

Web Service Oriented Standard Product Library

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Abstract: Using standard components or modules is vital in product design, development and manufacturing. Current catalogues cannot meet industry requirements for collaborative engineering. Drawbacks of the current catalogues are 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 a CAD system and allows 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.

Key Words: Web Service, Collaborative Engineering, Standard Product Library, CAD, E-Catalogue.

1. Introduction

Because of globalization, new products are often developed in various countries with the increasing use of standard components or modules so as to reduce both cost and product development cycle time [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 encourages standard product vendors to release their catalogues in a more effective way, compared to the present practice. In order to meet this requirement, it is essential to have a common system—one that 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 updated in a timely manner. 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 allows catalogue vendors to update their databases at any time. Moreover, it provides services to the end users with selection choices among different catalogues.

This paper is organized as follows. Section 2 explains drawbacks of existing component / product libraries / catalogues. Section 3 introduces the proposed Web service-oriented method. Section 4 then shows that the method has been implemented successfully in a standard component library for injection mold design, and Section 5 offers conclusions.

2. Drawbacks of the Existing Approaches

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

- Manufacturing companies often accept catalogues from major vendors, so the method is not feasible for new entries and niche component providers.
- It is difficult for catalogue providers to publish and market their new products in a timely manner due to 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 a great 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 catalogue book development and distribution all over the world.

Computer-based libraries are definitely superior in these aspects [1]. As of 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 many sizes and configurations [6]. Most of them are developed for a particular CAD system [5, 7]. We call this method as “CAD system approach”, and it has the following disadvantages:

- Quite often, due to the cost of development involved, CAD vendors implement very limited standard products from different catalogues. When updating catalogue models, suppliers depend on CAD vendors or developers. Usually,

CAD vendors care only about their CAD software updates, while developers demand extra significant resources.

- Again, CAD vendors do not support the small or niche suppliers.
- A lot of non-geometric information, such as design patterns, feature configuration, ordering forms, prices, and so on, is striped off. Standard product suppliers do not have control over validation of libraries.
- Each CAD vendor develops its library on its own CAD platform, and 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.

In order to avoid the drawbacks in this method, some suppliers develop and publish their catalogues on the Web. We refer to 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 either to create their own CAD models or to depend still on CAD vendors to update their CAD system libraries.

The second type implements all of the data and CAD models with a relational database system, and interfaces with users via the Web portal. This method is flexible for 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 that can be used for their downstream application. Following, however, are 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. It is possible to provide generic objects in a neutral format like STEP files, but the end user is not willing to accept the format due to the well-known interoperability problem. In order 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.

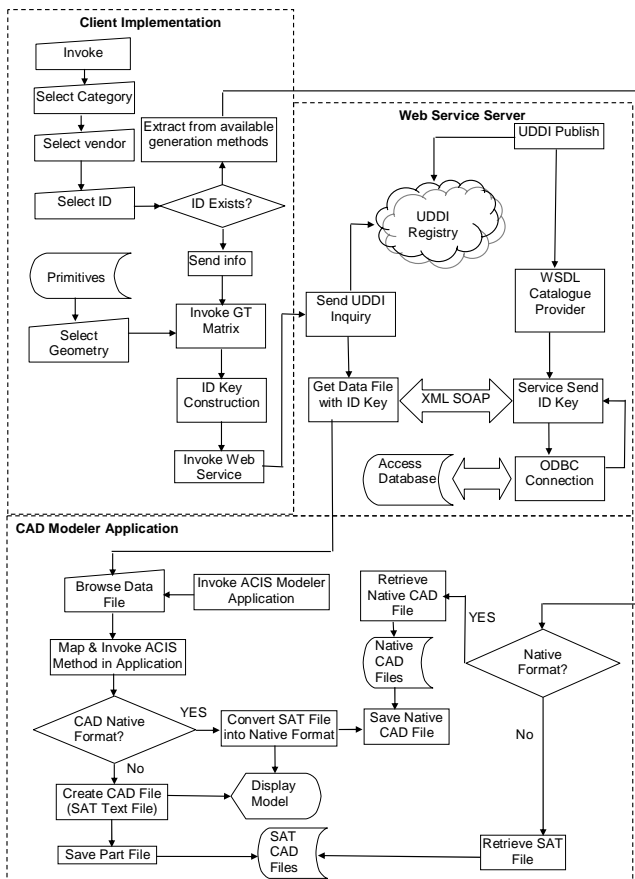


Figure 1: Web Service Enabled Catalogue System.

In conclusion, 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.

In order to address these limitations, this research studies a new technology, namely the “Web Service-Oriented” product library approach. Figure 1 shows the overall framework of the system. This method leverages some of the author’s 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 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 sections, such as with 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 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, and so on for a particular product required. Hence, this offers a great opportunity for competitiveness in cost and quality for OEMs as well as 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 during 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 follows:

- *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 discussed in further detail in the following sub-sections, respectively.

3.1 Web Server Module

For this research, the Apache Tomcat Web-server is selected-it 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 an 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.

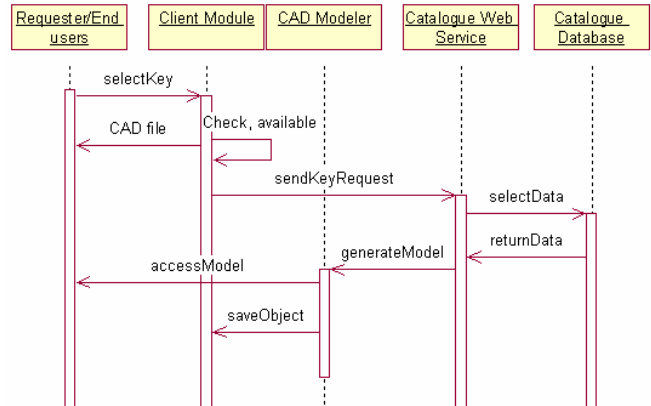


Figure 2: Process Sequence for Web Service Catalogues.

