Challenges for Deploying Web Services-Based E-Business Systems in SMEs

Ranjit Bose, University of New Mexico, USA
Vijayan Sugumaran, Oakland University, USA

ABSTRACT

E-business initiative in many companies had started in the 1990s. These companies have recently begun to explore the use of Web Services (WS) technologies within their e-business context, since they provide an attractive, language-neutral, environment-neutral programming model that accelerates application development and integration inside and outside the enterprise. Despite these advantages, companies are slow to deploy WS because it requires a considerable shift in their application development process. While a few studies have reported on some of the reasons for this wait-and-see approach, a thorough and systematic investigation of the challenges from the stakeholders’ — providers, consumers, and standards organizations — perspective is needed. This study addresses that and provides a framework for studying the factors that impact the deployment and use of WS. The framework is used to analyze small and medium-sized enterprises (SMEs), as they play a vital role in generating employment opportunity and turnover within many major economies globally.

Keywords: challenges for small- and medium-sized enterprises; Web services and e-business integration; Web services stakeholders

INTRODUCTION

The e-business initiative in many companies had started in the 1990s. The first generation e-business application, with a business-to-consumer (B2C) focus, had simple Web sites with databases and forms for buying and selling online products. Subsequently, the second generation e-business application, with a business-to-business (B2B) focus, had Web sites that were fully integrated with backend systems — consisting of the major legacy applications — internally, as well as with business partners’ information systems externally to provide a wide range of online services (Gonsalves, 2002).
The emerging field of Web Services (WS) enables different software components to be integrated without having to develop these components from scratch and without the hassle of custom coding (Stal, 2002). It is resulting in significant changes in the way applications and supporting infrastructures are integrated (Schmidt, 2003). These changes have led to the design and development of service-oriented architecture (SOA) of application systems (Fowler, 2003). WS are becoming the basic building blocks out of which new applications are being created, and service composition is becoming the main focus of the application development process (Peltz, 2003). Service composition combines two or more WS following a certain composition pattern to achieve a business process goal. Thus, service composition provides a mechanism for seamless integration of cross-enterprise and intra-enterprise applications (Chung, Lin, & Mathieu, 2003).

The SOA is built on a foundation of standards, which define the roles and activities of the architectural elements, and thus support the interoperability of incompatible systems across the Web. The SOA is distributed, permitting elements of an application to be deployed on multiple systems and executed across connected networks (Geng, Gopal, Ramesh, & Whinston, 2003; Kleijen & Raju, 2003). Because the transport mechanism is built on HTTP (Hyper Text Transfer Protocol), it is possible for application elements to interact within and across enterprises. The elements of an application are designed to support specific tasks within a broader workflow or business process. Each of these service elements of an application is responsible for defining its inputs and outputs using the standards for WS, so that other elements are able to determine how this element operates, how to make use of its functionality, and what result to expect from its execution (Papazoglou, 2003).

A Web service is thus a self-contained and self-described modular element of an application that can be published, located, and invoked across the Web. Based on existing and emerging standards such as HTTP, XML (Ex-tensible Markup Language), SOAP (Simple Object Access Protocol), WSDL (Web Services Description Language), and UDDI (Universal Description, Discovery and Integration Service), WS provide significant opportunities for technical and business innovation (Arsanjani, Hailpern, Martin, & Tarr, 2003; Maruyama, 2002). Since the WS technologies provide a language-neutral, environment-neutral programming model that accelerates application development and integration inside and outside the enterprise, they encourage an approach to application development that is evolutionary, building on investments previously made within an IT organization, and developing new capabilities incrementally (Khalaf, 2002; Rust & Kannan, 2003).

Because of this potential to enable a new paradigm for enterprise application development and deployment, companies have recently begun to explore the use of WS technologies within their e-business context (Hagel, 2002). The integration of WS into e-business provides several business benefits that include lowering costs, improving application sharing, increasing flexibility, streamlining business processes, and opportunity to create innovative business models among others. However, there are a few obstacles that need to be overcome before widespread adoption of WS into e-business is realized (Tilley, Gerdes, Hamilton, Huang, Miller, Smith, & Wong, 2004). They include security, availability, reliability, and performance of WS-based e-business systems.

WS-based e-business systems are currently in the early phase of adoption, primarily within large organizations that have well-established IT infrastructures and technically savvy staff (Chen, Chen, & Shao, 2003). Most of these organizations are experimenting with WS for application integration and developing innovative implementations within their e-business context. The deployment of WS is currently focused in two areas: (1) enterprise application integration, for integrating disparate components, mainly legacy applications, of an enterprise wide system; and (2) business partner integration and secure exchange of data.
with dedicated partners without using a proprietary approach (Manes, 2003).

Despite the advantages of WS and their increasingly vital role in integration initiatives, first within an organization and then between enterprises, several challenges exist with developing and using them (Tilley et al., 2004). A thorough and systematic investigation of these challenges is needed to help improve the rate of deployment of WS across organizations. WS computing poses significant challenges as developers determine how to leverage emerging technologies to automate individual applications based on cross-organizational, heterogeneous software components. WS standards permit application-to-application interoperability, but the coordination of a set of WS working toward a common end is currently an open issue (Orchard, 2002). The service providers need to learn how to develop WS interfaces that perform well, identify performance problems when they occur, and how to fix them.

