Implementation of Web Services to Enable Interoperability of Web-based Construction Products Catalogue

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Summary

This paper introduces the current development of electronic catalogues of construction products. The common system architecture of Web-based electronic products catalogues are discussed, followed by a discussion on construction products information standardization and latest distributed-systems technologies for communicating construction products information. Finally, this paper presents an implementation of Web service in e-commerce systems to enable sharing of construction products information.

1   Introduction

Construction products typically account for 40-45% of the cost of all construction work (Agapiou *et al*., 1998). It is important to ensure that construction products are procured at the right price, quality and time. On the other hand, architects require comprehensive products information for their building design works. Construction products information is needed throughout the whole life cycle of a building, including the design, construction, maintenance and demolition stages. Provision of comprehensive and updated construction products information to the construction industry practitioners is vital to the success of building project. Traditionally construction products information is available from paper-based catalogues. The advancement in computer technology make electronic products catalogues another efficient means for practitioners to acquire useful products information. The emergent of Internet and Web technologies changes the way people access electronic product catalogues. Construction products information can be ubiquitously available through Internet and can be easily accessed by people with a Web browser. However, construction products information is scattered in thousands of computers owned by different companies, and is structured in different formats. Accessing construction products information from these computers is still a time consuming and inefficient work.

Web services, a kind of distributed-systems technologies, can allow one machine to call methods on other machines via common data formats and protocols such as extensible markup language (XML) and hypertext transfer protocol (HTTP). This technology enables sharing of construction products information stored in different computers. By introducing a common standard of construction products information representation, electronic commerce (e-commerce) systems providing construction products information can utilize Web services technology to communicate with each other, making separated islands of information linked together.

The first part of this paper introduces the current development of electronic catalogues of construction products. The common system architecture of Web-based electronic products catalogues are then discussed, followed by a discussion on construction products information standardization and latest distributed-systems technologies for communicating construction products information. Finally, this paper presents an implementation of Web service in e-commerce systems to enable sharing of construction products information.

2 Electronic Catalogues of Construction Products

Electronic products catalogues are usually stored in and retrieved from two means: Compact Disk (CD) and computer. Nowadays more and more CD-based electronic products catalogues are shifted to computer-based, as the later can easily be shared by many users through networks like Internet. Electronic products catalogues shared through Internet allows customers to browse through multimedia product representations and to get relevant information concerning the product (Timm and Rosewitz 1998). It is also the reference for product selection that can assist with source selection and description of terms and conditions (Keller and Genesereth 1997). Stanoevska-Slabeva and Schmid (2000) define Internet-based electronic products catalogues as an interactive and multimedia interfaces between buyers and sellers on the Internet, which support product representation, search and classification and have interfaces to other market services such as negotiation, ordering and payment. The authors see Internet-based electronic product catalogues as an interactive front-end interface that provides classified and structured product information, and supports product searching, comparison and evaluation, and may have linkage with other e-commerce services such as bidding, ordering and payment. Web-based electronic products catalogue also utilizes Internet as the network for transmitting products information. In addition it uses Web browser as the front-end interface for accessing products information. The discussions of this paper will focus on Web-based electronic products catalogue.

2.1 Types of Construction Products Information

Products information in electronic catalogues can be classified into two types: structured and unstructured information. Structured information is stored in relational databases and can easily be offered online with available state-of-the-art databases and online merchant technologies (Lincke 1998). The form of unstructured information varies from documents to complex multimedia data structures (Ellsworth and Ellsworth 1995). For instant, construction products categories and product attributes like price, dimension, brand name, etc. are usually stored structurally in database. Product images, CAD drawings and test reports are typical example of unstructured construction products information. Besides information describing properties of the product itself, other information related to the product like user feedback, suppliers of that product, pricing and discount, etc. are also available in Web-based products catalogues. These kinds of information facilitate product evaluation and selection, and help buyers make better decision in their purchasing jobs.

2.2 Architecture of Web-based Construction Products Catalogues

Web-based applications like electronic products catalogues are multi-tier applications. Multi-tier applications divide functionality into separate tiers. These tiers can be located on the same computer, but they typically reside on separate computers. Figure 1 shows the basic structure of a three-tier Web-based application. The three tiers are client tier, middle tier and information tier.

The information tier maintains data pertaining to the application. This tier typically stores data in a relational database management system like Microsoft SQL server. Structured construction products information is stored in this tier. Products information or other related information can be stored in multiple databases, which provide the data needed for the electronic products catalogue.

