Web Services Composition for Process Management in E-Business

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ABSTRACT:

Business process management (BPM) includes the capability to discover, design, deploy, execute, interact with, operate, optimize, and analyze business processes. It is critical for businesses in the current intensive and competitive market. Traditional BPM has problems in interoperability, agility, and flexibility. This research investigates the role of Web services in process management. Web services are loosely coupled, reusable software components that semantically encapsulate discrete functionality. They provide a distributed computing technology for publishing, discovering, and consuming business services on the Internet or intranet using standard XML protocols and formats. Web services provide a way to empower business users to specify complex business functionality in a clear, building-block fashion that can be quickly modified. The paper presents the importance and benefits of using Web services for process management in e-Business. It also provides insights into various technical issues through the introduction to a Web services-oriented architecture for process management, which is exemplified using a prototype e-Procurement system.

Keywords: Web services, E-Business, Process management, Interoperability

1. INTRODUCTION

The advances of Internet technology have an increasing effect on the way we do business in the current knowledge- and network-based economy. The Census Bureau of the Department of Commerce announced on May 23, 2003 that U.S. retail e-commerce sales for

the first quarter of 2003 was $11.921 billion, an increase of 25.9 percent from the first quarter of 2002. Senior IT executives have identified "connecting to customer, suppliers and/or partners electronically" as the top ranked global management issue [11].

Business processes are critical components of almost all systems that support enterprise-level and business-critical activities. In any large business, there may be hundreds of business processes that need to be managed and integrated with new systems in an effective way. **Business process management (BPM)** is about taking control of processes all the way to the customer. It is the capability to discover, design, deploy, execute, interact with, operate, optimize and analyze processes. BPM systems aim to integrate systems, automate routine activities, manage all phases of processes, deploy process seamlessly, and provide end-to-end visibility and control.

Today, most companies are focusing on how to improve BPM in order to increase productivity, reduce cost, and seek reliable partnerships in order to compete in the intensive e-Business market. There are several features and trends in the current BPM: routine activities are automated by computers for higher speed and reliability; business processes and services are extended across different organizations; business processes need the agility to be able to quickly adapt to customers' needs and market conditions, which includes incorporating new customers, partners, or suppliers used in processes; and business functions are desired to be readily shareable at a small granularity level. Business collaboration is occurring in planning, designing, manufacturing, and service. This form of collaboration, called "collaborative commerce," integrates business processes between partners through sharing information and services electronically. It allows companies to maintain better relationships with their trading partners through automating their cross-enterprise process

logic, rules, and workflow. As a result, one of the key challenges for current businesses is how to effectively and efficiently integrate inter- and intra-enterprise applications. A study from IBM found that 85% of all e-Business infrastructures are some form of evolution, mutation, or integration of existing systems, and 90% cost of the IT budget is related to integration, software, and staffing [3]. However, existing methods for creation and management of business processes are not designed to interact with other processes or applications that go beyond organizational boundaries [11]. Traditionally, the development of business applications usually adopts an "independent" solution. Most software development based on object models such as Microsoft's Component Object Model (COM), CORBA (**C**ommon **O**bject **R**equest **B**roker **A**rchitecture), and Java Remote Method Invocation (RMI) is platform or programming language dependent. For example, COM-based applications can only work on the Windows platform. RMI requires an object running on a Java Virtual Machine (VM). Although CORBA supports multi-language and multi-platform applications, it requires both ends of interaction to be compatible with Object Request Broker. Therefore, developing and using standards to facilitate communications among heterogeneous systems is the most promising approach to facilitating e-business integration.

By using the Internet as the primary platform for communication, interoperability, and integration, information systems are playing an increasingly important role in providing businesses competitive advantages [13]. Businesses rely on the Internet and other information technology to manage business processes and make them transparent, flexible, and capable of integrating systems across all kinds of business and technology barriers. In recent years, XML (Extensible Markup Language) technologies, particularly Web services, have begun to have a profound effect on the way e-business applications are developed and

the way in which sophisticated processes are designed, implemented, and managed. Web services are referred to as loosely coupled, reusable software components that semantically encapsulate discrete functionality, and are distributed and programmatically accessible over standard Internet protocols. They provide a distributed computing technology for publishing, discovering, and consuming business services on the Internet using standard XML protocols and formats, which makes Web services an ideal candidate for dynamic and flexible e-Business process management because of their independence of platform, programming language, and vendor. As a result, Web services are emerging as the preferred architecture for integrating services across the boundaries of e-business companies and exposing application capabilities as reusable services. This paper presents the importance and benefits of using Web services for process management in the e-Business, and introduces a number of Web services standards to which can be applied. It provides insights into various technical issues through the introduction to a Web services-oriented architecture for process management, which is exemplified using a prototype e-Procurement system. Finally, several commercial Web-services-enabled BPM systems are introduced.