In order to develop e-business applications using leased components through WS, the challenges from the perspective of the three stakeholders of WS, namely the service providers, service consumers, and the WS Standards Organizations, need to be understood. The service providers offer WS. These are organizations that procure the service implementations, supply their service descriptions, and provide related technical and business support. The service consumers are the end users of the services as well as application assemblers who assemble several WS to build an application for the organization. A service agreement, which is a contract between a service provider and a service consumer, is used regarding the attributes of a Web Service and its usage. The Standards Organizations are bodies that are involved in developing standards for both the providers and consumers.

This study investigates the challenges that exist for each of the stakeholders, and presents a framework that organizes and interrelates these challenges in an easily understandable manner to help study the factors that impact the deployment and use of WS. The framework is used to analyze the challenges in small and medium-sized enterprises (SMEs), as they play a vital role in generating employment opportunity and turnover within many major economies globally. Particularly, as large companies downsize and outsource more functions, the importance and role of SMEs in the economy are increasing worldwide.

SMES AND E-BUSINESS

There is no universal definition of SMEs, each country has its own. However in general, SMEs are defined as non-subsidiary, independent firms, which employ fewer than a stated number of employees. This number varies across nations. The United States defines SMEs as firms with the size of the employees fewer than 500, the European Union sets the limit to 250 employees, while some other countries at 200 employees. Small firms are generally those with fewer than 50 employees, while micro-­enterprises have at most ten, or in some cases five, employees. Financial assets are also used to define SMEs. The United States, in its definition, also assumes that the SMEs are independently owned and operated, and they are not dominant in their field of operation within the overall marketplace.

Characteristics of SMEs

There have been many studies in the literature that have attempted to define several unique characteristics of SMEs compared with large enterprises. Central to all of these studies is the realization that many of the processes and techniques that have been successfully applied in large enterprises do not necessarily provide similar outcomes when applied to SMEs. In other words, SMEs are not “small large enterprises” but are a separate and distinct group of organizations compared to large enterprises. Therefore, it is appropriate to know some of their characteristics reported in the literature.

Some of these characteristics include lack of technical expertise as well as adequate hu-
man resources in SMEs to develop complex technological solutions and to undertake technical enhancements (Barry & Milner, 2002). Most SMEs avoid sophisticated software and applications and often suffer from inadequate organizational planning (Tetteh & Burn, 2001). They tend to have a small management team and are strongly influenced by the owner’s background and personal traits. Auger and Gallaugher (1997) identified a variety of business characteristics that affect the adoption and use of IT in SMEs. These business characteristics include business size, business age, business sector, market focus, and level of IT expertise among others.

**IT Adoption in SMEs**

SMEs in the United States, Canada, Australia, and leading European economies are realizing significant financial benefits from adoption and implementation of Internet-based business solutions. These Internet-based solutions fall under two broad categories: the first category is customer-focused such as customer development and e-marketing, whereas the second category is internally-focused such as accounting and supply chain management solutions. A recent study reported that 25 million SMEs in the United States generate 53% employment and 51% turnover and 18 million in the European Union generate 66% employment and 55% turnover.

In spite of these impressive statistics, the state of adoption, and implementation of Internet-based business solutions in SMEs worldwide can be divided into four evolutionary categories ranging from limited use of information technology through to full integration of business automated processes as seen in the digitized firm (Knol & Stroken, 2001; Mehrten, Cragg, & Mills, 2001). These categories are (1) no adoption — there is no information and communication technologies usage or limited usage, (2) basic adoption — e-mail and static Web pages are implemented within the business, (3) intermediate adoption — e-business platforms are being used including B2C online payment systems, and (4) advanced adoption — e-business platforms are used including B2B processes/exchange.

**Factors Influencing the Adoption and Non-Adoption of E-Business in SMEs**

The advent of e-business in the 1990s offered considerable opportunities to SMEs to expand customer base, enter new product markets, and rationalize their businesses (EMPG, 2002). Many smaller firms have started using e-business to customize products and services, manage supply processes and inventories, and reduce the time between order and delivery. The significant benefits achieved by those SMEs that adopted e-business include cost reduction, sales increase, and the ability to reach a global market.

The literature reports several factors that influence the decision to adopt and use e-business in SMEs (Fariselli, Oughton, Picory, & Sugden, 1999; Mirchandani & Motwani, 2001). They include the size of the business in terms of the number of employees; the age of the business; the business sector, for example, service, manufacturing, or retail; the market focus, for example, local, regional, national, or international; level of IT expertise available amongst staff; and the annual turnover of the business.

A firm’s past experience with information technologies in terms of exposure and organizational learning ultimately affects its future choices in adopting advanced information and communication technologies. At the business sector or industry level the factors include the availability of external know-how (for example, technology suppliers), the degree of innovativeness of the industry, the requirements imposed by major customers and external markets, and overall levels of competition and technological sophistication in the industry. The greater the computer literacy and computing skill of the owner, the more likely the firm will adopt e-business through awareness of its benefits, especially for the strategic management of the business.
The literature also reports several factors that influence the decision to not adopt and not use e-business in SMEs (Scupola, 2002). They include lack of awareness and knowledge of e-business; limited understanding of the complexity of electronic operations; inadequate skills and high initial investment required to develop a viable e-business strategy; infrastructure access and costs; lack of suitable software standards; lack of easily accessible, independent and inexpensive advice and assistance in e-business development to SMEs; and concerns with security and privacy.

