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Web Service Oriented Standard Product Library

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Abstract: Using standard components or modules is vital in product design, development and manufacturing. The current catalogues can not meet industry requirements for collaborative engineering. The drawbacks in the current catalogues are the platform dependency, the difficulty in version management, heavy CAD file translation, and content updating difficulties. In this research, a novel "Web service" oriented approach is proposed to address these limitations. Based on the in-house standard component and assembly libraries, the new method engages a generic CAD modeler with the Java Web Service technology. Potentially, it can eliminate all the aforementioned drawbacks. The new method also avoids hard coding of catalogues within CAD system and facilitates the catalogue owners to update their databases at any time. By taking injection molding design as an example, the paper introduces the key mechanisms in implementation, and shows the feasibility of industrial applications.

Keyword: Web service; Collaborative engineering; Standard product library; CAD; E-catalogue

1. Introduction

Due to the globalization, the new products are often developed in various countries with the increasing use of standard components or modules because in such a way the product development cycle time and cost can be reduced [1]. On the other hand, either the internal machining workshops or the external suppliers have to follow different sets of standard requirements from different customers and for different product structures. CIMdata Inc. has proposed a blueprint for product lifecycle management strategies in a collaborative approach [2]. The purchasing decision and ordering for standard components or modules should be made at the time of product design. This initiates the standard product vendors to release their catalogues in a more effective way comparing to the present practice. To meet this requirement, it is essential to have a common system, which seamlessly gives the most updated information of standard products from as many providers as possible. Detailed contents such as prices, ordering information, views of components, pictures, and generic 3D models should be timely updated. Ideally, such a system could eliminate catalogue books and hard-coded CAD models of a particular CAD system.

The objective of this research is to study the feasibility of a reference architecture that links the existing in-house electronic catalogue system with the new Java Web Service technology. The prototype system shows that hard coding of CAD specific catalogues as well as the misleading non-updated catalogue versions can be avoided; it also facilitates the catalogue vendors to update their databases at any time. Moreover, it provides services to the end users with the choices of selection among different catalogues.

This paper is organized as follows. In Section 2, the drawbacks of the existing component/product libraries/catalogues are elaborated. In Section 3, the proposed Web service oriented method is introduced. Then Section 4 shows that the method has been successfully implemented in a standard component library for injection mold design. Conclusions are drawn in Section 5.

2. Drawbacks of the Existing Approaches

Traditionally, standard product suppliers deliver book type catalogues to update the designs, configurations, prices and order or delivery information. Recently, suppliers provide CAD specific electronic libraries in the form of files delivered on disks, or via internet WEB portals. There are some major disadvantages of this method as follows:

- Manufacturing companies accept catalogues often from the major vendors and thus the method is not feasible for the new entries and niche component providers.
- It is difficult for the catalogue providers to publish and market their new products timely due to the periodical updates.

• The designer needs to create the CAD models. Many manufacturing companies support different customers. They also must create different CAD models according to different vendors.
• There is high possibility of using the outdated catalogues. Catalogue vendors face difficulty in changing the information of catalogue items before the next update.
• Finally, huge cost is involved in the catalogue book development and distribution all over the world.

Computer-based libraries are definitely superior in these aspects [1]. Recently, several design packages provide predefined 3D components [3, 4]. Of these, however, most generate or load in components in solid models with fixed geometry and dimensions, which makes them difficult to be adopted by different vendors to support the variations in component definitions [5]. We classify such CAD models as "hard-coded". Such CAD models are numerous due to the numerous sizes and configurations [6]. Most of them are developed for a particular CAD system [5, 7]. We call this method as "CAD system approach". This approach has the disadvantages as follows:
• Very often, due to the cost of development involved, CAD vendors implement very limited standard products from different catalogues. For updating catalogue models, suppliers depend on the CAD vendors or developers. Usually CAD vendors care only their CAD software updates while developers demand extra significant resources.
• Again, CAD vendors do not support the small or niche suppliers.
• Very much non-geometric information, such as design patterns, feature configuration, ordering forms, prices, etc, is striped off. Standard product suppliers do not have control for the validation of libraries.
• Each CAD vendor develops its library on its own CAD platform; this practice limits the use of catalogues. If end users or suppliers do not update their CAD systems, then the design may end up in using outdated libraries.