2. BUSINESS PROCESS MANAGEMENT (BPM)

According to the Workflow Management Coalition (WfMC), **business processes** are "a set of one or more linked procedures or activities that collectively realize a business objective or policy goal, normally within the context of an organizational structure defining functional roles and relationships [19]". A business process can be a routine process pre-defined as a procedure, a planned process defined at its beginning and changed, if necessary, during its execution, an evolutionary process, or a composition of the above ones [15]. It generally

consists of many activities, including automated (capable of workflow management) and/or manual activities, which are logically related in terms of their contribution to the overall realization of the business process.

Almost all modern enterprises include both internal and external processes. A toy manufacturer, for example, needs to analyze the market demands, make a production plan, assign appropriate personnel, monitor inventory, and so on (internal process management). In addition, it may also need to find qualified raw material suppliers and arrange product delivery with shipping companies (external process management).

Business process management includes the ability to discover, design, deploy, execute, interact with, operate, optimize and analyze processes, and more importantly, to do it at the level of business design, not technical implementation [15]. *Interaction* means allowing humans to interact with automated and manual processes. A BPM system should allow flexible and dynamic interactions among processes and/or activities. BPM is top-down and model driven — process models can be composed or decomposed, and process design is independent of technical implementation. This approach is often used in conjunction with bottom-up integration and aggregation of Web services [15].

Technology has not been able to cope with the dynamics, agility, and transparency of business processes until now. As the need of meeting increasing customer and business partner expectations for real-time information and services continues to rise, it is inevitable for e-Business companies to link a variety of services and integrate disparate systems to improve productivity, efficiency, and ultimately, customer satisfaction. The enterprise application integration (EAI) solution, for example, can be linked to the needs for seamless sharing and exchange of data between enterprise data warehouses, CRM (Customer

Relationship Management), SCM (Supply Chain Management), and other important internal systems within the company. Software for business process management has been available for years and products can be classified into two categories: workflow management and application integration. Those products attempt to coordinate and control the interaction of people and processes, and/or to eliminate or minimize human intervention in business processes through automating the flow of data and activities among applications.

In the past decade, workflow technology has been the most important software technology that supports and automates business processes [13]. According to the WfMC, **workflow** is "the automation of a business process, in whole or part, during which documents, information, or tasks are passed from one participant to another for action according to a set of procedural rules [19]." An example of workflow in e-Commerce is purchasing a new piece of furniture. This workflow may include steps such as selection of furniture features, placement of an order, delivery date determination, confirmation of order, manufacturing, and final payment and delivery. It consists of several sub-workflows. For example, manufacturing may involve ordering raw material, carpentry, finishing, assembly, inspection, and so on. A **workflow management system** (WfMS) "defines, creates and manages the execution of workflows through the use of software, running on one or more workflow engines, which is able to interpret the process definition, interact with workflow participants and, where required, invoke the use of IT tools and applications [19]".

In business process re-engineering (BPR) [4], the rapid change of business processes is facilitated through the use of workflow management technology that separates the construction of the flow model from the construction of individual activity implementations, which provides a competitive advantage to a company. The architecture of workflow

management systems has moved from mainframes to client-server architectures, and more recently to the Web [16]. The benefits of Web-based workflow management include: 1) saving time and money by automating business processes through the Web; 2) empowering employees, customers, partners, and vendors to participate in the workflow processes over the Internet or intranet; 3) accommodating business needs with flexible workflow design; 4) easily integrating with other applications using XML technology; 5) accessing workflow from nearly anywhere and using nearly any platform, including wireless devices such as cell phones and PDAs. While workflow management tools have benefited from using XML technology, the platforms for integrating applications and automating business processes have been the most profoundly affected [2].

There are several limitations and challenges of current workflow management systems, which hinder the advancement and user acceptance of systems. The first and the most critical one is the integration of inter-organizational workflow systems. Organizations may develop workflow systems in different programming languages and run them on different platforms. Within any workflow system, the sub-processes of a process may not support adequate interoperability. The problem can get further exacerbated when two business partners use different workflow models [1]. The second challenge is their ability to respond to evolutionary changes effectively, which range from modifications of processes to completely re-construct processes in the workflow. Third, many workflow software offered today are very restrictive and inflexible. Due to their relative independence, business processes can be highly dynamic – neither processes nor possible interactions are predefined. A process may be dynamically constructed under a certain situation. In other words, it is constructed on the fly in order to meet a specific customer demand. A new trend in B2B

commerce is to enable a business to dynamically connect arbitrarily complex services provided by different vendors over the Internet in order to create a new service. This kind of on-the-fly service composition relies heavily on the ability to quickly connect multiple workflows. It is difficult to implement it in workflow systems because it requires complicated coordination among various vendors based on exchange of data and process information. In order to enable interoperability, it is important that vendors agree on basic common standards. Fourth, the lack of real standards combined with a large number of vendors make customers reluctant to invest in workflow products [13].