**State of E-Business Adoption in SMEs**

More and more SMEs are adopting e-business by implementing Web sites with portals while focusing on the quality of these Web sites and the choice of functionalities that they offer to users (Jeffcoate, Chappell, & Feindt, 2002). The SMEs are defining the scope of their e-business operations by identifying (1) the functionalities and services they will provide, (2) the clienteles they will target, and (3) the geographic scope of their operations. The technological solutions that the SMEs have adopted for e-business fall within a range of options to complement their traditional operations (Cote, Sabourin, & Vezina, 2004).

These technological solution options are as follows: e-shop — information or information requests, sale and distribution of the business’s products and services; e-procurement — is a site on which vendors sell to big buyers; e-auction — is an electronic auction site; e-mail — several vendors operate on the same site; 3rd party marketplace — provides transactional support for vendors; and virtual communities — are designed to foster communication between the members of a given community.

**WEB SERVICES CHALLENGES FRAMEWORK**

Web services-based applications are being developed to increasingly support sophisticated e-business processes. The application development trend can be categorized into three categories. Category 1: Enterprise Application Integration — the first step is to integrate internal applications. WS allow enterprises to expose legacy applications to business applications in heterogeneous environments without having to rewrite significant amounts of code. Category 2: Interoperability with Key Business Partners — the next developmental step for most enterprises is to integrate one or two key partners outside the enterprise. Enterprises use WS because they allow for interoperability between applications across the public Internet. Currently, due to the lack of broadly adopted specifications, enterprises must agree upon the technologies they will use to develop these interoperating WS applications. Category 3: Interoperability Across Multiple Enterprises — the subsequent developmental step for most enterprises is to extend their computing out to more business partners and customers. Currently, due to the lack of broadly adopted specifications, enterprises are forced to implement a series of agreed upon ad hoc solutions to ensure secure and reliable cross-enterprise interoperability.

**Stakeholders of Web Services**

A survey of the literature shows that the variables at play in WS adoption and use can be grouped into two levels: (a) organization and (b) industry. Much of the research on WS has focused on the industry level and examination of WS-based software development has been ignored at the organizational level (Casati, Shan, Dayal, & Shan, 2003). In order for WS to take off, simultaneous progress has to be made at all levels. Issues at one level are invariably linked to issues at play at the other level. Thus, variables at play at the industry level such as
emergence of standards for WS, methodologies for service identification, composition, and advertising have an impact on organizational level adoption and use of WS. Organizational level variables in turn, such as, WS reuse strategy, technological infrastructure, training and education, management support, metrics and incentives, and so on, can influence WS adoption and use at both project and individual levels.

One important factor in the implementation of WS reuse programs is the relationship between suppliers and consumers. Thus, it is essential to examine the issues related to WS from the perspectives of all the stakeholders. Figure 1, schematically depicts these stakeholders and their interrelationships. The three major stakeholders are: (1) WS Providers, (2) WS Consumers, and (3) Standards Organizations. The WS providers primarily consist of WS Vendors and WS Integrators and Publishers. The WS vendors are the companies that provide the actual WS themselves. The WS integrators and publishers are third party services that get requirements from consumers for applications and identify appropriate services and integrate them to create the applications needed by the consumer. In other words, consumers outsource the service identification and integration aspects to these vendors, who deliver the complete application. WS consumers are organizations that utilize one or more WS in their e-business applications. These organizations may have two types of consumers. Application assemblers are usually IT department employees who are charged with developing organizational wide applications using WS. They are aware of all the available WS in a particular domain and particularly, the ones that their organization has subscribed to in developing prior applications. End users are individual users who are trying to develop simple applications using just one or two WS. Standards organizations oversee the specification and development of appropriate standards that govern all aspects of WS creation, identification, integration and execution.

The relationships between suppliers, consumers, and standards organizations have to be understood at all levels. For example, at the industry level, suppliers will be organizations that design and develop WS and make them available for sale through their Web site or via publishers and integrators to consumer organizations. Similarly at the organizational level, suppliers and consumers may be project teams and individuals. It is important to keep in mind, that a given organization, a project team, or an individual can be a Web service supplier, a Web service consumer, or both.

The following subsection identifies the typical challenges that exist for each of the three stakeholders, and presents a framework that organizes these challenges in a coherent manner.
Typical Challenges for Stakeholders

Much of the current excitement about WS is based on two factors. First, WS are designed to improve interoperability across information systems at lower cost by extensively using open Internet and Web standards. Second, the decision by WS vendors to initially cooperate on setting key standards and compete later has greatly reduced investment uncertainty and increased incentives for others to provide complementary applications, thus potentially reinforcing adoption of standards. The technical objective of WS is to provide an integration mechanism facilitating the loose coupling of systems and hence the dynamic replacement of a service with another one of the same characteristics. Currently the most important issues regarding the wide adoption of WS are: (1) in the areas of still outstanding or insufficient standardization, (2) low acceptance of service consumers, and (3) critical mass of available useful services (Kreger, 2003).

