TSINGHUA SCIENCE AND TECHNOLOGY
ISSN 1007-0214 20/26 pp383-389
Volume 13, Number 3, June 2008

Methodology for Web Services Adoption Based on Technology Adoption Theory and Business Process Analyses*

AN Liping (安利平)**, YAN Jianyuan (严建援), TONG Lingyun (仝凌云)†

Business School, Nankai University, Tianjin 300071, China;
† School of Management, Hebei University of Technology, Tianjin 300130, China

Abstract: Web services use an emerging service-oriented architecture for distributed computing. Many organizations are either in the process of adopting web services technology or evaluating this option for incorporation into their enterprise information architectures. Implementation of this new technology requires careful assessment of the needs and capabilities of an organization to formulate adoption strategies. This paper presents a methodology for web services adoption based on technology adoption theory and business process analyses. The methodology suggests that strategies, business areas, and functions within an organization should be considered based on the existing organizational information technology status during the process of adopting web services to support the business needs and requirements.

Key words: web services; technology adoption; business process; enterprise application integration

Introduction

With the rising customer expectations, higher competition, shorter product life cycles, and greater product diversity, business processes and the underlying services are constantly being removed and updated[1] to provide a sense-and-respond capability. Companies are becoming increasingly dependent on information technology (IT) to produce a variety of products in a short time at low cost. Many big companies have invested large amounts of money in enterprise resource planning (ERP) systems. However, many companies are confronted with hundreds of incompatible legacy systems. ERP systems then tend to lock companies into rigid business processes which are hard to quickly adapt to changes in the marketplace and restructuring strategies[2].

Web services are currently seen as the primary solution for dynamic integration of business functionality across the web. Web services are an architectural innovation that has the potential to alter the means by which organizations utilize information systems. Both the academic and practical literature has recognized that web services can provide interoperability among heterogeneous information systems. While there has been much research on web services technologies, architectures, and standards, there has been little research effort to address the specific issue of web services adoption in an organization[3]. Implementation of any new technology requires a careful assessment of the needs and capabilities of the organization to formulate effective adoption strategies. Companies need to fully understand the business value of these new technologies and the impact that they will have within their organizations.

Chen et al.[3] identified critical factors necessary for the successful adoption of web services technologies in the three dimensions of intranet, extranet, and Internet.

Received: 2007-06-06; revised: 2007-12-10
* Supported by the National Natural Science Foundation of China (No. 70471040)
** To whom correspondence should be addressed.
E-mail: anliping@nankai.edu.cn; Tel: 86-22-23506041

A model was presented to measure the IT sophistication by considering the relative importance of various factors and their current level of diffusion within the organization. Chen et al.[3] then provided simulation results to find the most cost-effective strategy for allocating resources to pursue web services adoption.

Chen[4] created a model for XML and web services technology adoption to analyze the factors affecting various adopters at various stages of e-business standards adoption. The five adopter categories in this model, innovators, early adopters, early majority, late majority, and laggers, refer to individuals or organizations who decide to adopt a standard or technology during the five phases of the technology adoption life cycle. Chen identified several factors affecting the adoption and diffusion decisions. The input factors that directly influence the adoption decision process are grouped into the three categories of stakeholders, organizational factors, and IT standards characteristics.

These studies have addressed the factors that influence the adoption of web services. Further research is needed to investigate the adoption decision and implementation process during web services adoption. This paper describes a systematic methodology for prioritizing the options related to web services adoption to provide a practical plan for implementation of the new architecture.

1 Web Services Programming Stack and Architecture

According to the W3C Architecture Working Group[5], web services are software applications identified by a universal resource indicator (URI), whose interfaces and bindings are capable of being defined, described, and discovered as XML artifacts. A web service programming stack is a collection of standardized protocols and application programming interfaces[6] as shown in Fig. 1.

The foundation layer for the web services programming stack is the basic Internet using transport layer protocols such as TCP/IP, HTTP, and SMTP. All web services must be available over some network.

On top of the networking layer is an XML-based messaging layer based on the simple object access protocol (SOAP). SOAP is an XML protocol that specifies the format of messages exchanged between the service requestor, the service provider, and the service registry.

Standards	Layer of services	Enterprise-class infrastructure
WSFL	Service flow	Quality of service
UDDI	Service discovery	
UDDI	Service publication	Management
WSFL	Service description	
SOAP	XML-based messaging	Reliability
HTTP, SMTP, FTP, E-mail, etc.	Networking	Security

Fig. 1 Web services programming stack

The web service description language (WSDL) is the service layer specification standard that describes available web services to clients. A WSDL description of a web service provides all the information needed to actually invoke it.