In order to address the issues of interoperability between workflow systems, WfMC has proposed the Wf-XML binding standard by taking advantage of XML standards. Wf-XML provides a structured and well-formed XML message structure to define the functionality required to achieve interoperability among workflow systems independent of underlying transport mechanism. On December 10, 2002, the Workflow Management Coalition announced the release of its Workflow Standard *XML Process Definition Language - XPDL 1.0*. XPDL "provides a framework for implementing business process management and workflow engines, and for designing, analyzing, and exchanging business processes." One of the key elements of the XPDL is its extensibility to handle information used by a variety of tools. The specification is intended for use by software vendors, system integrators, consultants and any other individuals or organizations concerned with the design, implementation, and analysis of business process management systems.

With the evolution of the Internet technology in e-Business, the focus has been shifting from the creation of tangible goods to the flow of information through the value chain, which is critical to a firm's business processes [1]. Consequently, it has triggered great

interest in methods to provide dynamic and flexible online services to businesses. Today, Web services have been emerging as a promising solution to process management and workflow interoperability. META Group predicts that by 2005, standards and platforms will have matured sufficiently to enable broad Web services based B2B collaboration [14]. Web services empower enterprises all over the globe to be able to transform the way they manage transactions and processes over the Internet.

3. WEB SERVICES

A Web service, defined by the World Wide Web Consortium (W3C), is a software system identified by a URI, whose public interfaces and bindings are defined and described using XML. Gartner (http://www3.gartner.com) defines Web services as "... a custom end-to-end application that interoperates with other commercial and custom software through a family of XML interfaces to perform useful business functions." The term "loosely coupled" implies that Web services are independent of any programming language, location, platform, and object model. A Web service has a standardized access protocol, and can be updated without affecting other parts of the application. It is a stack of emerging standards that describe service-oriented, component-based application architecture.

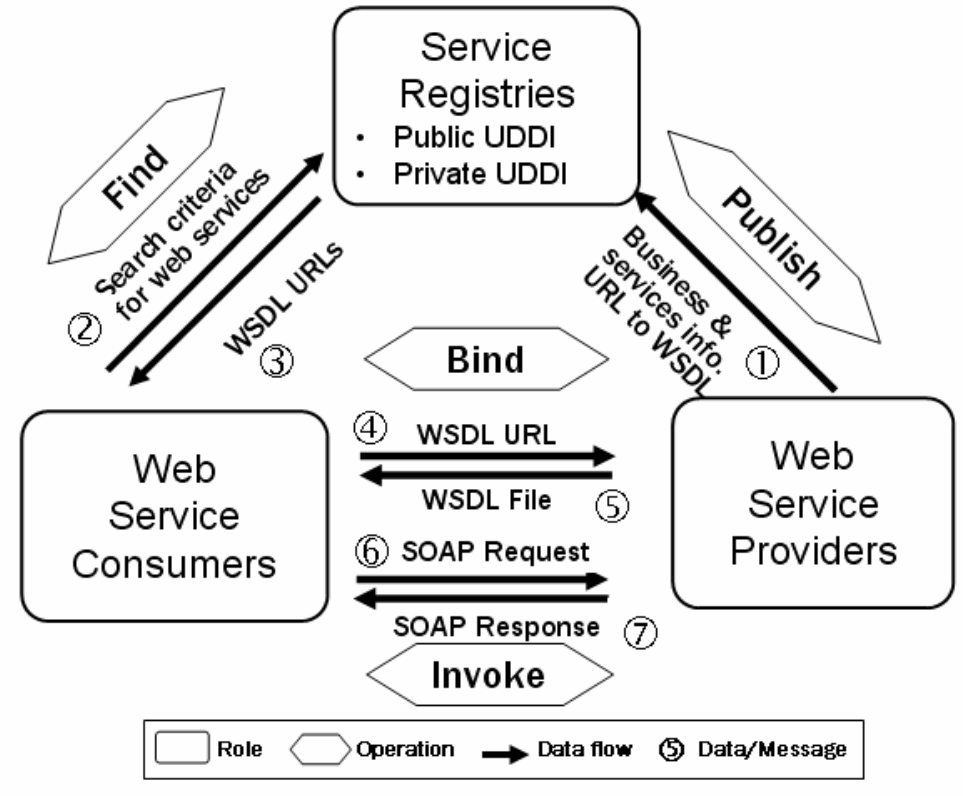

Figure 1. The Service-Oriented Web service Architecture

Web services are a set of standards to form a service-oriented architecture (SOA), as depicted in Figure 1. This architecture models the interaction between three roles: the Web service provider, service consumer, and service registries. The interactions involve service publishing, finding, and binding operations. Interfaces to a Web service implementation can be described by WSDL (Web Service Definition Language), enabling one to separate the description of the abstract functionality offered by a service from concrete details such as "how" that functionality is offered. A WSDL document describes Web services in an XML format, starting with the messages exchanged between the service consumer and provider. The messages themselves are described abstractly and bound to a concrete network protocol and message format. WSDL defines six types of description component about a service: type description, message description, portType description, serviceType description, binding