Most of the problems related to WS-based software development deals with its adoption and use in organizations (Lee & Runge, 2001). The IS discipline has a long history of having developed theories and frameworks to address such problems. These theories and frameworks should be drawn upon to provide frameworks to study non-technical issues related to WS adoption. Such frameworks will provide a systematic basis on which different propositions regarding organizational, and industry level use of WS can be tested. Sound experimental design procedures and research methodologies also need to be drawn upon to study them. Based on the previous discussion, we believe that a good framework for studying the challenges of WS adoption and use will need to look at both the technical issues and non-technical issues associated with WS deployment. Both of these types of issues have to be investigated for each of the major stakeholders, namely, Web service providers, Web service consumers, and standards organizations. The following three subsections briefly discuss the aforementioned issues related to each of the major stakeholders respectively and the last subsection puts together these issues into an overall challenges framework for further study.

Provider Challenges

A number of processes such as identifying new WS requirements, design, implementation, and testing of these services, eliciting customer feedback, and so on, are involved in WS creation by WS vendors. Their WS development processes are impacted by many factors, such as WS development strategy, architecture standards, design requirements, and so on. Vendors make these services available to consumers by publishing them in one or more WS directories (Geng et al., 2003). Consumers use these services by identifying and subscribing to them from the directory. Based on their experience with the services, they may provide feedback to suppliers so that they can refine their services. Consumers’ use of WS may involve many processes, such as, methodology standardization, project management, resource allocation, and so on and is impacted by many factors, such as, reuse strategy, organizational culture, technological infrastructure, and so on.

There are a number of ways in which Web services can be published such as UDDI, simple URI-based registry publishing, exchanging schemas, and so on. A service provider has to carefully consider how and where to publish its services. Depending upon the application domain, type of service, and the target audience, some approaches may be better compared to others. For example, ebXML is being adopted and pushed by some government institutions and is being evaluated by some industries (medical, traveling), while UDDI is pushed by some large software vendors. Hence, a Web services provider needs to understand the market space they are trying to target and publish their services accordingly so that consumers can easily find them.

A key “hidden” inhibitor is the lack of complementary WS, including support for service-provider-specific processes such as metering, accounting, and billing. Overcoming the lack of third party WS and service-provider
support is difficult because it requires foresight about how to decompose an automation problem and how to deliver it. Yet, doing so is critical because modularity and sharing are typically subject to positive demand-side network externalities. Service delivery overhead is another major obstacle to creating external services.

Research on Semantic Web is on the rise and semantic Web services are accompanied by mechanisms for “smart” invocation of Web services. Thus, this new breed of Web services will greatly impact the whole WS paradigm. Semantic Web services (SWS) support automatic discovery, composition, and execution across heterogeneous users and domains. To this end, several frameworks have been developed, namely, Internet Reasoning Service (IRS-II) (Motta, Domingue, Cabral, & Gaspari, 2003), OWL-S (OWL-S Coalition, 2004), and Web Service Modeling Framework (WSFM) (Fensel & Bussler, 2002). IRS uses a knowledge-based approach for SWS and allows applications to semantically describe and execute Web services. OWL-S provides an ontology for describing Web services capabilities. WSFM focuses on e-commerce requirements for Web services including trust and security.

A service provider needs to consider many aspects of Quality of Service (QoS). One of them is its QoS policy. Some WS adopt a best-effort policy, which offers no guarantee that requests for services will be accepted (they could just be dropped in case of overload), and no guarantees on response time, throughput, or availability are provided. While this type of policy may be acceptable in some cases, it is totally unacceptable in others, especially when a Web service becomes an important part of an application composed of various WS. In these cases, Web service providers may want longer-term relationships with users of their services. These relationships generate Service Level Agreements (SLAs), legally binding contracts that establish bounds on various QoS metrics.

Providers must monitor the load they receive from consumers (users) and check whether the service they provide to them meets the agreed-upon SLAs. Consumers, therefore, must also check on the quality of the service they obtain. QoS monitoring may be outsourced to QoS monitoring services such as the ones that monitor Web sites (such as www.keynote.com). However, the consumers also have many other challenges to address.

**Consumer Challenges**

One of the main issues in WS-based application development is the difficulty in identifying relevant WS and integrating them to generate a cohesive application (McIlraith, Son, & Zeng, 2001). UDDI requires consumers to manually search for WS, typically by completing a Web form to search a repository. This is fine if only one Web service is needed and once it is found it will never change. Unfortunately, this is usually not the case. In order for a Web-based application to adjust to changing WS, intelligent interfaces are needed that makes use of the semantics of the application domain.

Application assemblers and individual end users of WS can create integrated solutions by combining distributed WS over the Internet. However, there are several issues that such integrators face. For example, some of the integration solution requirements that WS would have to address are: (1) efficiency — to scale on an industrial basis, WS execution must be very efficient; (2) expressiveness — B2B interactions in supply chain scenarios are complex, requiring an expressive set of supported integration concepts; (3) security — interactions within as well as across enterprises must be secured to prevent security attacks of all types, and non-repudiation must be provided for reliable record keeping; (4) reliability — remote and distributed communication must be reliable, and messages must be sent exactly once to ensure dependable interactions; and (5) manageability — inter-enterprise communication changes frequently, requiring easily manageable technology. These requirements pose a high demand on a technology that addresses their implementation.

Security is a major concern for organizations attempting to deploy WS-based applica-
tions. One of the key aspects of Web services management is to ensure that services can be delivered and accessed securely according to the organization's security policies. Some of the security concerns are addressed through the WS-Security (WSS) specification, which has been developed through OASIS. WSS defines SOAP extensions to implement client authentication, message integrity and message confidentiality. It is built on current XML security technologies, including XML Digital Signature, XML Encryption and X.509 Certificates. It is designed to provide authentication and authorization for secure message exchange between Web services.