To avoid the drawbacks in this method, some suppliers develop and publish their catalogues in the Web. We refer this practice as the "Web-based approach". There are two types of implementation: the catalogue-only purchasing systems and those with the corresponding CAD model libraries. The catalogue-only system do not provide CAD models, so the end users need to either create their own CAD models or still depend on the CAD vendors to update their CAD system libraries.

The second type implements all the data and CAD models with a relational database system, and interface with users via the Web portal. This method is flexible for the catalogue owners to add or modify components. End users can select and get all the details of the required components or modules by browsing the Web site; they can download all the information relating to the catalogue and the CAD models which can be used for their downstream application. However, there exist some major disadvantages:
• It is difficult to provide CAD models for different CAD platforms available in the market because the CAD models are hard-coded. Although it is possible to provide generic objects in a neutral format like STEP files, but the end user do not willing to accept the format due to the well-known interoperability problem. To avoid this, native CAD models are preferred. Commonly, all these formats can only support pure geometry; hence, they are 'dead blocks' without engineering and business semantics.
• Even if the CAD models of libraries are developed in a neutral format (e.g. STEP, ACIS), then, whenever the neutral format provider makes some changes, the Web data contents have to be revamped thoroughly. Also, end users need to update their CAD design models as well as the system version in order to avoid translation problems.
• Standard component suppliers need to invest huge amount to develop and maintain the Web-based catalogue system with the third-party developers.

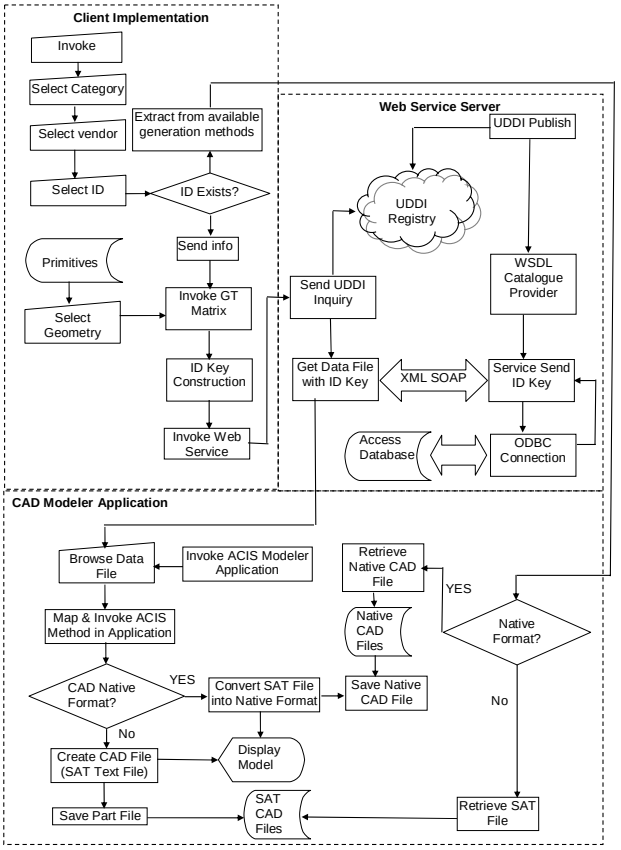


Figure 1. Web Service Enabled Catalogue System

To conclude, the drawbacks in existing standard component or product libraries are the platform dependency, the difficulty in version management, heavy load of CAD file translation, and the catalogue updating problems.

To address these limitations, this research studies a new technology, namely "Web Service-Oriented" product library approach. Figure 1 shows the overall framework of the system. This method leverages some of the author' previous research works [5, 8, 9].

3. System Design and Architecture

Web services [10-13] are becoming the basis for electronic commerce. In manufacturing enterprises, Web services have the great potential to be unleashed [14]. Companies invoke the services of other companies to accomplish a business transaction [15]. Java programming language is ideal for building Web services and developing applications [16] because of its portability. Java API provides the mapping between the Java programming language and XML (Extensible Markup Language) [17] so Java technology can work coherently with the XML-based technologies that underlie Web services. SOAP (Simple Object Access Protocol) is used to transfer the data.