description, and service description. A Web service provider can publish a Web service defined by WSDL to a service registry such as UDDI (Universal Description, Discovery and Integration). UDDI is the building block that enables businesses to quickly, easily, and dynamically find and interact with one another. It can be considered as a "meta service" for locating Web services by enabling queries against rich metadata of Web services stored in the UDDI registry. A UDDI registry, either for use in the public domain (i.e., a public UDDI) or behind a firewall (i.e., a private UDDI), offers a standard mechanism for registering and discovering Web services. It contains three kinds of information, described in terms of telephone directories: white pages (including contact information of a business such as the name, address, and telephone number), yellow pages (including information that categorizes businesses), and green pages (including technical information about Web services). After the service consumer initiates a search for services based on a general keyword, UDDI will find providers of relevant Web services or implementation of Web services based on a common abstract interface definition.

Technically, a Web service provider implements a collection of port types covering the required services. These services are made available via corresponding ports. The service consumer has to provide a port type with operations that work as “stubs”, which communicate with the ports on the business partner side [6]. A Web service requester (e.g., a business company) can search and retrieve a service description and the access point to the WSDL file from a service registry such as UDDI. The WSDL file will be used to generate a client-side Web service proxy. Then, the service consumer uses the service description to bind with the Web service. It can send a SOAP (Simple Object Access Protocol) message to the service provider to invoke a specific method of a Web service and receives a SOAP

response. A SOAP message is an XML-based construct that includes an optional SOAP header and a mandatory SOAP body. Using Web service standards, software components can be accessed by applications developed by customers and business partners independent of hardware, operating system, and programming language. Web services can facilitate the integration of different application programs and computing platforms, automate workflow processes, and coordinate business interactions among multiple participants.

The initial goal of the Web services effort is to achieve universal interoperability among applications via a set of Web standards. One key deployment area for Web Services is e-business [12]. From a distributed component perspective, Web services consist of distributed and reusable software components that semantically encapsulate discrete e-Business functionality and are programmatically accessible over standard Internet protocols. They can be used as a wrapper to expose functions of legacy systems to applications inside and outside enterprises. Therefore, Web services can be viewed as a new middleware technology for building middle-tier software components and implementing business computation and data access logics. They can streamline inter-business processes by creating an open, distributed system environment, and significantly reduce the cost of integration of business processes and applications.

In order to get the full value of Web services, business process management systems need to orchestrate them in support of the needs of the customer. The terms “orchestration” and “choreography” have been introduced to describe the composition of Web services in a process flow. Orchestration describes how Web services can interact with each other at the message level, and choreography tracks the sequence of messages that may involve multiple parties and sources [11]. The dynamic service composition describes the control- and data-

flow between the process activities [5]. To enable more complex execution sequences, a universal description language should provide all the control-flow elements including iterations, conditional branching, and concurrency.

4. ENHANCING BPM WITH WEB SERVICES

4.1 How Web Services Can Be Used For Process Management in E-Business?

Companies are trying to link and configure Web services into a flexible process flow to support dynamic e-business environments. During a business process, a company can query the UDDI directory or other service registries to find potential business partners that offer specific services, and selects a service provider for the required services based on certain criteria. During the interaction, business partners switch between the roles of service provider and service requester. By using a loosely coupled integration model, Web services allow flexible and seamless integration of heterogeneous systems in a variety of domains including B2C, B2B, and EAI. They offer the potential for creating highly dynamic and versatile distributed applications that span technological and business boundaries. Since XML is the standard data format for the input and output of Web services, the collaboration between business partners can be realized via exchanging XML messages.

There can be many decisions involved in an e-Business workflow. For example, in an online purchasing scenario, the first process is started with the submission of a purchasing request for approval. The process engine uses a decision facility to inspect the total amount of the purchase request. If the total is more than $1,000, the purchasing request will be denied and a denial message is sent to requester. If the total is equal to or less than $1,000, the request will be approved, and a purchase order is sent to the vendor ... To achieve the

desired business decision, the subtasks of the process can be combined into a procedural decision flow to conditionally use the proper subtasks in sequence. In a business rule such as "if <Calculate customer's credit rating> is greater than 90, then <Issue a Gold Visa Card>", both premise and action represent self-contained processes. Therefore, they are natural candidates for Web services and can be implemented and hosted by other business partners and accessed through a licensing arrangement. Since a well-formed rule service has a clear calling point, it is also possible to publish the rule service itself via a UDDI framework [10].