Service requesters find required services by searching the service broker's registry. Requesters then bind their applications to the service provider to use particular service. The lack of ready-to-use WS from either internal sources or third parties compels system architects and engineers to write most of the functionality from scratch. Because WS disregard the traditional separation between local and global applications, developers must carefully consider and anticipate design requirements related to trust, semantics, and coordination (Curbera, Khalaf, Mukhi, Tai, & Weerawarana, 2003). By piggybacking on existing infrastructure, a company reduces the size and specificity of its investments while providing customers a customized service that can be seamlessly integrated with their personal software.

Successful deployment of WS, particularly in the context of mission critical applications, requires adequate methods for performance management and monitoring. The Web services used should be reliable, extensible, scalable, and provide high performance. There should be mechanisms in place to check the service quality, end-point integrity, and runtime performance. WS monitoring and performance management tools are still evolving and organizations need to adopt a comprehensive and proactive strategy as opposed to piece meal approach. Typical tests that are carried out in monitoring Web services are stress test, integrity test, reliability test, and corrective measures monitoring. Some of the key factors for improving WS performance are: monitoring the whole transaction in real-time as a single unit, service level agreements and corrective actions, use of patterns, and clearly defining exception conditions.

From the consumers' point of view, several inhibitors of WS adoption exist. They include: (1) a lack of service provider processes such as metering, accounting, and billing; (2) a lack of semantic consistency in business processes such as ordering, billing, or shipping; and (3) a lack of workflow management mechanisms to orchestrate a group of specialized WS in support of a single business process. The QoS measure is also observed by WS users. Typically, these users are not human beings but programs that send requests for services to WS providers. QoS issues in WS have to be evaluated from the perspectives of the providers of WS and from the perspective of the users of these services. To support Web service management, factors that must be addressed include: WS monitoring, alert and notifications, alarm and traps handling, WS instrumentation at the application level, and WS interoperability with network management protocols. The standards organizations, therefore, are challenged to guide the development of several different standards in order to ease the WS adoption process.

Standards Organizations Challenges

There are several standards bodies that exist related to WS such as the World Wide Web Consortium (W3C), the Organization for the Advancement of Structured Information Standards (OASIS), and WS Interoperability Organization (WS-I).

World Wide Web Consortium (W3C), which developed XML and SOAP is a major contributor to WS standards. Its “Web Services Activity” group builds a set of technologies that allow application-to-application interactions on the Web: an XML-based protocol for communication, a description language for describing interfaces to services, and so on. In other words, the goal of the WS Activity group is to
Develop innovative technologies in order to lead Web Services to their full potential.

OASIS is a not-for-profit, international consortium that drives the development, convergence and adoption of e-business standards. Members of OASIS set the technical agenda, using a lightweight, open process expressly designed to promote industry consensus and unite disparate efforts. OASIS produces worldwide standards for security, WS, conformance, business transactions, supply chain, public sector, and interoperability within and between marketplaces.

WS-I is an open, industry organization chartered to promote WS interoperability across platforms, operating systems, and programming languages. The organization works across the industry and standards organizations to respond to customer needs by providing guidance, best practices, and resources for developing WS solutions. WS-I’s goal of promoting standards-based interoperability between Web Services will have wide-ranging repercussions for the Web Services, enterprise application integration (EAI), and middleware industries.

The three organizations mentioned earlier, along with other standard setting bodies such as the IETF, OAGI, OMG, and UDDI are working on addressing some of the shortcomings of integrating WS into e-business applications, as discussed in subsequent paragraphs. One of the fundamental shortcomings of WS is that business process dynamics and nonfunctional properties of service-enabled processes are poorly addressed by existing service description languages and WS flow languages. These languages seem to target service signatures and signature interactions only. Another basic shortcoming of WS is that current standards do not put forth a methodology to assist designers in building WS on top of legacy assets.

The Web services stack provides a conceptual framework for establishing the relationships and dependencies between various standards. It consists of several layers with well-defined functionalities that facilitate the development of WS-based applications. The WS-stack consists of the following layers: transport, messaging, description, discovery, quality of service, and orchestration/integration. Each of these layers has one or more protocols (standards) associated with it. For example, the transport layer supports HTTP, BEEP, IIOP, JMS, SMTP, and so on, while the messaging layer utilizes XML, SOAP, and REST protocols. The quality of service layer deals with WS-reliability and WS-security. The orchestration layer focuses on choreography and employs standards such as BPEL4WS, WSCI, and BPSS. This layer also deals with transaction and coordination. While considerable efforts have lead to the acceptance of several standards at the lower layers of the WS-stack, the WS choreography and orchestration standards are still evolving. These standards have a tremendous impact as the organization and customer business processes get more intertwined. Vendors that provide a complete and coherent WS-stack would attract early adopters and gain competitive advantage.

To support the SOA, WS must provide standards-based definition of an interoperability communication protocol, mechanisms for service description, discovery, and composition as well as a basic set of quality of service protocols. The unique strengths and limitations of WS suggest unique design guidelines, including: large granularity of messages, asynchronous messaging, bi-directionality of services, endpoint discovery, service agents, request pipeline, context, and content-based routing.

