, for example, entities for description of product data in phase of customer requirements clarifying or conceptual phase of design process. That could be one of possible ways for expanding the proposed informational infrastructure in the future research, together with including the requirements for product data from other phases of product life cycle.

3 STEP/XML integration

XML (e**X**tensible **M**arkup **L**anguage) is simple approach to marking up content (data) with tags to convey information. The tags delimit the context and the XML syntax lets us define data structures of arbitrary complexity. XML tags name the concept you are describing, and named attributes modify the tagged structure. On that way it is possible to formally describe the syntax you have devised and share it with anyone using any other language on any other computer platform. XML 1.0 specification became a W3C Recommendation in February 1998. The formal specification, including the grammar notation, is readily available on the Web from W3C (at http://www.w3c.org/TR/REC-xml). There are a number of different viewpoints as to what constitutes the best way of working with XML, each of which has an appropriate place: XML as document format; XML as a document management format, XML as a data format, XML as a transformation language, or XML as a programming language.

The decision to use both standards, STEP and XML, was based on the fact that they are both aimed at supporting data exchange and sharing. For the generation, processing and management of product data describing complex products and systems (like a car), many different computer-aided systems are currently in use. On the base of XML it is possible to share this information beyond network borders independent to where it is stored: in a database or a document. It is possible to link information objects from different domains and to integrate information stored in different databases. XML provides all essential facilities for implementing STEP data models. Although the current use of XML is in the field of data transfer and communication between applications, STEP is still better aimed at modelling the needs of that information [Kimber 1999]. The basic advantages of STEP/XML for product data integration:

- Data exchange requires an "agreed" data model. In this case semantic of the information is defined via STEP PDM Scheme. Based on STEP standard, the rules for defining the structure and syntax of elements used in appropriate XML file are determined.
- W3C aims the separation of data and presentation. Using this functionality the same product data (e.g. physical product structure) can be presented in different ways, what is of special importance in heterogeneous product development environments.
- The full integration of product documentation in product data management systems can be achieved (e.g. crating of configurable technical documentation for configurable products).

Due to the generic nature of XML and its flexibility that results from descriptive power, there is no one right way to apply STEP/XML integration. On example, advantage of ISO TC184/SC4 Part 28 Late Binding, approaches is that they are direct reflection of the STEP standard and are therefore easily understood by anyone familiar with the STEP standard. By contrast, the other approaches (i.e. OMG-XMI) require several layers of mapping and abstraction between original EXPRESS model and instance representation and its eventual expression as an XML document. In research presented in this article, the XML-STEP mapping is not a primary research goal. For that purpose, the recommendations of STEP PDM Schema developers are followed [Pro STEP GmbH & PDES Inc 2000.].

4 Web service

4.1 Concepts and architecture

After the informational infrastructure had been analysed and confirmed, the next step of research process was designing the solution architecture for implementing proposed infrastructure. For that purpose, implementation of the informational infrastructure into functionality of the web service was achieved by the integration of the selected STEP entities with the benefits of the XML technology. A web service is an application that accepts request from other systems or users across the Internet or an Intranet. The foundation of the web services is XML messaging over standard web protocols, which are computer platform independent. This is a very lightweight communication mechanism that any programming language, middleware or computer system can participate in, easing interoperability greatly. These industry standards enjoy widespread industry acceptance, making them very low-risk technologies for corporate to adopt. With the web service, it is possible to integrate two clients, departments or applications quickly and cost-effectively. Web services represent the new age of Internet application, essentially founded on three major technologies:

- *Web Services Description Language (WSDL)* is language programmer can use to describe programmatic interfaces of Web services. The WSDL specification is an XML document, which describes the interface, semantic, and administrative rules of a call to the web service.
- *Universal Description, Discovery and Integration (UDDI)* lets Web services register their characteristics with a public registry (UDDI Business Registry - UBR) so that other applications can look them up. Users can query the UBR to discover web services and to locate information needed to interoperate with the service.