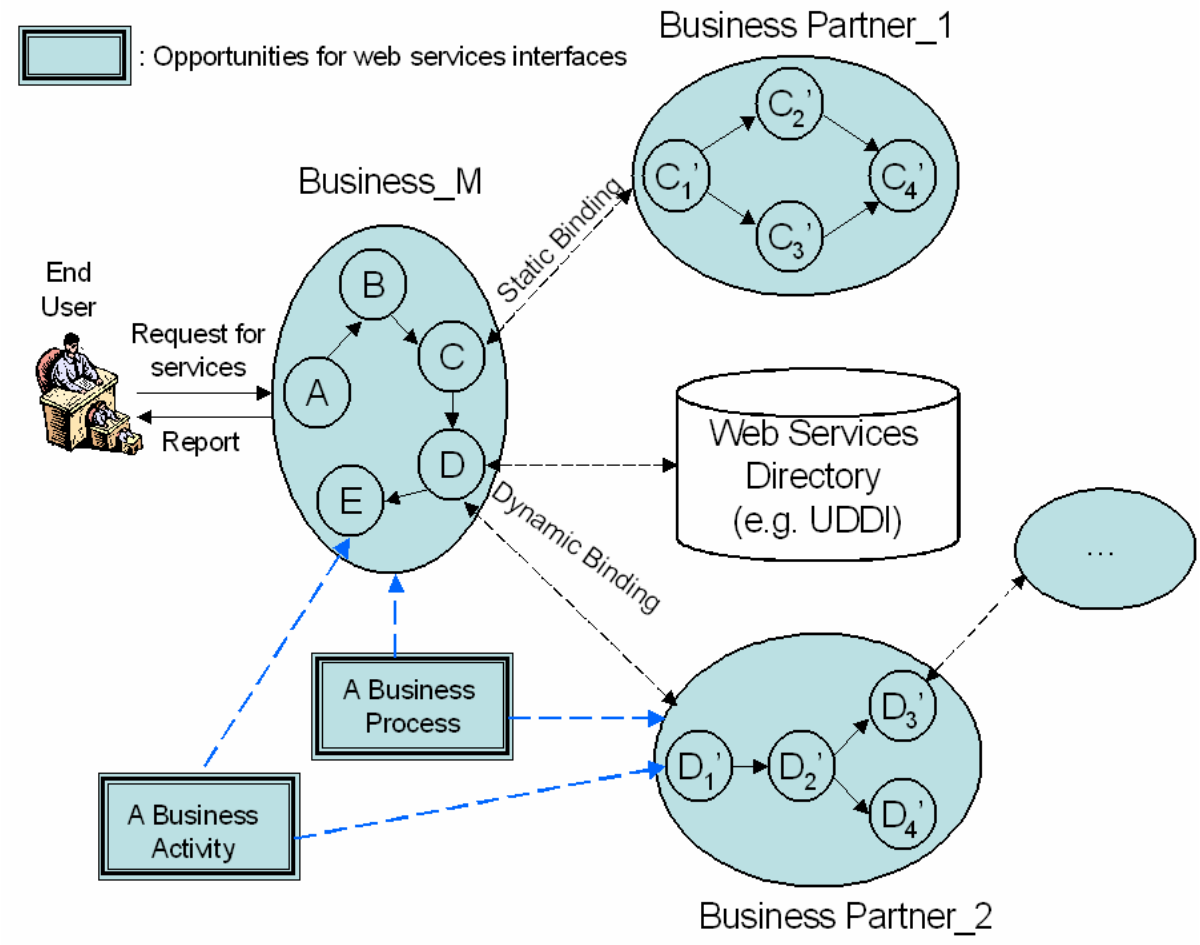

Figure 2. An Architecture for Process Management Via Web Services Composition

As Figure 2 illustrates, the flow model of e-Businesses may consist of a number of processes and activities, which can be potentially created as individual Web services through functional decomposition. The use of Web services for process management in e-Business can address the problems of interoperability and interaction that traditional BPM systems have, and bring a number of distinct benefits including software reusability, flexible business partnership, and easy application integration and maintenance (Figure 2). As a result, the process flow becomes "flow of Web services".

A company normally works with one or more business partners, who provide indispensable services required in its operations. For example, business partner one and two in the Figure 2 carry out two processes for operating activities 'C' and 'D' in the process of 'Business_M', respectively. All three processes, as well as activities included in each process, can be created as Web services. The execution of those services follows a sequence defined based on the business model. There are two ways for an e-Business company to interact with its business partners in the service-oriented approach. One method is through static binding — two businesses establish a partnership in advance. In other words, the corresponding service partners and their interaction are pre-defined, like traditional business relationships (e.g., the partnership between 'Business-M' and 'Business Partner_1'). Another method is through dynamic binding — the business partnerships are not pre-established. The process can query the Web service directory, such as an UDDI registry, to look for potential partners who provide certain Web services in the run-time. After obtaining the relevant service information, the process attempts to establish a partnership dynamically and invoke the corresponding service (dynamic service composition). In order to realize dynamic binding, all Web service providers in a specific domain should implement their

services through a standard, agreed set of interfaces to enable automatic service bindings from external consumers in real time.