Overall Challenges Framework

Based on the discussions in the previous three subsections, we present a framework that classifies the challenges that are being faced in integrating WS into application development, particularly e-business applications, which have a very short development cycle. The challenges are organized under two broad categories, namely, technical, and managerial. We present these challenges from the three stakeholders’ perspective.
A schematic representation of the major challenges faced by the stakeholders is provided in Figure 2. The WS Suppliers consists of two groups: the vendors that actually provide services and third parties that support Web Service integration and publication services. Suppliers of WS face several challenges. The technical challenges that they face relate to: (1) service description and profile, (2) Web service accessibility, and documentation, (3) architecture standards and infrastructure, (4) design requirements, and (5) WS evolution. The managerial challenges that they face are: (1) pricing and quality of service commitments, (2) identifying new services, (3) customer feedback and support, (4) partnerships with third party providers, and (5) demand management and liability.

The WS Consumers are essentially application developers in the IT department within an organization who are responsible for integrating WS into applications or individual end users that merely use these applications and articulate specific requirement to application developers. One of the major challenges these groups face in using WS is finding the appropriate WS to integrate that meet the application requirements. Simple applications with a single Web service may be easy to accomplish; however, large-scale applications that incorporate a variety of heterogeneous WS are very difficult to develop because of a number of interoperability issues. Some of the technical challenges that are still faced by this group of stakeholders are: (1) search and identification of relevant WS, (2) customization and integration, (3) validation and testing, (4) matching technology, domain and task characteristics, and (5) necessary tools, infrastructure and metrics. In addition to these technical challenges, organizations also face the following managerial challenges in order to institutionalize WS-based application development: (1) WS utilization strategy, (2) promoting WS training and education, (3) resource allocation and support, (4) incentives and rewards, and (5) partnership management and security.

The standards organizations play a vital role in moving the WS technology forward. While there exists some basic standards such as SOAP, WSDL, and UDDI that are used as building blocks for transport, describing, publishing and invoking WS at the physical level, there is lot more work to be done in standardizing various aspects of WS such as coordination, transaction, semantics, quality of service, security, and so on. Since members of the standards organizations come from both IT users (mainly enterprise customers) and IT vendors communities, managing conflicts of interests and getting vendors with competing interests and products to agree on “open” standards is a non trivial task. Some of the technical challenges that the standards organizations face are: (1) open standards for service description, publishing and invocation, (2) identifying appropriate WS technology stack components, (3) modeling WS, (4) overarching architectures for WS applications, and (5) specifications for all aspects of WS. From a managerial perspective, the leadership of these standards organizations faces the following challenges: (1) future directions for WS research and practice, (2) WS implementation guidelines, (3) vendor cooperation for common standards, (4) open standards and interoperability, and (5) consistency between the various standards.

**CHALLENGES FOR SMES**

As mentioned in the previous section, there are several technical and managerial challenges that SMEs face in order to fully integrate Web services into their e-business applications. Regardless of whether an SME plays the role of a consumer or a supplier or both, it may not be able to contribute much in terms of solving technical problems in the Web services area due to lack of man power and expertise. Thus, solutions to technical challenges have to come from the large corporations in the industry and standards organizations. SMEs can adapt the solution architectures and configurations developed as industry standards in order to implement Web services-based e-business applications. However, SMEs would still face a number of managerial challenges in order to successfully integrate
Figure 2. WS challenges for the stakeholders

[Diagram of WS challenges for the stakeholders]

- **Technical Challenges**:
  - Search and identification of relevant WS
  - Customization and integration
  - Validation and testing
  - Technology, domain & task characteristic
  - Tools, infrastructure and metrics

- **Managerial Challenges**:
  - Service description and profile
  - WS accessibility and documentation
  - Architecture standards & infrastructure
  - Design Requirements
  - Web services evolution

- **Technical Challenges** for Web Services Supplier:
  - Service description and profile
  - WS accessibility, and documentation
  - Architecture standards & infrastructure
  - Design Requirements
  - Web services evolution

- **Managerial Challenges** for Web Services Supplier:
  - Pricing & Quality of Service commitment
  - Identifying new services
  - Customer feedback and support
  - Partnerships with third party providers
  - Demand management and Liability

- **Technical Challenges** for Web Services Consumer:
  - Search and identification of relevant WS
  - Customization and integration
  - Validation and testing
  - Technology, domain & task characteristic
  - Tools, infrastructure and metrics

- **Managerial Challenges** for Web Services Consumer:
  - WS utilization strategy
  - Promoting WS, training and education
  - Resource allocation and support
  - Incentives and rewards
  - Partnership management and Security

- **Technical Challenges** for Web Services Registry:
  - Service description, publishing & invocation
  - WS technology stack components
  - Modeling Web services
  - Architectures for WS applications
  - Specifications for all aspects of WS

- **Managerial Challenges** for Web Services Registry:
  - Future directions for WS research & practice
  - Implementing and using WS
  - Vendor cooperation for common standards
  - Open standards and interoperability
  - Consistency between standards

- **Technical Challenges** for Web Services Standards Organizations:
  - WS description, publishing & invocation
  - WS technology stack components
  - Modeling Web services
  - Architectures for WS applications
  - Specifications for all aspects of WS

- **Managerial Challenges** for Web Services Standards Organizations:
  - WS utilization strategy
  - Promoting WS, training and education
  - Resource allocation and support
  - Incentives and rewards
  - Partnership management and Security
Web services into their e-business applications. In the following paragraphs, we elaborate on these challenges first from the perspective of SMEs that are Web services consumers and then from the point of view of SMEs that are suppliers of Web services.