In the system proposed, suppliers can provide catalogue data and CAD model information to catalogue providers, who can publish their WSDL (Web Services Description Language) to the service registry. This service registry is categorized into many varieties like telephone yellow-page books. By using the UDDI (Universal Description, Discovery and Integration) information that presents in the registry, end users can develop a link with service providers and use the information in the WSDL to send and get the SOAP messages with data. Apart from overcoming the disadvantages of the traditional as well as the existing catalogues, the main advantage of this Web service system is that the end user or the third-party service provider can access many catalogues from different suppliers via a uniform platform so as to compare the specifications, prices, quality etc. for a particular product required. This will provide a great opportunity for the competitiveness in cost and quality for the OEMs as well as the suppliers [1]. At the same time, a new third-party Web catalogue service business can be created by connecting the suppliers according to a common protocol.

In the proposed system, catalogue vendors will have full control on the entire system. End users or CAD vendors are not required to invest and develop separate system for their specific CAD systems. The system is divided into three major modules which are briefly introduced as below:

- *Web server module*. This is the portal server module implemented with the Java Web Services technology.
- *Client implementation module*. In this end, user applications, their interfaces, transactions, uploading and down-loading functions, are hosted.
- *CAD application module*. This module incorporates a solid modeler, which provides fine-grain geometrical services and data processing functions.

These three modules are further discussed in detail in the following sub-sections respectively.

3.1 Web Server Module

For this research, the Appache Tomcat Web-server is selected, which is free to use. Tomcat is the Servlet container that is used in the official Reference Implementation for the Java Servlet and JavaServer Pages technologies. Tomcat is developed in an open and participatory environment and released under the Apache Software License.

In the proposed system, catalogue providers publish their services and WSDL information in the UDDI registry under the category of standard products for any industry. The service requesters (the end users) discover the above service by using the UDDI registry with the client application, or manually, and uses the published WSDL to generate the client proxy. At runtime the client uses the client proxy to construct and send SOAP messages to the Web service. Figure 2 illustrates the process sequence of the system upon reception of the end user requirements.

One of the important tiers in this system is the database. All the catalogue data have to be kept in the database for the electronic catalogues. Since enormous amount of research and development have been done in this area, this research does not focus on this area and a small database had been developed for testing purpose only.

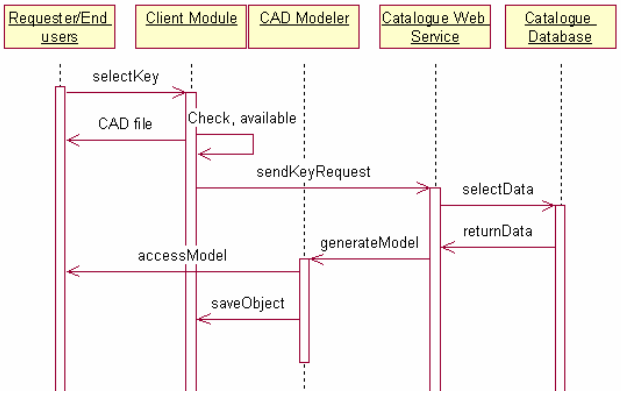


Figure 2. Process Sequence for Web Service Catalogues

3.2 Client Implementation Module

This module generates the request code through the end user selection. Basically, all the catalogues are generated with the reference catalogue number, which is the key for the customer to order according to their requirement. This module generates the catalogue number as request key. The catalogue selection and catalogue key generations are made through the server. The implementation may be done with simple JavaScript, HTML programming languages and ActiveX components (For the actual implementation, developers can use the Java Server Pages (JSP) and Java

bean technology to connect the client selection and data retrieval from database through the Java programming).