The universal description, discovery, and integration UDDI defines a standard method to publish and discover information about web services. The publication of a service makes the WSDL document available to potential service requestors by the service provider. Companies use public UDDI directories to register their businesses and services or set up private UDDI systems for internal integration projects. The discovery of a service is any action that gives the service requestor access to the WSDL for a service.

The highest layer, i.e., the service flow layer of the stack, facilitates the composition of web services into workflows and the representation of this aggregation of web services as a higher-level web service.

In addition, the system must supply an enterprise-class infrastructure including quality-of-service, management, reliability, and security as represented on the right side of Fig. 1.

These sets of standards form a service-oriented architecture (SOA)[7,8] which is a strategic technology framework that allows all interested systems to expose and access well defined services. This architecture involves the three roles of service registry, service provider, and service requestor, as shown in Fig. 2.

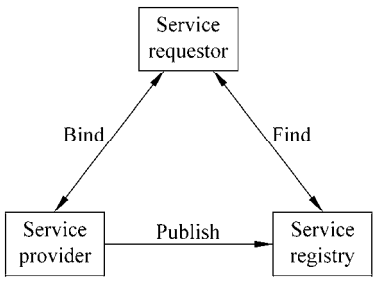

Fig. 2 Service-oriented architecture

A service provider publishes its services to WSDL files in a service registry based on the UDDI. The service registry holds all the information about all the available services. A service requestor uses the service registry to find an appropriate service via the UDDI interface. A service registry returns the matched universal resource locators (URLs) of WSDL files requested by the service requestor. Then, a service requestor sends a request to a web services provider to obtain a WSDL file.

The requested WSDL file is returned by the service provider to the service requestor. The service requestor then uses the WSDL file to generate the necessary web service client-side stub to bind to the web service that provides the functions defined in the WSDL file. The service requestor sends a SOAP request to the service provider to invoke a function provided by the web service.

An organization can integrate its internal business processes with its partners' applications and data sources published as web services and can externalize the business processes as web services to its partners. Web services are independent of any programming languages and platforms and can be invoked by applications developed using different technologies.

2 Methodology for Adopting Web Services

According to Checkland[9], a methodology is defined as a collection of problem-solving methods governed by a set of principles and a common philosophy for solving targeted problems. The methodology for web services adoption consists of five stages: finding preferred strategies for web services adoption, decomposing and documenting current processes, determining where and when to use web services, integrating via web services, and defining, decomposing, and documenting the future states of the web services.

2.1 Finding preferred strategies for web services adoption

Web services are an architectural system that alters the means by which organizations utilize information systems[10]. Thus, organizations need to evaluate the implications of web services on their enterprise information architecture in view of the economic, technological, and organizational effects to formulate the proper adoption strategies.

In most cases, the primary motivation to consider the use of web services starts with a strategic plan which leads to systems development initiatives. A company needs to fully evaluate its current position in the technology adoption space, understand the business value and the impact of the new techniques, measure the resources that the company would need to adopt the web services, and understand the cost savings and other value generation opportunities. The next step is to decide on an effective adoption strategy.

Chen et al.[3] considered that companies with higher levels of IT sophistication required fewer resources to adopt web services technologies. Hence, they first identified the organizational and technological factors that collectively determine the level of IT sophistication in a company. They organized these factors into the three application domains of intranet, extranet, and Internet. Then, they investigated three different scenarios: HW-HD scenario, LW-LD scenario, and HW-LD scenario, where HW and LW refer to high weight and low weight and HD and LD refer to high diffusion and low diffusion. Once an organization evaluates its current position in the technology adoption space, the next step is to determine an effective strategy to achieve the desired level of sophistication. Their simulation results for strategies for different scenarios suggest that it is better to focus on the dimension that needs the most improvement in both the HW-HD and the LW-LD scenarios; while in the HW-LD scenario, the preferred strategy is to spend resources on the factor that has the highest overall importance. The framework to illustrate the relationships between factors and the web services adoption strategies is shown in Fig. 3.

Because web services are based on open standards, companies can implement web services in an incremental way or a staged approach, which allows a company to shift its IT architecture slowly, avoiding disruption and focusing only on systems that will deliver real economic paybacks at each stage of development[2]. For example, General Motors (GM) Corporation used web services to enhance its traditional build-to-stock model at the first stage. The incremental or staged approach provides the basis for the methodology described here.

