E-Supply Chain Orchestration Using Web Service Technologies: A Case Using BPEL4WS

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ABSTRACT

The world today is witnessing a growing interest in conducting supply chain business processes electronically. Different supporting technologies are emerging, and many are already available on the market.. The adoption of these technologies is hampered by the fact that organizations demand that their data and inner business processes remain hidden. Recent research and innovations have shown that Service Oriented Architectures (SOA) and Web Services can address the major issues encountered in complex supply chains. One of the largely unsolved issues is the orchestration of the variety of Web Services in the supply chain. This paper presents an investigation on orchestration of supply chain business processes using the Business Process Execution Language (BPEL). A fictitious but realistic case study was used to demonstrate and test the orchestration of an end-to-end supply chain though BPEL for Web Services (BPEL4WS).

INTRODUCTION

Trends indicate that one of the major 'means of survival' organizations use in the current business era, is creating alliances with partners so as to form business networks (Hengst et al, 2001). As a result, operational business processes tend not to be self-contained within an organization. They have to include external partner processes that have a limited visibility. This increases the difficulty for decision makers to understand and re-design the operational processes in the business network. In addition, the dynamic nature of the business network, e.g. a changing number or types of partners, or an involvement in several networks, increases the difficulty and complexity. Unlike previous approaches and technologies, the emerging Service Oriented Architecture (SOA) and Web Service technology significantly decreases the difficulty decision makers face, by addressing key business network issues such as interoperability, scalability, heterogeneity, and decoupling of information systems. Previous component-based middleware and web technologies have proved to be insufficient for the integration of business processes and applications at inter-organizational level (Stal, 2002). Integration of different data models, workflow engines, or business rules are some of the issues.   Web-services technology has shown to contribute to the solution of the mentioned challenges. Web services are self-contained, web-enabled applications capable not only of performing business activities on their own, but also possessing the ability to engage other web services in order to complete higher-order business transactions (Yang, 2003). Orchestration specifications and technologies of web services enable loosely coupled business processes and applications with much less effort compared to previous technologies. Therefore, it is the aim of this paper to demonstrate the feasibility and applicability of orchestration supported by the Business Process Execution Language (BPEL) within a case study.

BACKGROUND

Different middleware technologies have been researched and applied to enhance and support the supply chain business processes operations (Serian, 2002; Linthicum, 1999). CORBA, RMI, EDI, and RPC are just a few of the examples. Though these technologies were used for integration purposes, they don't address interoperability issues that are key in business networks consisting of several partners each using different type of applications and information systems infrastructures (Stal, 2002). SOA and web service technology promises to solve these problems (Rhody 2002). The technology facilitates interactions and sharing of information in a heterogeneous environment. Supply chain process partners need to share and access information like stock levels and inventory. Web services can 'glue together' applications running on two different platforms, enable database information to be accessible to others, and enable internal applications to be made available over the Internet (Kreger, 2003).

Papazoglou et al (2003) stress the importance of SOA and web services with regards to business processes like supply chains. They covered the issue of coordination, monitoring, conformance, and quality of service compositions. Meredith et al. (2003) point out how contracts and trust can be reached between partners using web service for their business processes.

Various architectures for the technology lay out and their corresponding programming languages have been researched. Current architectures have gone further covering quality of services, security, management, business level agreements, service level agreement, etc, (Kreger, 2003). Researchers have also focused on standardizing protocols, languages, models, etc., for proper use of the technology in the area of coordination. Curbera et al (2003) point out the need of web service technology in business processes and the standards that these business processes should follow to efficiently utilize the web service technology. They focus on business-to-business and enterprises applications integrations. They further mention that XML is becoming the standard interoperable programming language and consequently SOAP, UDDI, WSDL, and BPEL4WS have deployed the language.

With these developments towards standardization, companies are investing to see the technology working. IBM and Microsoft work concurrently on making the business process execution language (BPEL) and its supporting tools popular and standard (IBM, 2001). Supply chain management systems are technologies that are also used for business process integration. Though this technologies are already used widely, their main focus is not in process orchestration and automation; instead on integration of ERPs and other information systems of supply chain partners. This gives web services and particularly web-service BPEL a unique position in addressing automation and orchestration business processes in business networks.

SOA AND WEB SERVICES

A Service Oriented Architecture (SOA) is essentially an architecture which describes the communication pattern between services communicating with each other, functions and their operations (Papazoglou et al, 2003). These architectures provide the ability to register, discover, and use services, where the architecture is dynamic in nature (O'Toole, 2003).