3.3 CAD Object Modeler

The returned XML SOAP from the server contains the data to generate the CAD object and there should be an application to handle this XML data to CAD object conversion. For the actual implementation, the standard component library is constructed with a CSG-based architecture [8], and the Group Technology (GT) classification system was adopted, whereby the primitives of standard components from different supplier catalogues are modeled in a matrix form. Such a matrix scheme is used for identifying and grouping related or similar shape features in order to take advantage of their similarities in constructing the final geometrical model. The part feature configuration and parametric product model construction is based on the author's reported on-going work which is the standard component library (SCL) for mould design [5]. It allows designers to select, load, identify and edit standard components in a dynamic and unified manner. The component representation includes rich information such as suppliers, major types, sub-types, alterations, sizes, constraints, tolerances, etc. It is flexible to deal with both dimensional and topological variations of CAD objects. For modular mechanical products, standard assembly library has been implemented [7]. The concepts used in these researches are the feature-based rich CAD objects which provide good engineering informatics support for the current work [9]. There is a feasible solution to achieve feature-level uniformity for CAD model generation by using a neutral feature operation scheme as reported in [18-20]. For this research the ACIS 3D CAD modeler has been chosen simply for the availability of research license.

ACIS [21] integrates wireframe, surface, and solid modeling by allowing these alternative representations to coexist naturally in a unified data structure, which is implemented in a hierarchy of C++ classes. ACIS bodies can have any of these forms or combinations of them. Linear and quadric geometry is represented analytically, and non-uniform rational B-splines (*NURBS*) represent free-form geometry. ACIS is platform independent and freely available for the university research project development. All the necessary basic objects are available with functions, and user can easily integrate the basic objects to create the required CAD objects. ACIS is written in C++ and consists of a set of C++ classes (including data and member functions, or methods) and functions. As such, we can use these classes and functions to create the generic CAD modeler, which is used to generate ACIS 3D files to be inserted into the end user CAD system. When the end user sends the catalogue request key to the Web server, it process internally to find the values from the database and return as XML file to the client (end user) side. Presently, the CAD modeler is proposed in the client side and the received XML message is processed by the CAD modeler. Figure 3 illustrates the CAD modeler sequence of the system.

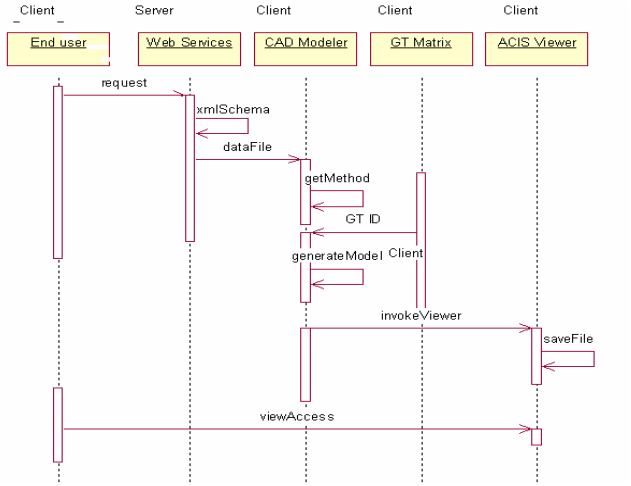


Figure 3. CAD Modeler Sequence

4. System Implementation

4.1 Development Environment

The system implementation takes into account the major aspects discussed in the previous sections. Several software modules, including Web service module development and deployment, Web server deployment, user interfaces, database system, and CAD modeler application and integration, have been developed. As mentioned before, Java technology has been used to create the Client/Server system and also the Web services. The details are as follows:

- Programming language - The Java 2 Standard Edition JDK 1.4.2, containing all the basic Java libraries and tools.
- Web Service development tool - The Java Web Services Developer Pack, version 1.3, an integrated toolkit that allows Java developers to build, test and deploy XML applications, Web Services, and Web applications.
- Web Server/Servlet - Tomcat 5.0 servlet/JSP container for Java Web Services.

4.2 System Structure

There are three layers in the system structure. The upper layer is an '*interface*' layer. This layer contains merely the interface classes for SOAP call, which represent the gateway of the main functionalities offered by this catalogue service system. It is used directly through SOAP call. The middle layer implements business logics for catalogue services which are encapsulated into one package, "Data.src". The lower layer is the database of the

application where a package, named as “Data”, is used to provide some common functionalities needed for the database manipulations.