The following sections describe how to determine

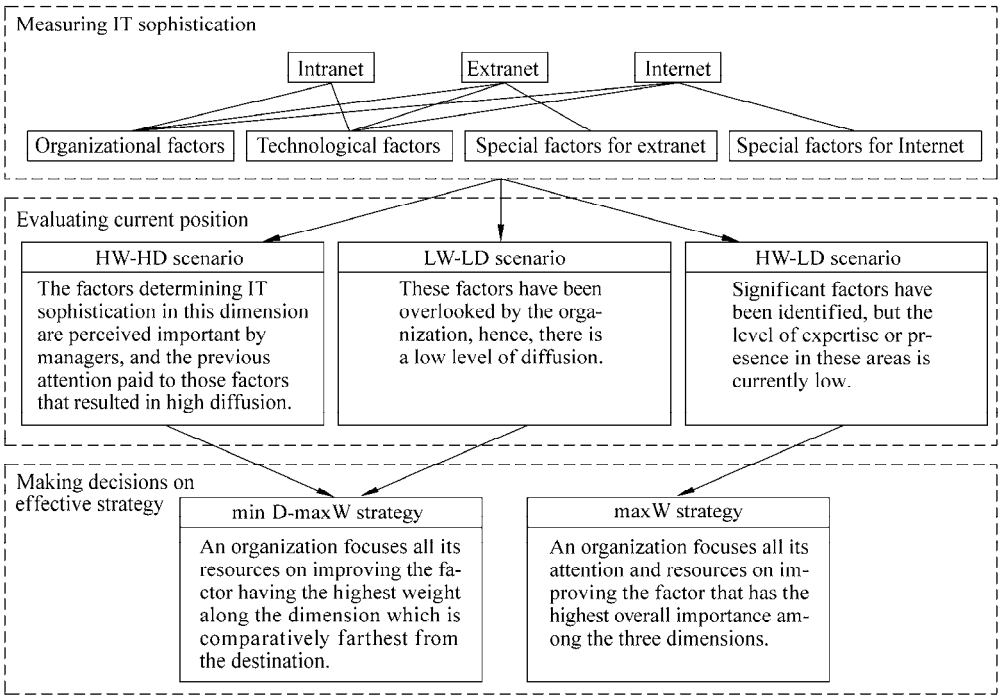

Fig. 3 Strategy formulation for web service adoption

which system or functions are to be redesigned via web services. The analysis is based on a business process analysis[11].

2.2 Decomposing and documenting current processes

An information systems strategy plan defines an overall vision and architecture for the information systems[12]. This architecture frequently includes an enterprise process model which typically identifies only the business areas and functions within an organization, such as marketing, production, finance, accounting, and human resources. Priorities are usually based on which business areas, functions, and supporting applications will return the most value to the business as a whole. Business areas and functions are then prioritized into application development projects with detailed processes rarely examined in the enterprise process model.

Business areas and functions may consist of a number of processes and activities. The process can be decomposed into several parts by defining a hierarchical process tree where the top node in the tree represents the entire process. The top node is then decomposed into many parts which in turn are broken into further parts as shown in Fig. 4. This may result in several thousand activities as one of the most time consuming steps in the methodology. Some of the processes and activities can be defined as individual web services through functional decomposition.

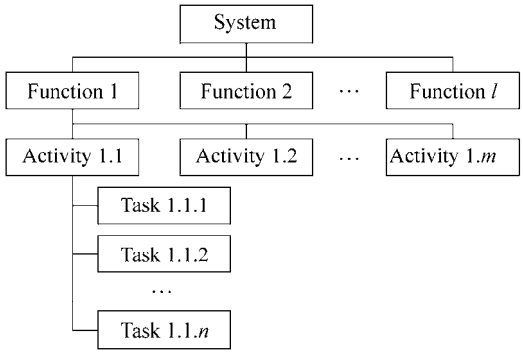

Fig. 4 Functional decomposition

2.3 Determining where and when to use web services

The company then needs to determine where and when to use web services for the decomposed processes. Most new technologies are adopted to increase revenues, reduce costs, or improve customer satisfaction. In addition to such high-level goals, Mackay[13] summarized the following four major web services project objectives after studying more than 60 cases:

(1) Real-time application interoperability gets applications from heterogeneous business systems to provide services to each other in real time.

(2) Common business services aggregate individual back-end application capabilities into grained business services used by multiple front-end systems.

(3) Architectural agility develops an agile and responsive application infrastructure where required changes can be quickly implemented.

(4) Customer or partner self-service gives customers, partners, and branch offices secure access to company data to improve service levels, reduce costs, and/or increase revenue opportunities.

