A Collaborative Web Service Platform for AEC Supply Chain

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Abstract: Information sharing within and across companies is crucial for an effective supply chain. For the AEC industry, however, information sharing is difficult due to the highly fragmented and temporary, project-based nature of its supply chain. As Internet access becomes ubiquitous and online information grows, the web services model has emerged as a promising approach for integrating scattered information sources and software applications to achieve interoperability. A prototype web-based platform, *SC Collaborator*, is designed to facilitate information sharing and to support collaborative communication for AEC supply chain. Using web portal technology, the web-based platform can be easily set up to integrate distributed application services and provides a single point of access for each participating partner to collaborate on a project. This paper describes the system architecture and the features of the platform. An example scenario is included to demonstrate the potential of the web-based supply chain platform in managing material delivery and facilitating online collaboration.

Key words: AEC supply chain; information sharing; online collaboration; web services model; service-oriented architecture

Introduction

Having information available as needed can significantly reduce lead-time as well as increase project accountability. Sharing of information within and across companies is crucial for an effective supply chain. Information sharing can not only add values to a supply chain but also improve the efficiency and performance of the entire chain [10, 18]. Information sharing and supply chain management pose a significant challenge to the architectural, engineering and construction (AEC) industry due to its high fragmentation and its temporary project-based nature. The US construction industry is fragmented among general contractors, subcontractors, architects, engineers, material suppliers, laborers, and developers [9]. According to a study on the US construction industry, the top eight AEC companies control less than twenty percent of the market share while by contrast the top companies in aerospace industry control over seventy-five percent of all trades within the industry [14]. As reported by Jupiter Research, "the biggest general contractor in the US has less than five percent of the market [14]." There are more companies, particularly small businesses, participating in the AEC industry market than other manufacturing industries. Information sources are scattered among the project participants, which often reside in different locations geographically and utilize different software and hardware platforms. The multi-participant nature of AEC supply chain makes it difficult to set up standards and information channels to exchange data and knowledge.

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Supply chain management tools exist to help managers to deal with project management tasks. However, most of the tools focus their applications in the manufacturing industry. These tools are not suitable for the AEC industry since they are targeted for large manufacturers and retailers with relatively stable supply chains, and they rarely include upstream design and downstream operational activities. Implementation and configuration of these tools are complex and often time-consuming. AEC supply chains are characterized by its temporary, project-based nature. That is, the supply chains change from project to project and, in most cases, cannot afford to spend much time for system configuration and deployment. In other words, an application for the AEC industry needs to be easily configured to accommodate different supply chains. Effective and flexible information sharing and service integration are important for supporting supply chain activities in the AEC industry.

The Internet has emerged as the most cost effective means of driving supply chain integration and information sharing [11]. Companies have begun to take advantage of the Internet and information technology to create a virtual supply chain where business partners can communicate and collaborate with each other [15]. The Internet can serve as the medium for information and service integration, engineering simulation, and other collaborative tasks [6, 17]. In this paper, we present a prototype collaborative system, *SC Collaborator*, for managing AEC supply chains. The system integrates distributed information sources and web applications utilizing the web services model. Web portal technology is leveraged to provide each project participant a single point of access to the integrated network of information and services. The system architecture and features of the system are discussed in this paper. An example scenario is also included to demonstrate the potential of the system to manage the information flow in AEC supply chains.

1 Web Services Model

With the rapid development of communication technologies, the Internet has become ubiquitous and instantaneously accessible. Together with the rapid growth of online information sources, the web services model is a desirable approach to connect remote software applications and information sources, utilizing well established Internet protocols and commonly used machine readable representations.

A “web service” can be described as a specific function that is delivered over the web to provide information or services to users. It can create dynamic responses and is different from conventional websites which deliver only static information. Although a wide variety of definitions exist, a typical web service can be said to have the following features: “web services are modular, self-describing applications that can be published, located and invoked from just about anywhere on the Web or a local network. The provider and the consumer of the XML web service do not have to worry about operating system, language, environment, or component model used to create or access the XML Web service, as they are based on ubiquitous and open Internet standards, such as XML, HTTP, and SMTP [4].” Web services are usually encapsulated. In other words, their implementation is not exposed to the users. Changing the implementation of one web service function does not require changes of the invoking function.