4.3 Case Study with Injection Mold Design

Plastic injection mold design covers a very important industrial sector. Due to the pressure for faster delivery and high precision, intelligent mold design with advanced CAD tools have been widely accepted [5, 7, 22, 23]. One of the major aspects is to use standard components or modules as much as possible. This work is based on an existing in-house standard product library to explore its integration with the Web services technology. Because of the high development cost expected, this research has simplified the prototype system with emphasis on the information flow and application integration. In the prototype system, the user interface contains the following aspects (see Figure 4(a)):

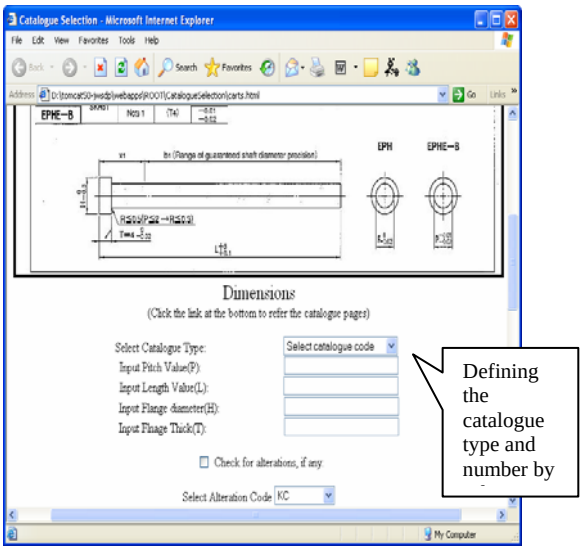
- The available product types/variants, and sizes.
- The picture of the product alongside with its master parametric dimensions.
- Some detailed information about the configurable parameters.
- Some other important information such as configurations, prices, delivery times, etc.

Figure 4(b) shows a typical part generated from the system.

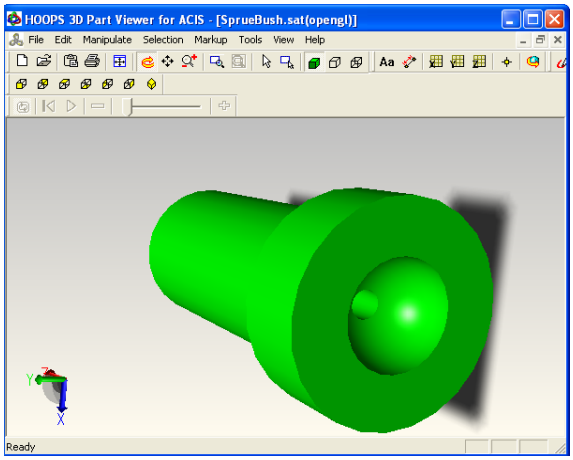
5. Conclusions

Although traditional book type catalogues are still being used in current industrial practice, and some standard product suppliers have already implemented different electronic catalogues which are either standalone or Web-based, but they have built-in drawbacks as identified in Section 2. The informatics for standard component and assembly libraries is still in the evolution and development stage. This proposed system overcomes those drawbacks concerned to the currently existing systems. The Web service technology is an entirely new concept and the application developments are still at the research stage [14]. There is no Web service enabled application for CAD systems in the industry.

The presented approach gives the framework to develop a system by using the Web service and to integrate with a CAD modeler on the platform supporting XML formats. Then catalogue providers will have full control on their catalogues and the CAD objects, thus avoiding the intermediate CAD vendor’s involvement, which in turn makes the catalogues instantly updated. Another advantage of this Web service oriented approach is that the third-party service providers can integrate many catalogues together and customers are able to compare the prices, quality, services, etc. for a particular product. This will provide great enhancement on the competitiveness and service quality of the end users, standard product providers, and potential third-party businesses.



(a) Input the catalogue values in the UI



(b) Display of CAD Object in the HOOPS Viewer

Figure 4 System Illustration

The presented work has provided only an initiative and reference architecture for the future system. Further development on this proposed system is necessary. This is because that Web service is a new technology [24] and has limited ready-to-use applications in the area of CAD and product lifecycle management so far. In addition, we observe that (1) there is pressure on the end users to follow up with the updates even though they are informed; (2) regardless the CAD model format (e.g. STEP, ACIS) that is used, deep knowledge and skills are required for the end users to extract the required data and to associate with their downstream applications.

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7. Author Biography

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