2.4 Integrating via web services

Web services enable individuals and organizations to integrate business processes, functions, and data sources within and across the organization in a ubiquitous fashion. The three types of integration used by companies are business to business (B2B) integration[14], internal integration, and multi-channel implementation[15] via web services.

2.4.1 B2B integration

Business partners can integrate transactions based on agreed web services standards for each step in a business process to reduce custom business processes. Companies can provide web services to others in areas in which they have distinctive expertise while at the same time buying web services in areas in which they lack special skills[2]. Thus, a company switches its role between the service consumer and the provider.

Most inter-enterprise applications, including private trading exchanges, procurement services, and supply chain management services, add new functions to attract and retain customers. Many companies source these services from specialized providers because they are more efficient to dedicate their scarce resources to acquiring customers. Web services for functions like invoicing, payments, and logistics are critical to these companies. As a service consumer, a company consults its favorite UDDI directory to find potential business partners that offer such services and then contract with a service provider for the required services based on their criteria.

For example, a travel agency may use various third-party vendors for hotel reservations, car rental reservations, and flight booking. The hotel reservation, car rental, and flight booking companies register their offerings as web services in a UDDI registry. The travel agency uses these registry services as a part of its internal workflow as shown in Fig. 5.

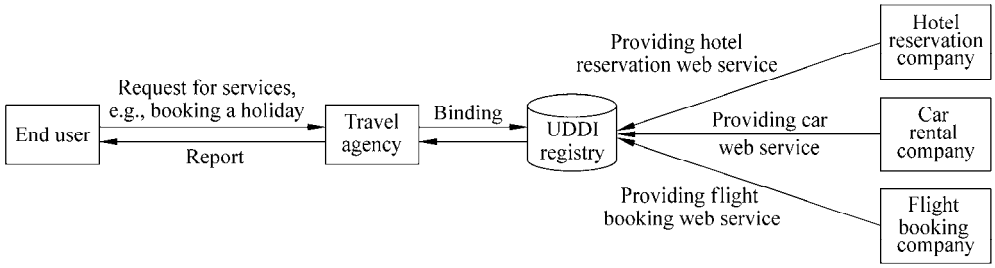

Fig. 5 Example of B2B integration

This architecture provides a platform for service providers to offer their core competencies as services to other companies. Smart businesses not only consume web services, but also sell them[2].

2.4.2 Internal integration

Internal integration involves integrating heterogeneous systems and legacy applications, and automating internal business processes.

Most existing businesses have heterogeneous systems and legacy applications and data with many internal systems running on different platforms and using different languages provided by various vendors. Combining applications that support the same business function into one system requires costly and lengthy redevelopment efforts. Instead, these existing systems can be replaced by a set of reusable web services that can be consumed by composite business applications. For example, a company can use web services to transfer the order processing capability to small customers so that the sales force can have more time for account management.

Web services provide a simple solution to automating internal business processes. With the development of mobile businesses (m-business), data should be

accessible at anytime and from anywhere by field staff remotely through wireless networks using various hand-held devices, such as cellular phones, personal digital assistants (PDAs), and notebook personal computers. The use of web services can greatly simplify the integration process. For example, a major insurance company uses web services to unify its customer data from multiple systems into a single view for its sales and service staff.

In addition, for multi-channel implementations, extended integration across various parties and supply chains allows re-tooling of their existing applications across different channels to adapt to business innovations and extend the reach of systems[15].

2.5 Defining, decomposing, and documenting the future state of web services

A company then needs to envision a future world where web services will be utilized to replace various functions and activities within its system. Because a company cannot predict the future, it is desirable to determine a few future states. For example, one can assume that web services are broadly adopted by the industry or they are only used within a company. Some of the analysis steps may be iterated until a satisfactory result is obtained depending on the results of a process performance analysis.

3 Case Study of B2B Integration: Sabre's Step-by-Step Web Services Adoption

This section describes a case study of Sabre, a premier provider of travel services to various businesses and travel agencies[16,17]. Prior to the web services implementation, Sabre's customers had to seek the needed data and then code the data to a specific format to obtain structured information. This multi-step process severely complicated integration of the content into customer's applications.

To help Sabre's customers reduce the complexity and expense of accessing their online products and services, a web service research and development project effort was begun in 2003. Web services were used to give business partners flexible, direct access to their air, car, and hotel bookings and other travel services. Business partners can tap Sabre travel services without knowing how Sabre's back-end systems work. For travel agents, airlines and other travel services companies, the web services provide faster and easier access to Sabre's global electronic travel reservation system. The costs of handling web services-based transactions are much lower and the bookings are more efficient. Today, Sabre offers more than 50 products and services to its clients through web services, including fuel and inventory management tools for airlines.