Web-service-enabled BPM helps organization and understanding of business processes and activities, and can efficiently support reuse, generalization, refinement, and specialization of process elements. It enables interweaving existing applications as process components of larger processes, and makes it easy to distribute processes at will across process participants and computing resources, because it is easy to aggregate the services of multiple service providers to generate a new service. In addition, it enables process upgrade on the fly at the level of sub-processes. In dynamic service composition, the evolutionary change made to a process or an activity does not affect other processes and business applications. The use of Web services significantly improves the efficiency of process management and reduces cost.

4.2 A Prototype E-Procurement System Using Web Services Composition

We have developed a prototype e-Procurement system based on the architecture presented in the Figure 2. The basic scenario is that a retailer makes an online order to a wholesaler, who processes and fulfills the order through internal and external business processes. The detailed workflow of the system is illustrated in Figure 3.

In this scenario[1], there can be a number of wholesalers and suppliers, who have created their Web services and publish them in a Web service registry. When a retailer plans to purchase a product A with a quantity of n, it first queries the service registry to find out the service information of wholesaler(s). Then, it places an online order to the identified

[1] This scenario is created just for illustration purpose only. It may not exactly reflect the workflow of e-Procurement in the real world.

wholesaler. After receiving the order, the wholesaler executes its internal process started with customer credit checking, which is carried out by an external credit-checking service provider through static binding. If the credit checking is approved, the process continues