Many languages have been proposed to facilitate the development and reuse of web services. Examples include Web Services Description Language (WSDL) [3] and Flow Language (WSFL) [12], Business Process Execution Language for Web Services (BPEL4WS) [1], and Web Service Ontology based on DARPA Agent Markup Language (DAML-S) [2]. There are many research efforts on web-based service integration [5, 8], which deals with the mechanisms to invoke, terminate and orchestrate web services. Studies on the semantics of web services have also grown recently [7].

One key idea of the web services model is its implementation of the service-oriented architecture (SOA). SOA is a model in which information sources and software functionality are delivered as individual distinct service units, which are distributed over a network and combined to create business applications to solve complex problems. SOA facilitates interoperability among information sources and systems, which are converted into modular and flexible service components that can be requested through a standard protocol. The components can be reused by multiple applications or other services resided in a network. They can be updated or replaced without affecting the functionality or integrity of other independent services. Reusability enables modular system and application devel-

opment, and is essential for building a flexible system for fast changing supply chains.

2 SC Collaborator

Leveraging the web services model, we have developed a prototype web-based collaborative system, *SC Collaborator* (see Fig.1). SC Collaborator is a collaborative platform designed for supporting AEC activities and integrating loosely coupled information and services. The platform provides each participant a single point of access to the needed information and services using the web portal technology. The platform is developed using open source tools and can be installed and configured easily.

2.1 Web Portal Technology

A web portal is a web-based application that acts as a gateway to a larger system or a network of web applications. It is a useful tool to aggregate scattered, distributed information and services into a single point of access. Web portal has been commonly used as a repository of information and documents within companies or between business partners for content management [16]. There is also an increasing trend to develop and publish websites via web portals, which allow personalized settings and configurations.

Web portal is a container of multiple web portlets, which are sub-programs that encapsulate a single or a number of web applications. Portlets do not generate a complete HTML code, but only a fragment of it which is subsequently aggregated by the web portal to form a complete webpage. Portlets are contained in a web portal in order to be visible and accessible. Web portals also manage the portlet sessions and store the portlet preferences.

Fig. 1 SC Collaborator viewed in web browsers

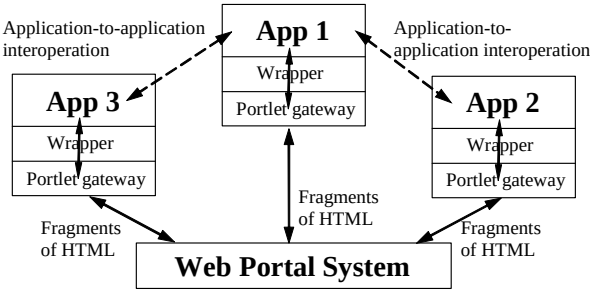

Fig. 2 Conceptual framework of web portal systems

As illustrated in Fig. 2, applications and information sources are wrapped and deployed as individual web portlets, which are web service units that a web portal system can integrate and reuse. Through the portal system, multiple applications can be accessed, related and integrated into a workflow or a supply chain. A web portal system provides the clients a single point of access to information and applications regardless of their location or storage mechanism. Clients can access to multiple systems or applications with a single authentication.

2.2 System Architecture

Fig. 3 shows the system architecture of SC Collaborator. On the server side, SC Collaborator is divided into three tiers – the web server / servlet container tier, the business implementation tier and the database tier. The servlet container tier allows clients to access the system through standard web services protocol by SOAP messaging and WSDL description, through wireless devices by Wireless Markup Language (WML), or through web browsers. The business implementation tier provides connectivity to the database, manages the sessions of the system, manages the information transaction, and performs business functions. The database tier serves as the back-end information source to support the whole platform. It stores information such as user privileges and settings, portal and portlet configurations, and page layout settings.