In the perspective of SOA a service is a function that is well defined, self-contained, and does not depend on the context or state of other services. SOA do not have any specific technology or a description language. Before, services were conducted and worked only on the environment of the origin programming languages. SOA defines how two computing entities interact in such a way that it enables one entity to perform a unit of work on behalf of another entity. The unit of work is referred to as a service, and the service interactions are defined using a description language. Each interaction is self-contained and loosely coupled, so that each interaction is independent of any other interaction.

Web service technology facilitates collaboration between services and their orchestration and in addition defines how to describe these services, the operations and their flows. It uses a loosely coupled integration model that allows flexible integration of heterogeneous systems in a variety of domains including business-to-business, business to customer and enterprise application integration (IBM, 2001). Web service technology is an Internet technology, which allows applications based on it to communicate with other applications to offer business data or functional services programmatically (Jin, et al, 2002). As a web based technology, web service technology includes all the network layers, but on top various authors have added specific layers that make uniquely suitable for facilitating business processes. These layers include a process layer, a description layer and a messages layer, etc., (Curbera, 2003). Martin (2003) described further the additional layers to Curbera relating to the technology components and functions, such as presentation, process flow, transaction, discovery, description, messaging and transport. Furthermore, Kreger (2003) added business- and service-level agreements as technology components.

This paper focuses on orchestration of a supply chain case. *Orchestration* describes how web services can interact with each other at the message level, including the business logic and execution order of the interactions (Peltz, 2003). These interactions may span applications and/or organizations, and result in a long lived, transactional, multi-step process model. Another aspect is *choreography* which tracks the sequence of messages that may involve multiple parties and multiple sources, including customers, suppliers, and partners (Peltz, 2003). Choreography is typically associated with the public message exchanges that occur between multiple web services. In this paper orchestration refers to both aspects.

With these aspects, two layers will be described further. The description layer uses a language called web service description language (WSDL), and its function is to provide a grammatical description of a service given at one point in the network of web service based business processes. The Process flow layer provides the orchestration of activities to be performed within a node and between nodes in the network. Process flow layer has several modeling languages are available including Business Process Execution language (BPEL), Business Process Markup Language (BPML), Web Service Choreography Interface (WSCI), extensible Language (X-LANG), Web Service Flow Language (WSFL), etc. In section 5 we will present why we selected BPEL.

DESIGN OF WEB SERVICE BASED E-SUPPLY CHAIN

A realistic but fictitious case was used in the orchestration processes. The case is about the Faplin Company. The case has been based on the WS-I organization's supply chain case. In this section we present this case, and the business processes.

The Faplin Case

Faplin Electronic Supplies is an electronics retailer that has around 80 stores in several countries. The company sells over 12,000 electronics products ranging from resistors and communication components to computers and telecoms accessories. The company already has a transactional website, which is regularly used by thousands of customers.

Due to the growing trend of integrating information systems of supply chain, Faplin considered to extend its website and use the emerging Web Service technologies to connect with its upstream and downstream partners. Faplin is convinced that by doing these the company can increase its performance and customer service level. For the initial pilot case study, it considered integration with its three main warehousing partners: Warehouse 1, Warehouse 2, and Warehouse 3. It also considered incorporating its three main electronics suppliers: Manufacturer 1, Manufacturer 2, and Manufacturer 3. Although, these suppliers produce various types of electronics products, only three product types with specific model are considered for the pilot case study: TV, DVD, and Video Camera.

Process Demarcation

For the study we considered three main business processes namely: *Catalog access*, *Purchase Goods* and *Replenish stock*. Catalog access process involves customers sending a request to Faplin and getting the response consisting list of items available.

Purchase good involves two sub-processes: (1) the *ordering process* where a customer sends an order to Faplin and later receives the response for the order and (2) the *Source Goods* process where Faplin finds the suitable warehouse to fulfill the available order. As an example of UML, figure 1 shows the UML diagram of the purchase good process.

The *Replenish stock* process involves interactions for three partners Faplin, Manufacturers and warehouses. The process aims to control the stock level by providing updates and handling the ordering of new products from the respective manufacturer to respective warehouse. The UML sequence diagram for this process looks similar to the purchase good process presented in Figure 1.