**SMEs as Web Services Consumer**

**WS Utilization Strategy**

Until the WS standards and technologies mature and become universally accepted by the stakeholders, all organizations including SMEs should create a roadmap that will guide them to adopt WS in a manner that avoids risks to deliver the expected business benefits. The strategy should be to implement WS incrementally, first within the organization and then expanding outward as standards and technologies mature. By deploying WS first within their own organizational boundaries, SMEs can gain operational efficiencies and a unified understanding of how best of breed WS could be potentially utilized in their complex business processes. Once they are comfortable and knowledgeable with the use of WS internally, the deployment domain could expand to include their trading partners.

To quickly gain operational efficiency, SMEs should focus on integrating internal legacy systems by exploring different WS interface mechanisms to extract data and make them available to existing and new e-business applications. Therefore, instead of making the data and transaction only available to the specific application that the legacy code was developed for, they can be made available to any application across the enterprise and can be reused as often as necessary.

Two levels of integration are possible: data integration and process integration. With the use of standard WS interfaces, it is relatively easy to create applications that bring together data from multiple, possibly remote, locations. Similarly, existing functionalities can be integrated as well as new functionality can be incorporated using standard SOAP interfaces to make them available across the organization. Additionally, these integrations help create a Web-enabled environment for the execution of the business functions.

**Promoting WS Training and Education**

Since most SMEs lack adequate human resources and technical expertise available internally to develop complex technological solutions, promoting enterprise clusters can enhance SME performance and competitiveness. The SMEs working in clusters — formed through partnerships and networks at the business sector or industry level — can attain the advantages of large firms while retaining the benefits of specialization and flexibility. Grouped in local systems of production, these SMEs can often be more flexible and responsive to customer needs than large integrated firms. They can pool resources and share the costs of training, research and marketing. Clustering will facilitate exchange of personnel and diffusion of technology and creates new possibilities for efficiency gains. More importantly, these local networks of support systems can help SMEs meet the challenges of globalization by increasing their ability to reach a global market.

SMEs’ deployment of WS-based e-business systems depends on their perception of the opportunities afforded by such systems and the relevance of these opportunities to their business. SMEs can be made more aware of the benefits and opportunities of such systems by providing more hands-on, customized delivery of information, assistance and demonstration tailored to specific business sector needs or specific business functions. Thus SMEs should promote WS through awareness campaigns within and between the enterprise clusters. Knowledge of best practice, what works elsewhere, is also important in formulating the awareness campaigns.

**Resource Allocation and Support**

As SMEs gain expertise and knowledge on WS use in their e-business environment,
they need to develop methods for monitoring and managing WS for better utilization of their resources. With any new technology, customers are first concerned about how the technology can benefit them. As the technology matures and first versions of products utilizing the technology are released, the emphasis invariably shifts to performance. Not only do customers expect the new technology to improve ease of development and interoperability but they also want it to perform at an optimum level. Through their experiences with WS technologies, SMEs need to constantly improve the methods for configuring, building, and calling WS to obtain optimal performance.

The benefits of integration and flexibility that WS bring to an enterprise are wonderful, but if an enterprise cannot determine an effective way to manage their services, the benefits are unattainable in any sort of meaningful way. Thus, it becomes paramount for SMEs to adopt a comprehensive services management solution to ensure rock solid services execution and in turn, guarantee smooth business operations for customers and partners. Such a service management solution should include components such as access mechanism — which includes authentication and authorization effectiveness; WS provisioning — which includes effective subscription, service level agreement (SLA) with the supplier, license (contract) management, monitoring, metering and billing; secure communications; and workflow management.

**Incentives and Rewards**

The WS technologies potentially facilitate a new trend towards products and services that can be designed and delivered to customers, who can pick and choose only the desired ones. To the consumers or customers, WS technologies can provide greater flexibility and promote integration. Because theoretically, customers can buy different pieces from multiple product and service providers, put these pieces together the way they want, and do not worry about the communication and interfacing problem. That is, customers can choose “best of breed” products and/or services and put them together in a way desired to build their system architecture in achieving their business and technical objectives. At the same time, due to the use of WS technologies, the cost of switching product or service providers will be reduced to minimal.

The incentives and rewards structures in SMEs should be designed around the tangible and intangible benefits that will be derived from the deployment of WS in their e-business context. The tangible benefits could include such things as reduced administrative costs, reduced production costs, reduced lead time, increased sales, and creation of additional revenue streams. The intangible benefits could include such things as quality of information, improved internal control of the business, and improved relations with business partners.

**SMEs as Web Services Supplier**

**Pricing and Quality of Service**

As WS evolve in the industry, there will be an increasing need for WS providers to create business models that will measure the value of their service. These business models should efficiently measure WS invoked by service requestors, particularly those services of high value. SMEs face several managerial challenges in creating WS pricing models, which depend on a number of factors such as reliability and security, transactions and scalability, accessibility, integrity, performance, accounting, and so on. SMEs need to gain experience in pricing and negotiating WS contracts and maintaining them over a period of time. This issue becomes even harder if different customers require different billing rates.