- *Simple Object Access Protocol (SOAP*) provides the means for communication between web services and client applications. SOAP is specification for performing business method request as XML documents, and can support a variety of lower level protocols such as HTTP or SMTP.

There are three major challenges in building a web service that participate in a business web [Figure 3]:

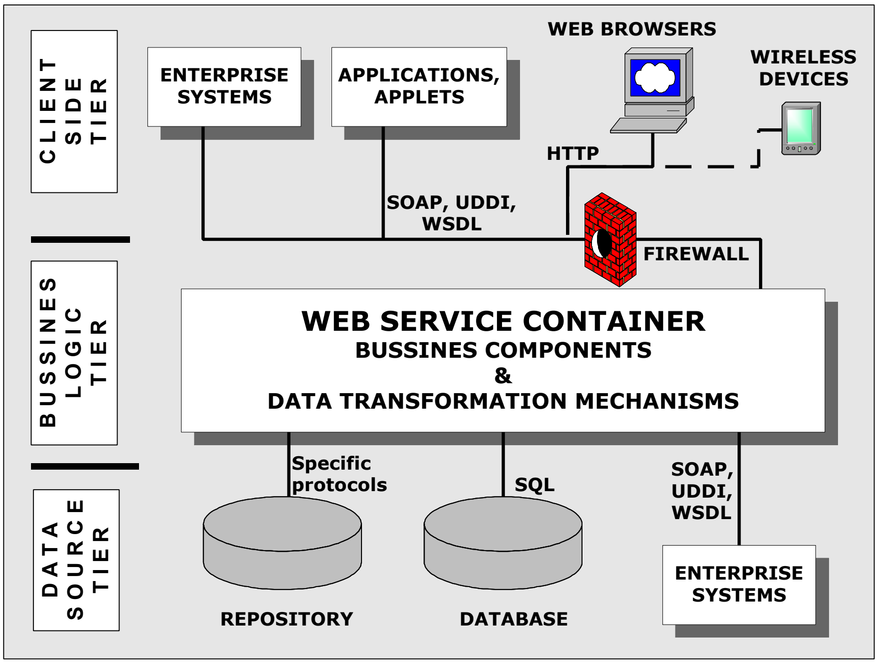

Figure 3: Three-tier architecture of web services

- **Build client tier-connectivity** to allow consumers of web services to connect and make use of a web service. Three major types of clients that can connect to a web service are:
  - Business partners, distributors, resellers;
  - Web browsers, PDA-s, wireless devices;
  - Applets, standalone applications, existing systems.
- **Implement the web service** including any workflow logic, data transformation logic, business logic and data access logic. There is the functionality behind the web service that performs work on behalf of the clients.

  In the particular research the business level was made up of the following groups of components using the Java™2 Platform, Enterprise Edition (J2EE™): components that manage operation for permanent store of product data values into permanent store, components that perform business logic based on the rules for product data manipulation, XML operations as a main communication mechanisms and utility components of the web service (user authorization, different types of Id generation, files upload/download mechanisms, reports generators, archives operations, working environment settings, users help).
- **Connect to back-end systems** that may include one or more databases, existing enterprise information systems. Business partners that publish their own web services, and a shared context repository for user information shared across many systems.

  In particular research the entities of relational database (tables, relations, constraints) were used for the permanent storing of product data.

4.2 Implementation

The use cases diagram of the web service, class structures diagram for business components, their attributes and methods, were firstly defined by using the UML (**U**nified **M**odelling **L**anguage) and then built by using a features of Java2™ technology. The XML Operations were developed as run-time components for communication between web clients and the business level components. Besides the logic for the input requests processing, the XML Operations contain the data presentation logic for transformation output product data into form specified for the particular client type (B2B clients, web browsers, PDA & cell phones.