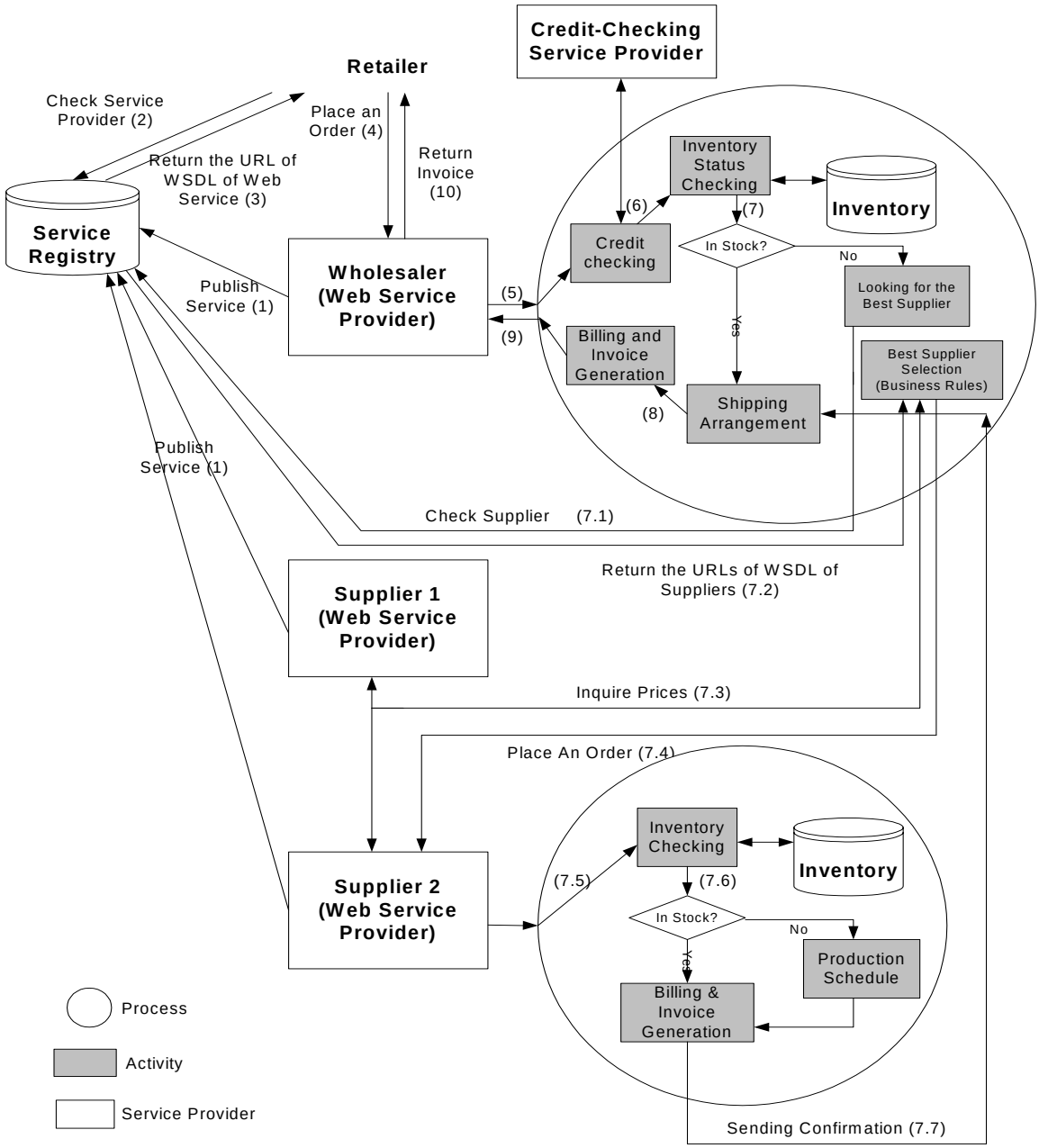

Figure 3. The Workflow of the Prototype E-Procurement System

by checking the inventory status. If there are sufficient quantity of product A available in the inventory, then the process advances to shipping arrangement, which can be also carried out by an outside shipping service provider, followed by the billing and invoice generation. Finally, the wholesaler returns the invoice to the service consumer (retailer). However, if the quantity of product A in the stock is less than n, the wholesaler has to order more from a supplier. Since product prices fluctuate all the time, the wholesaler desires to find a supplier who offers the best price of the product and the fastest delivery. Therefore, it queries the service registry and retrieves the service information of all relevant suppliers. By using a decision module consisting of a set of business rules, the process identifies the best supplier (in this case, supplier 2) and makes an order through dynamic binding. When the supplier receives an order, it carries out its own process and returns a confirmation message to the wholesaler … As demonstrated above, the wholesaler switches its role between service provider and consumer throughout the processes.

The system was developed using object-oriented Pascal language in the Inprise Borland Delphi 7.0 environment, which is a development tool providing various components in support of Web services. It can generate WSDL documents and wrap communication messages into SOAP messages automatically. The basic steps involved in using a Web service include 1) generating the Web service itself; 2) producing and publishing the WSDL file of the service; 3) generating a client stub for the Web service; 4) offering the interface definition; and 5) requesting the Web service through the service interface. The Web server used was IIS 5.0. For the purpose of simplicity, we implemented a Web service registry and inventory using Microsoft Access 2000. The Figure 4 shows the description of a published Web service and the detailed content of its WSDL file. The service requests and results were

transformed into the SOAP format. The credit checking Web service, for example, gets information about the retailer from the wholesaler's service request and returns the result, both in the form of SOAP messages. The use of dynamic binding and business decision module enables the wholesaler to find the most appropriate supplier for the transaction. The composition of several web services greatly enhances the flexibility and agility of business processes, and overcomes the interoperability problem of traditional e-Businesses. The change made to one Web service will not affect others.

Figure 4. A Web Service Information Page and Content of the WSDL File

4.3 Industry Standards and Commercial Software for Web Services Implementation and Composition for Process Management

In order for organizations to collaborate with each other, it requires a universal description language to specify how business processes are enacted and carried out in a precise and unambiguous manner. In addition to building Web service interfaces to existing applications, there must also be some standard approaches to Web services composition in order to form more meaningful business processes. In 2002, a number of new standards were introduced to address this problem, including BPEL4WS ((Business Process Execution Language for Web services), WSCI (Web service Choreography Interface), and BPML (Business Process Modeling Language).

BPEL4WS, layered on top of several XML specifications including WSDL 1.1, XML Schema 1.0, and Xpath 1.0, is a specification that enables a task to be accomplished using a combination of Web services, possibly involving more than one company. Written by developers from BEA Systems, IBM, and Microsoft, BPEL4WS combines and replaces IBM's Web Services Flow Language (WSFL) and Microsoft's XLANG specification. It describes executable business processes that rely on the import and export of Web services, and provides a formal standard for specifying business processes and business interaction protocols. At the core of BPEL4WS is the notion of peer-to-peer interaction between services described in WSDL. The processes are specified at an abstract level disregarding any binding information of service implementations. BPEL4WS uses " message properties" to identify protocol-relevant data embedded in messages. The specification of a business process within a BPEL4WS document mainly consists of three sections [17]: the partners that participate in the process interactions, the activities with the corresponding control-flow, and

the containers for the required messages and their data-flow. The part of interaction partners in a BPEL4WS document declares Web services imported or exported by the business process. At execution time, a business process calls the operations provided by the port types of partners. By this way, the business process and its partners can establish a collaboration.

WSCI (http://www.w3.org/TR/wsci/) is a specification from Sun, SAP, BEA, and Intalio that defines an XML-based language for Web service collaboration. It describes the messages exchanged between Web services that participate in a business collaboration, and supports message correlation, sequencing rules, exception handling, transactions, and dynamic participation. The WSCI choreography includes a set of WSCI documents, one for each partner in the interaction. It supports both basic activities (e.g., sending, receiving, and invoking services) and structured activities (e.g., conditional choices handling, sequential and parallel activities, and looping).