The business tier consists of the Plain Old Java Object (POJO) implementation core and two supporting frameworks, which are all bundled in the Liferay Portal [13]. The POJO implementation core takes the com-

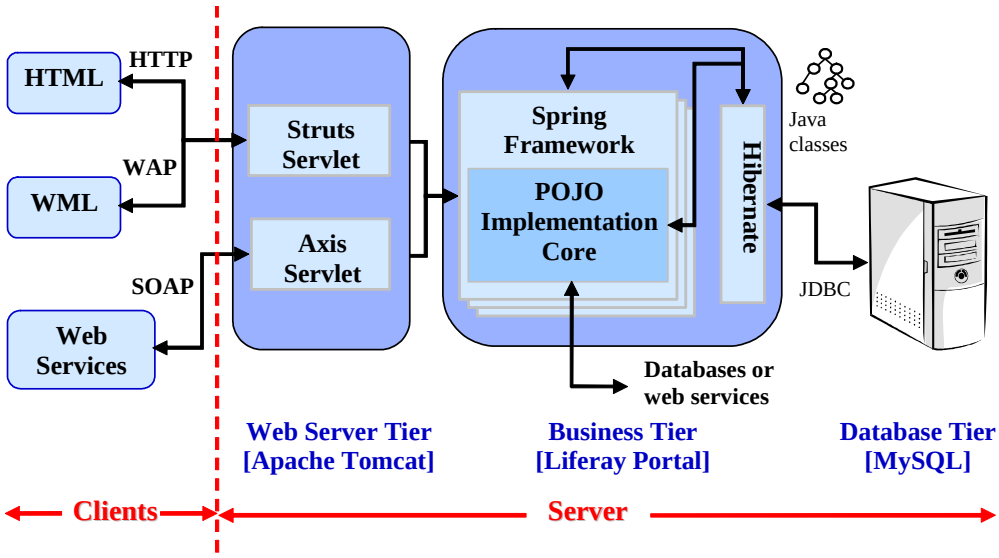

Fig. 3 System architecture of SC Collaborator

putational job and connects to other applications or web services. The core is extended with two lightweight frameworks, Hibernate and Spring. The Hibernate framework maps the objects in the relational database into Java object-oriented classes. The Spring framework wraps the POJO core and provides additional features such as messaging, session management and transaction management.

2.3 Characteristics

SC Collaborator is a web-based solution to integrate distributed information sources and engineering services and suits the needs of the multi-participant, fast changing AEC supply chains. The system provides an economical solution by adopting open source technologies, supports flexible configuration and modular development with SOA, ensures delivery of right information to the right person, and provides a unified easily accessible user interface.

2.3.1 Open Source Software

The three tiers of SC Collaborator are implemented with open source software – Apache Tomcat, Liferay Portal and MySQL. Therefore, SC Collaborator provides an economical and desirable platform for the AEC companies, which are usually medium to small in size and reluctant to invest on a system that requires frequent changes.

2.3.2 Service-Oriented Architecture (SOA)

In SC Collaborator, each web portlet encapsulates one or more web applications and acts as a web service component unit of an integrated service network. The SOA structure makes SC Collaborator flexible and scalable, and allows agile configuration and development. System developers can consider each portlet as a separate component and implement the portlet functionalities independent of the other part of the system. The separation of portlets also allows greater system flexibility and scalability. Whenever there is a change in the integrated network, only the relevant portlet services need to be added, extended, modified or removed. The system, therefore, can be quickly reconfigured for any changes in the supply chain activities. In addition, the ability to reuse the portlets saves time and effort when building a system for a new project.

2.3.3 Information Delivery

SC Collaborator is a role-based system. It can be customized so that some modules or portlets are available only to the designated roles. For example, the administrative module may be accessible by the main contractor but not the suppliers. Some modules or portlets are available for all roles in the system. However, the functionalities and the rights of access may vary among the users of different roles. For instance, in the materials management module a subcontractor can change its own procurement orders, whereas the main contractor can only view the part lists.

Although clients of the same role usually need the

same information and functionalities, they may have different working styles and preferences. The portal systems can also be personalized to provide individualized configurations, layout and preferences. In this way, SC Collaborator ensures that the right amount of information is delivered at the right time to the right person.

2.3.4 Unified, Easy-to-Access User Interface

SC Collaborator provides the clients a single point of access to information sources and applications. A single authentication of the system allows clients to gain access to multiple systems or applications with a unified user interface. This reduces the effort to manage a network of systems. While some collaborative systems require the client-side to install particular communication software in order to be connected for collaboration, the users of SC Collaborator can access the system via web browsers. The usability of the system is therefore enhanced.