Current specifications don’t have an agreed upon mechanism for handling WS metering and accounting; hence, SMEs providing WS tools have to build their own solutions. This can lead to problems when moving from one vendor’s tools to another. Companies providing WS for their business partners typically do not post their services on public registries.
SMEs typically face challenges in providing adequate monitoring and billing facilities because of their lack of resources and expertise. SMEs that provide WS with a high degree of value have to develop Service Level Agreements (SLAs) or their equivalent, which implies that the parties involved have to agree to the contract. The contract lays the foundation for metering the services to be used and also include environmental prerequisites for the use of the Web service. The contract should provide details concerning the type of contract, start dates and expiration dates of the contract, time model to be used, limits to the amount of service to be provided, and security signatures or certificates for encryption and authentication. SMEs have to clearly spell out the details of the contract which is important for billing purposes and prevent inaccurate charges to the service requestor.

**Developing New Services**

SMEs need to identify how WS can truly serve the business needs of its users. They must be seen not only as a technology but also as an enabler for delivering new forms of business value. End users might not realize that WS are responsible for delivering value-added services but enterprise strategic planners and IT executives are aware of them as a fundamental way of conducting business. Hence, SMEs have to identify potential new WS that serve as the strategic enabler for delivering business services to the right person, at the right time, on the right device.

SMEs that once positioned themselves as WS companies might feel pressured to differentiate their products further as WS become standard. Emerging technologies often have life spans that match market changes. Specialized markets exist for a technology, but over time, the market expands and the technology becomes widely adopted and commoditized. Hence, SMEs need to be aware of the changes in the WS market place and make changes accordingly in terms of identifying new services.

Also, the SME sector may not have access to highly qualified software developers with WS skills and be subjected to design solutions from amateur and inexperienced designers. This may lead to WS that are highly static, not scalable, and exceedingly difficult to enhance.

**Customer Support and Feedback**

Typically, a language gap exists between SMEs promoting technical features of their products and organizations looking for business value. SMEs must better articulate the business benefits of their technologies to bridge this gap. For instance, if SMEs can back up their products’ claims using real case studies and metrics that drive home their points and provide industry-relevant details.

Problems are encountered when WS use a different platform than the client application. This leaves the developers building a client application unable to understand and appreciate the strengths and limitations of services their applications call. Typically, WS are developed and maintained by groups other than those building the application. Application developers working with WS lack insight into the application details, and even the platform upon which the service is built. Providing customer support would facilitate technical appreciation of how the Web service does its chores. This may assist with issues surrounding how to make calls to that service or help developers resolve problems that are inherent within the service itself. Hence, SMEs should allocate enough resources to help developers analyze and diagnose problems they encounter with the Web service.

Web service developers have a good understanding of what the Web service should do, and how to implement those requirements. However, they lack the real-world experience of designing an application directly in support of end users. Developers of client applications can assist WS providers by providing real-world feedback on their performance and reliability. This enables application developers to better understand Web service strengths and limita-
tions, while providing service developers with invaluable information on service use. This type of information is essential to SMEs when architecting and building new services. Service consumers can field test the work of service providers, which may provide the only true test of the Web service.

**Demand Management**

A great benefit of WS is that it can be reused. This may have unintended consequences. For example, many different consumers can reuse these services that the provider did not anticipate. Since Web service providers are loosely coupled from their consumers, a service can experience an unexpected demand as consumers increase their usage. The risk that an SME service provider faces as its services find new users is an increased risk of downtime or lower performance for critical users. The application servers used by the SMEs can address some of the risks of downtime that results from unexpected WS traffic, but not all of the risks. Thus, an SME has to create an active WS management solution that provides dynamic routing, load balancing, and prioritized messages.

**CONCLUDING REMARKS**

E-business adoption and use in organizations including SMEs have resulted in significant financial benefits to them worldwide. In recent years WS have generated considerable excitement in the global computing industry because of its promise of full-fledged application software that needn’t be installed on one’s local computer, but that allow systems running in different environments to interoperate via XML and other Web standards. The integration of WS in e-business, consequently offers an enterprise considerable opportunities for integration within the enterprise, either with legacy applications or new business processes that span organizational silos.

However, WS computing offers significant technical and managerial challenges to its stakeholders — suppliers, consumers and standards organizations — as they determine how to help leverage the emerging technologies to create service components and automate individual applications. WS technologies are maturing and industry analysts predict that the market for WS components is either about to take off or has already arrived. This study investigated the challenges that exist for each of the stakeholders and presented a framework that organized and interrelated these challenges in an easily understandable manner to help study the factors that impact the deployment of WS. SMEs were studied and then analyzed using the framework to provide insights into the managerial challenges they need to overcome to deploy WS-based e-business systems. It was suggested that SMEs should start deployment of these technologies now, but they should start within the firewall, inside the enterprise, and work outwards as they gain experience and knowledge along the way.

The challenges framework presented in this paper is by no means exhaustive; however, it does provide a useful insight into the factors that impact the deployment of WS. The next stage of our research is to investigate some of these factors in more detail. We expect this article to shed some light for researchers and practitioners to better understand the important issues and future trends of Web services-based e-business systems.

**REFERENCES**


Ranjit Bose is a professor of management information systems and holder of Albert and Mary Jane Black endowed professorship at the Anderson School of Management of the University of New Mexico. He has received his BTech and MTech from Indian School of Mines, India and his PhD from the University of Texas at Austin. His primary research emphasis is on the design and development of intelligent decision support and e-business systems. His research has appeared in several computer science and MIS journals.