BPML (http://www.bpmi.org/bpml.esp) is a meta-language for modeling business processes. The specification is developed by Business Process Management Initiative (BPMI.org). Although it was originally designed to support business processes executed by BPMS systems, the first draft of BPML incorporated the WSCI protocol. The BPML specification provides similar process flow constructs and activities compared to BPEL4WS. It brings middleware capabilities and provides an abstracted execution model for collaborative and transactional business processes.

In the past few years, a number of software companies have developed a variety of products to support Web service composition in e-Business. The IBM WebSphere J2EE (Java 2 Platform, Enterprise Edition) environment provides basic facilities for implementing business components as Web services. For any WSDL-defined Web service, Java wrappers

can be generated to make the service accessible to any WebSphere intra-enterprise business component. This provides the basic mechanism for publishing intra-enterprise business components as Web services and for using external Web services as components in intra-enterprise processes. BPWS4J from IBM (http://alphaworks.ibm.com/tech/bpws4j) is an implementation of the BPEL4WS specification that includes a run-time engine and an editor for creating BPEL4WS processes. The runtime engine for BPWS4J can be developed on either Apache Tomcat or IBM WebSphere. Once a process is developed, it is assigned a SOAP endpoint. Then, a SOAP client from the WSDL can be automatically created, providing an efficient way to interact with other business processes.

5. DISCUSSIONS

In this paper, we have highlighted the importance and benefits of coupling Web services and business process management, introduced an architecture for process management via web services composition, and discussed various technical issues. The service-oriented business process management can also be applied to the mobile business by extending the concept of Web services and process management to the wireless environment. It refers to requesting and running Web services on mobile devices (also called m-services). An application component is considered as an m-service if it is: transportable through wireless networks; flexible in terms of composition with other m-services; adaptable according to the wireless devices' computing characteristics; and accessible by wireless devices via a micro browser as a mobile Web application or able to interact with a mobile client software component that consumes Web services [8]. It is estimated by Gartner Group that at least 40% of B2C e-commerce will be initiated from smart phones supported by WAP (Wireless Application

Protocol) in 2004. Popular content-oriented applications of m-commerce include financial news, stock portfolio tracking, stock quotes, and telephone directory assistance. M-commerce marketing applications may alert users of new shops or special sales based on their locations and interests. In m-commerce, transaction-oriented m-services such as trading stocks often require immediate actions even when people are traveling.

Due to the intensive competition, it is critical for businesses to not only retain the current customers via providing satisfactory services, but also find new customers. Therefore, it will be beneficial to both businesses and service consumers if consumers can post those activities that require certain Web services in a service directory. This enables businesses (service providers) to be able to query for potential consumers of a particular service. Some researchers have also explored techniques to generate intelligent e-Businesses by incorporating case based reasoning, intelligent agent technology, and ontology [7, 12].

A major challenge in achieving the goal of Web services composition for process management is semantic interoperability. Communication among heterogeneous, independently developed Web services demands a well-defined mechanism for semantic description of services and their properties so as to make services semantically understandable by business processes. It relates to the issue of precise interpretation of a Web service, which is a prerequisite for automatic service discovery and composition. Driven by the demand of more effective discovery of Web services, the necessity of developing standardized ontology and service profiles has been well recognized. The Semantic Web (http://www.w3.org/2001/sw/) can support a service description language that improves query matching, negotiation proposals and agreement, and advertisement [18]. The objective of its initiative is to make the Web machine-processable. Adding semantics to

service annotations can reduce ambiguity in interpreting structured information and promote a qualitative advance in the quality and quantity of e-commerce transactions [9]. The shift to Semantic Web services enables computers to automatically access information, understand it, fuse it as needed, and engage in collaborative problem solving to better support decision making. There have been several ontology markup languages developed for creation of domain-specific ontologies and instantiation of those ontologies, including Resource Description Framework (RDF, http://www.w3.org/RDF/) and DAML-based Web Service Ontology (Called DAML-S). For example, DAML-S provides Web service providers "… with a core set of markup language constructs for describing the properties and capabilities of their Web services in unambiguous, computer-interpretable form (http://www.daml.org/ services/)". It aims to facilitate the automation of Web services tasks including automated Web service discovery, execution, interoperation, composition and execution monitoring.

Security of Web services in the e-Business is also a major concern in widespread practical use. The industry and standards committees are developing various mechanisms for encryption/decryption, message confirmation, and user logon identification. Microsoft's .NET Passport is one example of the single sign-on (SSO) framework that enables companies to tie their proprietary authorization strategies and policies to the external user information needed to make access decisions. The secure, reliable, and choreographed execution of Web services is worth to be examined in more detail because it taps on the potential capabilities of a standardized business process execution language [2]. Web services are emerging, and will continue to evolve, as a promising solution to process management in the e-Business.

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