3.2 Client Implementation Module

This module generates the request code through the end user selection. Basically, all of the catalogues are generated with the reference catalogue number, which is the key element in relation to the customer ordering according to his or her 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 ongoing 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, and so on. It is flexible to deal with both dimensional and topological variations of CAD objects. For modular mechanical products, a 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 university research project development. All of the necessary basic objects are available with functions, and user can easily integrate the basic objects easily in order 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 returns 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.

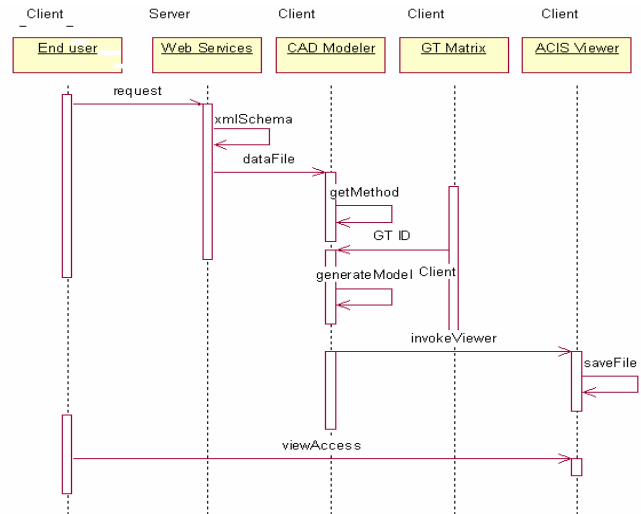


Figure 3: CAD Modeler Sequence.

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; and
- *Web Server/Servlet* - Tomcat 5.0 servlet / JSP container for Java Web Services.

4.2 System Structure

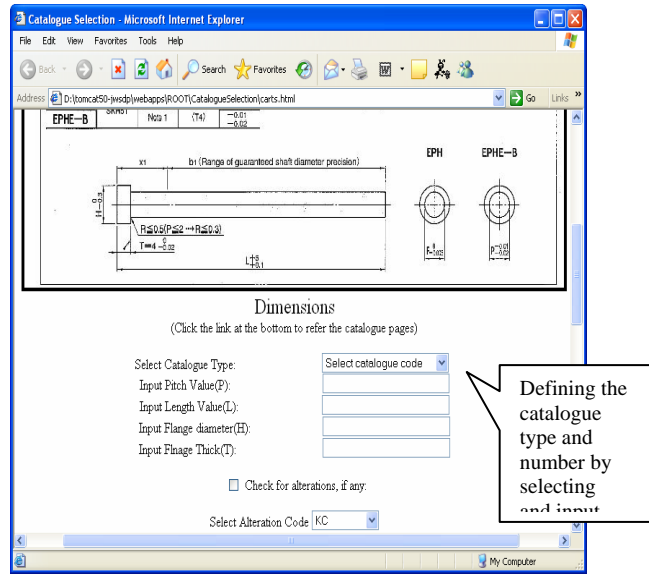
There are three layers in the system structure. The upper layer is an ‘interface’ layer. This layer contains merely the interface classes for SOAP call, which represent the gateway of the main functionalities offered by this catalogue service system. It is used directly through SOAP call. The middle layer implements business logics for catalogue services that 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

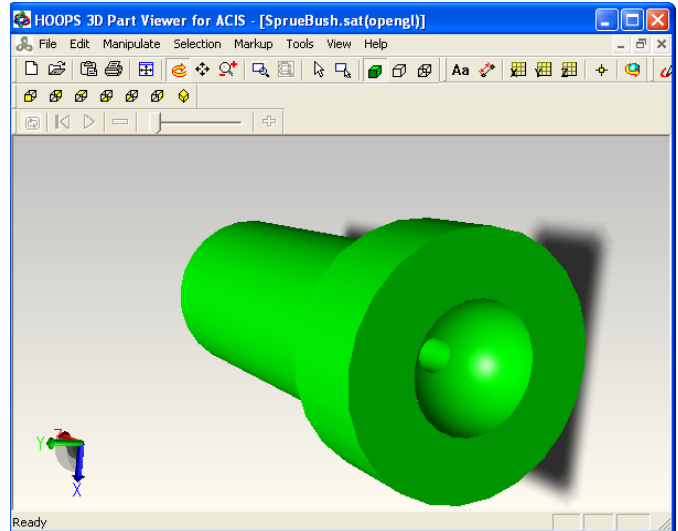
Plastic injection mold design covers quite an important industrial sector. Due to the pressure for faster delivery and high precision, intelligent mold design with advanced CAD tools have been widely accepted [5, 7, 22, 23]. One of the major aspects is to use standard components or modules as much as 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, and so on.

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



(a) Input the catalogue values in the UI



(b) Display of CAD Object in the HOOPS Viewer

Figure 4: System Illustration.

5. Conclusions

Although traditional book-type catalogues are still being used in current industrial practice, and some standard product suppliers already have implemented different electronic catalogues (either stand-alone or Web-based), 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, as they relate to existing systems. The Web service technology is an entirely new

concept and 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, and so on for a particular product. This will enhance competitiveness and service quality of the end users, standard product providers, and potential third-party businesses to a notable degree.

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 of the CAD model format (e.g. STEP, ACIS) that is used, considerable knowledge and skills are required in order for the end users to extract the required data and to associate with their downstream applications.

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Biography

Dr. Yongsheng Ma has been an Associate Professor at the school of Mechanical and Aerospace Engineering, Nanyang Technological University (NTU), Singapore, since 2000.

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