The middle tier acts as an intermediary between data in the information tier and the application's client. It implements business logic, controller logic and presentation logic to control interactions between application clients and application data. The middle tier controller logic processes client requests, such as requests to view a specific type of construction product in a catalogue, and retrieves data from the database. The presentation logic then processes data from the information tier and presents the content to the client typically in the form of hypertext markup language

(HTML) documents. Business logic in the middle tier enforces business rules and ensures that data are reliable before the server application updates the database or presents data to users. Business rules dictate how clients can and cannot access application data and how applications process data. For instant construction products information in the electronic catalogue may only be available to registered members, and members cannot view information of each other. Also, before new construction product information is added to the database, it is necessary to validate the format of this information and to make sure that this information is provided by authorized users.

The client tier is the application's user interface, which is typically a Web browser like Microsoft Internet Explorer and Netscape Navigator. Users of electronic products catalogue interact directly with the application through the user interface. User interface in the form of standard HTML format is quite limited. However, with the addition of Java technology or other third party plug-ins in the Web browser, there are unlimited way of building user interface. The client tier interacts with the middle tier to make requests and to retrieve data from the information tier. It than displays to the user the data retrieved from the middle tier.
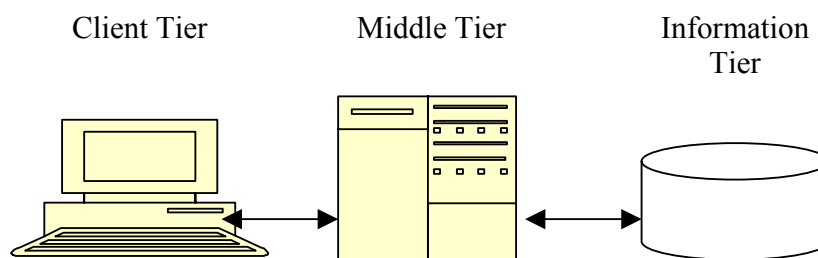
Client Tier   Middle Tier   Information Tier

Figure 1: Three-tier architecture of Web-based application.

3   Standardization of Construction Products Information

One of the keys to systems interoperability is the ability to understand meaning of the information provided by each system. Currently Web-based electronic catalogues of construction products present products information in different formats. These catalogues provide different interfaces for accessing products information and the types of products information are various in each catalogue. While establishing standardized construction products information format can facilitate buyers in searching and selecting jobs, it is important to let products information providers keep their own style of products information presentation in electronic catalogues as diversity in products information presentation is considered as an important differentiation possibility to attract customers (Keller and Genesereth 1996).

Standardization of construction products information facilitates information exchange between computers. Search engines cannot present accurate search results if the semantic of information is not standardized. Currently there are two major standards in the building and construction domain that specify the representation of construction products information. They are bcXML developed in the eConstruct project (eConstruct 2003), and ifcXML and aecXML currently under development by the International Alliance for Interoperability (IAI) in North America (IAI 2003). The eConstruct project aims to help the European building and construction industry to build faster, cheaper and better by developing new communication technology specifically tailored to the industry's need. IAI is a global standards-setting organization committed to promoting effective means of exchanging information among all software platforms and applications serving the AEC+FM community by adopting a single Building Information Model (BIM). IAI define specifications for Industry Foundation Classes (IFC) as BIM. IFC BIM are published in ifcXML and aecXML for e-

commerce and Internet purpose. IFC provides a means to encode and store information for the entire project in a model that can be shared among diverse project participants; aecXML is intended to support specific business to business transactions over the Internet.

Both of the above standards specify construction products information using XML. XML is a simple and very flexible text format derived from Standard Generalized Markup Language (SGML) (W3C 2003). XML is a portable and widely supported open technology for describing data. It is becoming the standard for storing data that is exchanged between applications. Construction products information can be described in an XML document that can be read by both human and machine. Attributes, like price, dimension and weight, of construction products can be represented structurally and hierarchically in the tags of XML document. Figure 2 shows an example of XML documents containing construction products information.

```xml
<?xml version="1.0" encoding="utf-8" ?>
<product>
    <category>
        <first>Door</first>
        <second>Wood</second>
        <third>Plain</third>
    </category>
    <dimemsion>
        <height>2</height>
        <width>1</width>
        <depth>.08</depth>
        <unit>meter</unit>
    </dimemsion>
    <weight>
        <amount>30</amount>
        <unit>kg</unit>
    </weight>
    <price>
        <amount>800</amount>
        <currency>HKD</currency>
        <unit>per unit</unit>
    </price>
</product>
```

Figure 2: An XML document showing construction products information.