3 Example Scenario

The example illustrated in Fig. 4 demonstrates the online collaboration and information flow among a general contractor, subcontractors and suppliers using SC Collaborator to manage material delivery. In this example, one of the suppliers of the MEP subcontractor has to delay the material delivery of two items. As shown in Fig. 4, the delay notice sent by the suppliers triggers a message in SC Collaborator delivered to both the general contractor and the MEP subcontractor. The general contractor provides the subcontractor two options – to change the supplier so that the schedule remains unchanged, or to request a task delay with a penalty. The subcontractor uses SC Collaborator to connect to the systems of the suppliers with partnership agreements, and checks the available alternative suppliers for the two items. The subcontractor finds that one of the items is out of stock among the partner suppliers, which means that a task delay is unavoidable. The subcontractor then makes a schedule delay for the affected task in SC Collaborator, as illustrated in Fig. 4. All the project participants obtain an updated schedule instantly to plan and revise their tasks. This example demonstrates the potential of using SC Collaborator to connect distributed web applications and services, and

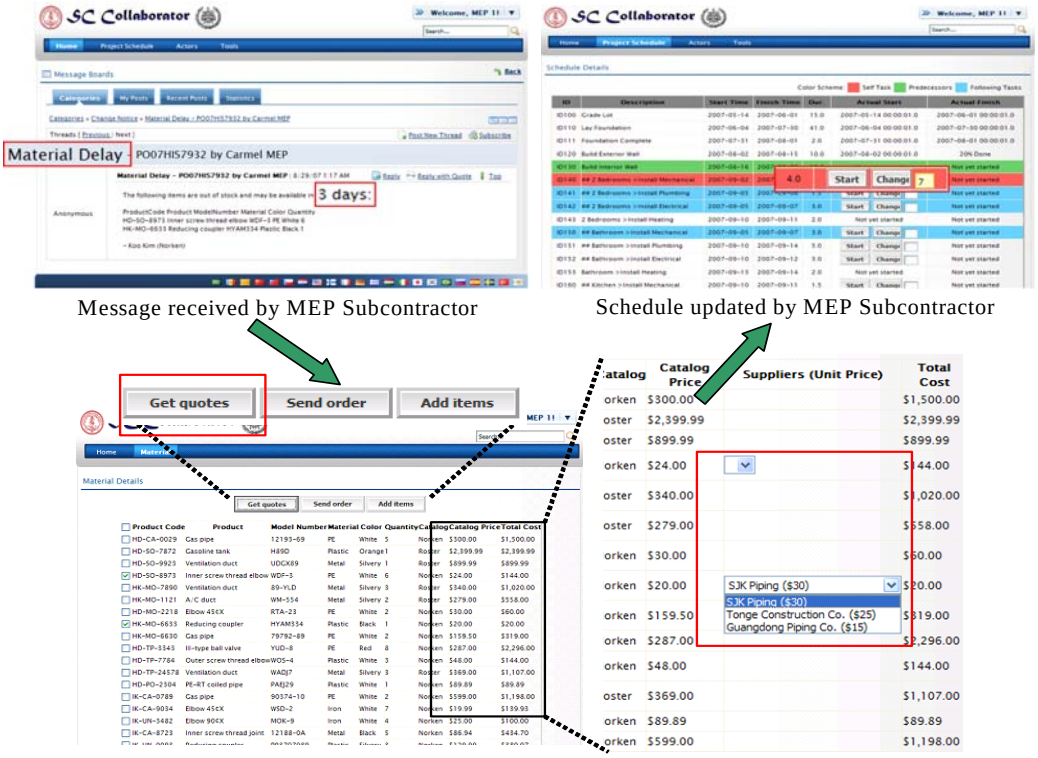

Fig. 4 Project collaboration example scenario using SC Collaborator

to act as a unified communication channel among project participants.

4 Conclusions and Future Work

Current supply chain tools are mainly targeted for the manufacturing industry and are not suitable for managing the highly fragmented, project-based AEC supply chains. With the rapid development of Internet technologies, the web services model emerges as a promising approach to integrate loosely coupled information and applications. With the SOA, the web services model provides a flexible and modular solution for AEC supply chain integration and collaboration.

In this paper, we present SC Collaborator, a prototype web-based portal platform designed to facilitate information sharing and support collaborative communication among project partners in AEC supply chain. The platform leverages open source software tools, and enables an easily configurable portal system. For each participant, the web portal provides a single point of access of the information. The illustrative example shows the potential of using SC Collaborator for managing material delivery. Other complex modules such as scheduling, organization and management of material resources are being developed to extend the functionalities and usability of the platform.

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