IMPLEMENTATION OF A WEB SERVICE BASED E-SUPPLY CHAIN

The business case shows that there are several interactions between several partners in the e-supply chain business processes. The implementation focused on supporting these interactions. The implementation considered two important aspects necessary for accessing and using the web service based system for providing/getting the services. These are service description and process orchestration.

To describe the interfaces of the services, we used Web Service Description Language (WSDL). For the whole supply chain, 19 services were defined using WSDL.

The business processes that make use of these web services were described and implemented in Business Process Execution Language (BPEL). Each business process has its flow formally described in BPEL. The reasons for selecting BPEL include:

- Support modeling of numerous process patterns (van der Aalst et al, 2003)
- High interoperability
- SOA complaint
- De facto standard for B2B orchestration

The specific tool used was Collaxa orchestrator, now called Oracle Process Manager.

The orchestration as implemented, assumed Faplin as the hub of interactions between all partners. The architecture behind the implementation is shown in Figure 2. For example, the customer sending an order, using the web portal, initiates the interaction of the Purchase good process. The order is received at Faplin and the interactions continue further to the warehouses until the order is fulfilled or a failure response returned.

BPEL is an XML based language. XML can only support data transfer in the network environment but cannot store data or handle variables.

Figure 1. Purchase Good Business Process
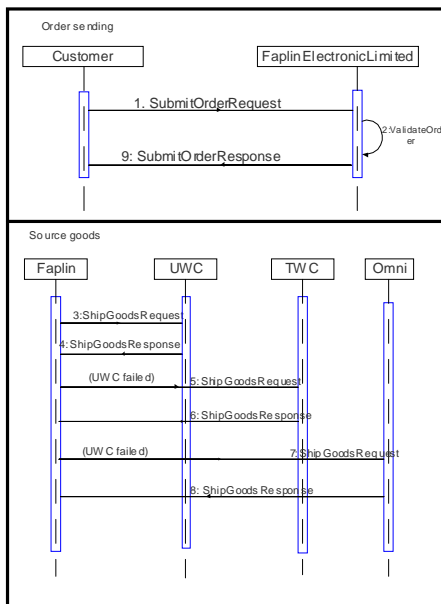
The facts that the business partners need to store data and even handle changing data such as stock levels and inventory levels were handled by developing a database system. Web service technology provides an interface that can be used to access information from applications developed with different technologies and platforms. Therefore, we implemented database using MySQL to enable handling such variables. Figure 3 shows as an example the implementation layout for the Replenish stock business process that involved access to various services from different partners, as well as databases.

The deployment of the services for accessing on the web uses Collaxa BPEL server software. However, the user interface provided by this software gives right to any user to access all files. Enhancing system security, we developed separate user interfaces. The user interfaces were required to be dynamic so as to enable users to send information or data to the system or in real business to the dealer. Due to the dynamic nature of the web pages, a programming language was required that allows part of the page contents to be dynamic, while the other part remains static. Also the platform independency was another criterion to choose the programming language. Servlets and JSP were the options that could be used to develop such user interface. However, most of the contents of the web site were static and very few were changing; only the data input fields. JSP is more suitable when most of the content on the page is static and few are dynamic, as opposite to the servlets. JSP was selected since the most of the content on the web pages were required to be static.
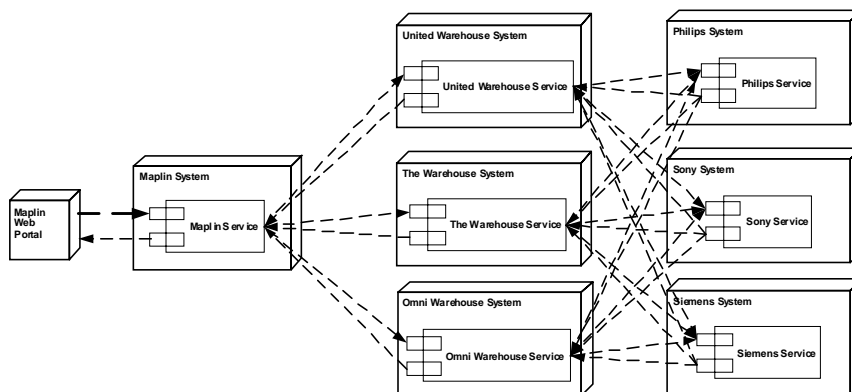
Three kinds of user interfaces were implemented (1) for reading information like catalog, (2) for sending request like order (figure 3), and (3) for authorization like Faplin internal process.