XML document contains individual units of markup called elements. An element contains one or more pair of tags and data. The name of tags in the XML document of figure 2 represents product attribute. The relationship between attributes is shown by the hierarchical structure of the tags. Data inside a pair of tags is the value of a product attribute. Processing of XML documents requires a program called an XML parser. XML parser is responsible for checking an XML document's syntax and making the XML document's data available to applications. Some popular parsers include Microsoft's MSXML, the Apache Software Foundation's Xerces and IBM's XML4J. XML documents can reference optional documents that specify how the XML documents should be structured. These optional documents are called Document Type Definitions (DTDs) and Schemas. DTDs provide a means for type checking XML documents and thus confirming that elements contain the proper attributes and arrangement.

4 The Web Services Model of Interoperable Web-based Construction Product Catalogues

The use of the Web for application to application communication is becoming more and more popular. The programmatic interfaces made available for this use are referred to as Web services (W3C 2002). Web services describe a standardized way of integrating Web-based applications using open standards over an Internet protocol backbone (Webopedia 2003). The open standards

include XML, Simple Object Access Protocol (SOAP), Web Services Description Language (WSDL) and Universal Description, Discovery and Integration (UDDI). Data is tagged in XML and is transferred using SOAP over the Internet. SOAP is a platform-independent protocol that uses XML to make remote procedure calls over HTTP. The Web services available are described in WSDL and can be listed in UDDI directory for other applications to explore them. Two popular platforms for developing and deploying Web services are Microsoft ASP.Net Platform (Microsoft 2003) and Sun Java 2 Platform (Sun 2004).

To achieve interoperability between Web-based construction product catalogues, it is necessary to have a standard interface for data exchange and also a standard method of data representation. Web services and XML-based standard method of construction product representation together make Web-based construction product catalogue interoperable. Figure 3 shows the Web services model of interoperable Web-based construction product catalogues.
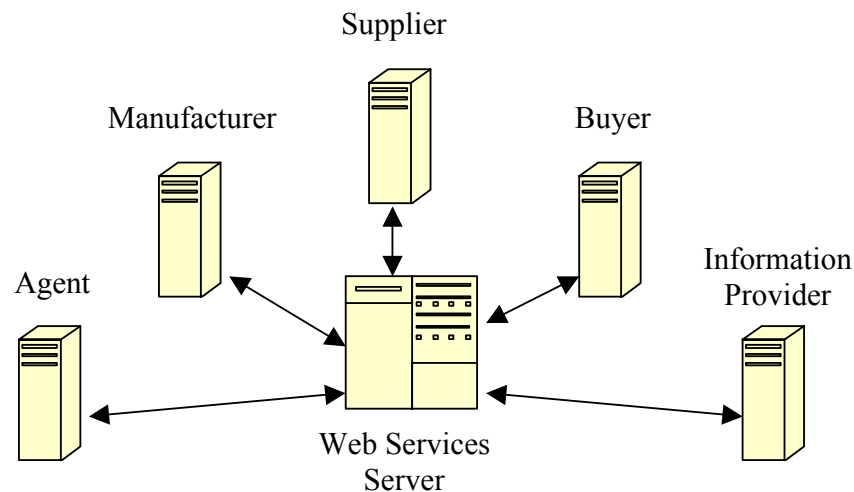

Figure 3: Web services model of interoperable Web-based construction product catalogues.

The model shown in figure 3 is an application services provider (ASP) solution. Five types of identified practitioner that will provide or retrieve information to and from Web-based construction product catalogue are agent, manufacturer, supplier, buyer and information provider. Manufacturers provide information of their products in the catalogue. Suppliers provide information of the products that they sell. Agents need to search for product that meet their client's requirement. Information providers provide products information to their subscribed users. Buyers search for products that meet their project requirement. In this Web services model, the Web services server link up these practitioners' product catalogues through common Web services interface. The server holds a standard format of products information representation. A practitioner having a Web-based products catalogue can tell the server the types of products they have and implement Web services interfaces for communication with the server. Practitioners requiring products information can link to the server and get information from other connected practitioners. The Web services server acts as a mediator to facilitate sharing of construction products information among the connected practitioners. The server maintains a list of connected practitioners and also the types of products information they provided.