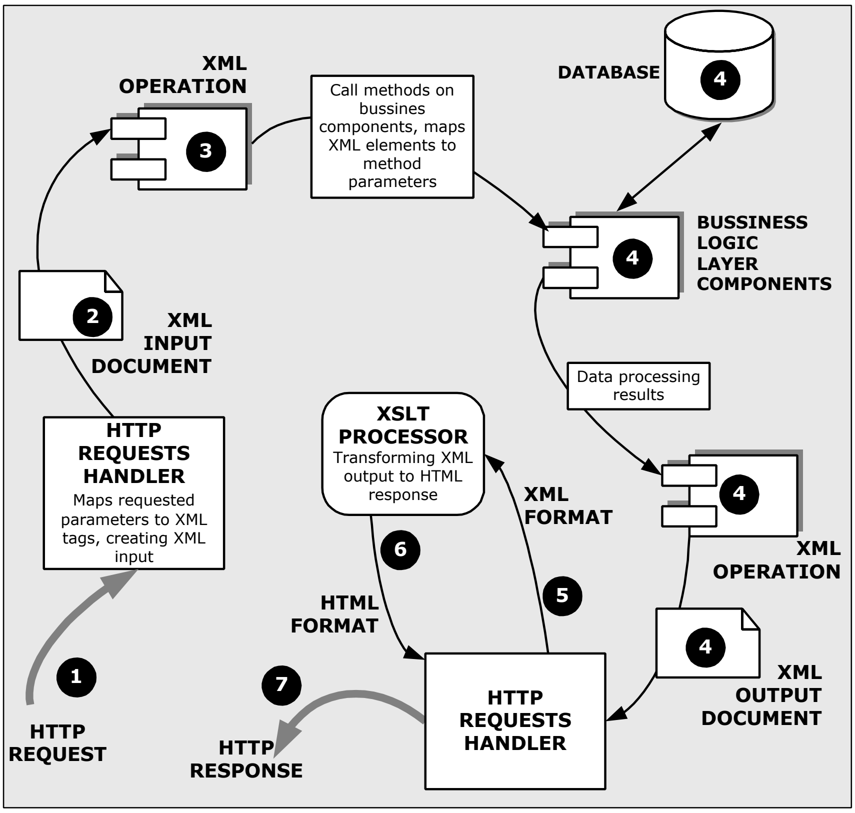

Figure 4: The main steps of the web service runtime interactions

The following steps describe the typical web service runtime interactions based on XML messaging [Figure 4]:

1. A client makes an HTTP request targeted at the web client JSP page deployed on a web server (part of main web service infrastructure). The targeted XML Operation and its input parameters are specified as name-value pairs using query parameters.
2. The HTTP request object is passed to the request handler. The request handler component of web service container has already parsed the request and creates an XML input document by mapping request parameters to XML tags.
3. The service manager locates, or instantiates the target XML Operation.
4. The XML Operation then: maps elements of the XML input documents to method parameters names; call the methods defined in the XML Operation; formats return values into an XML output documents; returns the XML output documents to request handler.
5. Request handler passes the XML output document to its XSLT processor.
6. The XSLT processor transforms the XML output documents to result data format depending on client - could be HTML, WML, XML, PDF, etc.
7. The JSP page includes the HTML in the HTTP response as a dynamic region of the web page for the web clients.

5 Conclusion

We have introduced the way in which the new technology of the web services could be integrated in context of the management process of data and technical documents that are connected with the physical product components. In our opinion, by building the web service based on the proposed information infrastructure model, the computer implementation that fulfils requirements for supporting collaborative product data management in heterogeneous and distributed engineering environments, is achieved. The benefits of such implementation are:

- The traditional approach to integration of engineering data between different systems are improved;
- Managing and data sharing mechanisms for structured product documentation and product data are realized;
- Structured product information repositories becoming easier to manage interactively via web browsers;
- Better control of the engineering data and engineering activities is established.

XML and Java2™ technology, enable realization of platform neutral and portable solution that could form a foundation for integration of product data management process and other information systems (i.e. CAD tools or ERP systems). Developing support for other phases of product development process or different phases of product life cycle (product specification, conceptual design, manufacturing, assembling, maintenance, recycling etc.) requires expansion of the presented informational model that will be considered in the further research.

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