TESTING AND DEMONSTRATION
The orchestrated end-to-end e-supply chain was demonstrated to students taking an E-Business course, a course provided to the Master of Science students in Delft University of Technology. The students were able to use the orchestrated system using the web based user interface developed, to conduct their supply chain game exercise, in a matter of a few hours (2-3 hrs). Among them, other students assumed the role of a customer, and others the role of employees of the company.

An interview with some students revealed that the system was easier to understand and use, and also the system was transparent and thus, the assumed customers could track the progress of their orders. During the demonstration to the students, some crucial tests were made on the system, including expire time for an order and feedback upon such event. This test worked successful.

Besides using the case for demonstrating purposes, the case also is used to conduct research on bottom up simulation model construction from the web-service based process orchestration. Such simulation models can help evaluating and redesigning the structure of the business processes orchestrated by web services.

DISCUSSION AND CONCLUSIONS
Web service technology is a new emerging technology. As technology enters in market it usually faces several challenges. This applies for web service technology as well. The adoptions in the market, the realization of users' demands, and its usability to people with no adequate knowledge of computer science are the crucial challenges. Related to the adoption and realization of use is the performance measurements, evaluation and potential improvements.

In this paper we presented an orchestration case study modeled it using BPEL. The demonstration shows that introducing BPEL requires re-engineering of business processes and provides good experimentation possibilities.

Still lacking are theories and methods on how performance of processes facilitated or running using web service can be measured or evaluated. This is a real challenge that needs to get attention from researchers. On the market side, real cases and experiments that focus on real orchestration of processes are still lacking. More implementations have to be done to realize this.

Further research needs to be done on several areas regarding the future of web service. One of them is performance realization, measurement and evaluation. Parameters such as quality of service need to be defined and put forward to measure processes and tools performance.

Figure 2. The Architecture of the System

Figure 3. Replenish Stock Business Process, BPEL Implementation and User Interface of Purchase Process
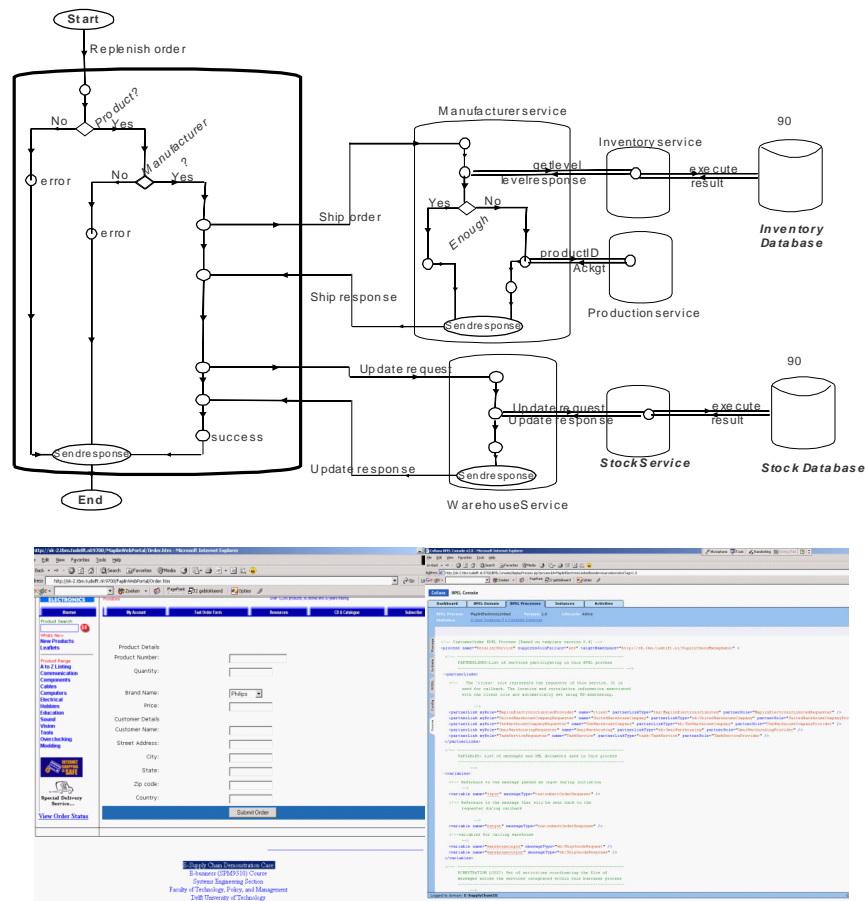
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