The number of agents and customers using web services-driven online reservations engines, call center systems, and other applications has risen 500% since early 2005. Sabre expects to add 300 new online customers over the next three years. Web services have enabled Sabre to create business models for its products based on its clients' abilities to obtain information themselves. This has allowed Sabre to attract more customers while providing its existing customers more flexibility in integrating its content into their systems and business activities.

Although web services provide an opportunity to break away from its decades-old approach of delivering mainframe-based services to travel industry customers, Sabre does not have any immediate plans to discard its mainframes. The company is going to take a while to transit its customers off the mainframe because of a high volume of data and applications. Some of the services that Sabre has moved on to its midrange platforms include its airfare and hotel shopping and pricing systems. In the future, Sabre plans to add other capabilities for its customers and will emphasize orchestrating various functions through web services, such as the ability for travel agents to easily shop for airfares and hotel rates at the same time.

4 Conclusions

Web services are maturing as an accepted technology but companies need to determine when and where to use web services. This paper presents a methodology that supports the potential deployment of web services to meet strategic company goals. The methodology helps organizations launch web services initiatives to make timely adoption decisions and formulate appropriate adoption plans. Two of the most important advantages of the web services architecture are its openness and modularity. Therefore, an enterprise may lay out a step-by-step approach for adopting the new

architecture to mitigate the potential for organizational disruption and enable the organization to focus initially on opportunities that give immediate efficiency.

In addition, the successful introduction of the web services technology requires careful consideration of organizational changes. People within the enterprise and in extended enterprise partners must be prepared to understand how to effectively utilize the technology, how it will enable them to better fulfill their roles and responsibilities, and how the technology enables the company's goals and objectives.

References

[1] Blake M B, Gomaa H. Agent-oriented compositional approaches to services-based cross-organizational workflow. *Decision Support Systems*, 2005, **40**(1): 31-50.

[2] Hagel III J, Brown J S. Your next IT strategy. *Harvard Business Review*, 2001, **79**(9): 105-113.

[3] Chen A, Sen S, Shao B. Strategies for effective web services adoption for dynamic e-businesses. *Decision Support Systems*, 2006, **42**(2): 789-809.

[4] Chen M. Factors affecting the adoption and diffusion of XML and web services standards for e-business systems. *International Journal of Human-Computer Studies*, 2003, **58**(3): 259-279.

[5] Booth D, Haas H, McCabe F, Newcomer E, Champion M, Ferris C, Orchard D. Web services architecture. The World Wide Web Consortium (W3C). http://www.w3.org/TR/2004/NOTE-ws-arch-20040211, 2004.

[6] Gottschalk K, Graham S, Kreger H, Snell J. Introduction to web services architecture. *IBM Systems Journal*, 2002, **41**(2): 170-177.

[7] Burbeck S. The Tao of e-business services. http://www-4.ibm.com/software/developer/library/ws-tao/index.html, 2000.

[8] Leymann F, Roller D, Schmidt M T. Web services and business process management. *IBM Systems Journal*, 2002, **41**(2): 198-211.

[9] Checkland P. Systems Thinking, Systems Practice. Chichester and New York: John Wiley & Sons, 1981: 1-330.

[10] Estrem W A. An evaluation framework for deploying web services in the next generation manufacturing enterprise. *Robotics and Computer-Integrated Manufacturing*, 2003, **19**(6): 509-519.

[11] Subirana B, Eckes C, Herman G, Sarma S, Barrett M. Measuring the impact of information technology on value and productivity using a process-based approach: The case for RFID technology. MIT Sloan Working Paper, No. 4450-03, 2003.

[12] Whitten J L, Bentley L D, Dittman K C. Systems Analysis and Design Methods, 5th Ed. New York: McGraw Hill, 2001: 305-361.

[13] Mackay J. Patterns in web services projects. http://java.sys-con.com/read/39757.htm, 2003.

[14] Shah J, Murtaza M. Effective customer relationship management through web services. *Journal of Computer Information Systems*, 2005, **46**(1): 98-109.

[15] Accenture. Web services and enterprise integration: Friends not foes. https://www.accenture.com/ NR/ rdonlyres /606D3027-FCCB-4BB5-A995-768342F4BD24/0/web_ enterprise.pdf, 2002.

[16] Hoffman T. Sabre's web services journey: A three-year effort transforms customers' businesses. http://www.computerworld.com/action/article, 2007.

[17] Tonkel J. Flexibility, finances key to web services adoption. http://www.computerworld.com/developmenttopics/development/webservices/story/0,10801,95745,00.html, 2004.