The increased construction products information flow in this Web services model may alter the supply chain. Relationships between buyers, sellers and agents may change and it may create new channels of distribution. By enabling information sharing between the practitioners, buyers and sellers may operate with lower levels of ambiguity and uncertainty due to the provision of greater volumes of timely and accurate information, thereby enabling them to make decisions in a more efficient and effective way.

5   The E-Union Web Services Implementation

An implementation of Web services for enabling interoperability between Web-based construction products catalogues is done on a platform named E-Union. E-Union is designed to facilitate information sharing between e-commerce websites that trade construction products (Kong *et al* 2004). Currently E-Union is connected to two websites: a construction products e-trading website named COME (Kong *et al* 2001) and a surplus construction material trading site. Figure 4 shows the current system architecture of E-Union with the two e-trading websites.

HTTP/HTML Request & Response
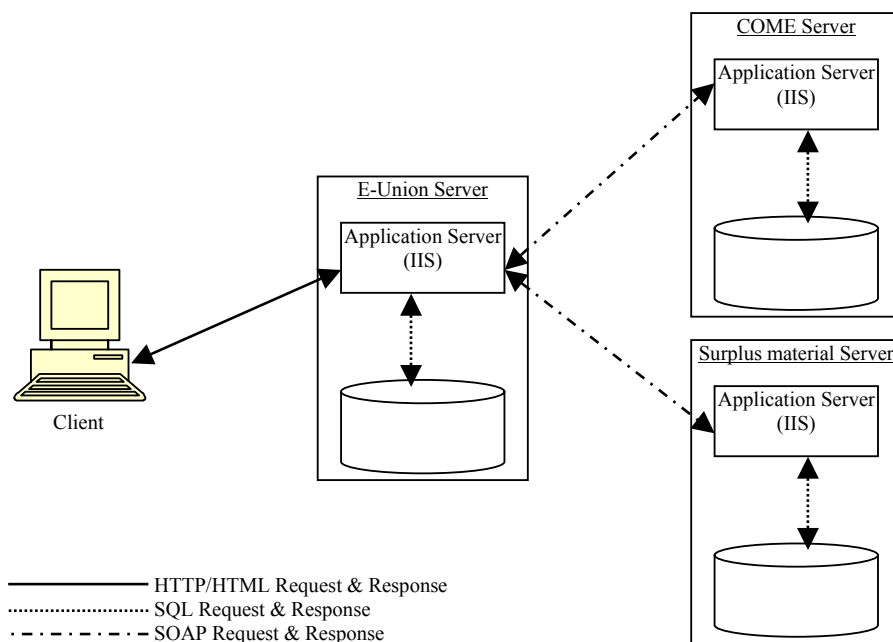SQL Request & Response
SOAP Request & Response

Figure 4: System architecture of E-Union platform.

The E-Union server and the two member websites use Microsoft Internet Information Services as application server and Microsoft SQL Server 2000 as database server. Microsoft ASP.Net framework, Microsoft SOAP and Microsoft SQLXML are installed in these servers to provide Web services. The E-Union server itself does not contain any construction products information. It allows its member to register in it and to specify which types of construction products they have. E-Union provides services to a client who wants to access product information in E-Union's member websites. A client firstly accesses the Web-based interfaces of E-Union and then sends a request for certain construction products information through HTTP/HTML. The E-Union application server receives the request and gets information from database server through SQL request and response to find out which member(s) has the required products information. It then gets the required products information from members through SOAP request and response. Figure 5 and figure 6 show some

of the Web-based interfaces of the E-Union system. Figure 5 shows the interface for member registration and figure 6 shows the display of search results.

Figure 5: The E-Union member registration interface.

Figure 6: The E-Union search result display.

6   Conclusions

The advancement in information technology has changed the way people work today. Web services as an emergent technology has the potential to change the way we share information and provide services. The increased sharing of construction products information will ultimately benefits both the buyers and sellers as buyers can be more informed and sellers can increase their market reach. The implementation of E-Union demonstrated the feasibility of providing interoperable construction products catalogues. Currently buyers can only get products information in multiple catalogues through the E-Union interfaces. To realize the Web services model of interoperable construction products catalogues proposed in this paper, it is necessary to implement more Web services in the E-Union members website so that every member can both get and provide products information through the E-Union system.

7   References

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