Editorial

Web services and process management: a union of convenience or a new area of research?

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Abstract

Two recent trends are reshaping the research landscape in business process management. One such trend is the adoption of process-driven application integration by major e-business middleware vendors, and the other is the advancement of web services as a universal computing platform. In this paper, we investigate the impact of web services on business process technologies and present our viewpoints on research directions in business process management in the presence of web services. Finally, we introduce the papers published in this Special Issue on Web Service and Process Management.
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1. Introduction

Web services have been hailed as the new industrial standard for distributed computing and are considered, for the first time, a real opportunity to achieve universal interoperability. However, the value of web services goes far beyond merely to enable universal interoperability. In this paper, we investigate the impact of web services on business process technologies and present our viewpoints on research directions in business process management in the presence of web services.

We first recognize the recent surge of research in web services and describe the main achievements in this area in Section 2. We then discuss in Section 3 the renewal of interests in process management research induced by its unique role in the development of web services. In Section 4, we examine the unique relationship between web services and business process management and discuss the research directions in this area. Finally, Section 5 introduces the papers published in this special issue.

2. The surge of research in web services

Recently, there has been a surge of web services research. This dramatic increase of research interests in web services is clearly indicated by the increasing number of publications during the last few years. Table 1 summarizes the results of search on the phrase "web services" that appears in the abstracts of the journal and conference articles indexed in the three major reference sources—the IEEE Xplore, the ACM Digital Library, and the INSPEC index database. As

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Table 1
Number of "web services" articles in three major digital libraries

Year	IEEE Xplore	ACM DL	INSPEC	Total
1995	2	5	3	10
1996	5	4	7	16
1997	6	6	15	27
1998	6	12	17	35
1999	15	14	17	36
2000	15	61	25	101
2001	54	97	56	207
2002	149	161	207	517

shown, there appears to be an exponential growth of articles according to the three reference sources, and this trend becomes particularly apparent from 2000 to 2002.[1] We choose these three reference sources because they are widely recognized as the best sources for literature in information technology. Although the articles quoted in INSPEC do overlap somewhat with those in IEEE Xplore and ACM Digital Library, the former include journals and conferences focusing more on applications. There is little overlap between the articles in IEEE Xplore and ACM Digital Library.

A web service is a "software application identified by a URI, whose interfaces and bindings are capable of being defined, described and discovered by XML artifacts, and which supports direct interactions with other software applications using XML based messages via internet-based protocols" [21]. According to a recent survey by Delphi Group, 14% of organizational respondents had web services initiatives underway to expose APIs, services and/or content to their business partners, 8% had initiatives to share software with business partners as web services, and 33% were actively engaged in using web services to support the integration of internal applications [2].

Web services represent the latest approach to address the integration of enterprise applications, a core challenge of corporate information technology [10]. As the business world moves towards globalization, firms are expanding their territories into new markets abroad to create growth. Supply chains are being established with partners spanning different geographical regions to increase sourcing efficiency.

To reap the full benefit of globalization, a firm oftentimes needs to standardize or reengineer its business processes, which calls for the "integration" of various Information Systems built on different platforms at different times. Further, the globalization of business requires a distributed computing environment that allows companies to take advantage of the computing power at various operational units regardless of the geographical location. One popular answer to the quest for integration in the 1990s was to implement a company-wide enterprise resource planning (ERP) system. It becomes well known now that the ERP system implementation entails tremendous human and financial resources at unacceptably high risk of failure.

Today, the web services technology helps streamline business processes by creating an open, distributed system environment and promises to reduce the cost of business process management because it enables dynamic process integration without "hardwiring" the code [6]. As a result, firms are no longer locked into the products from a single company, thus enhancing the flexibility of the Information Systems.

Web services grew out of numerous past efforts directed at the collaboration and interaction among heterogeneous systems such as RMI (Remote Method Invocation) by Sun, CORBA (Common Object Request Broker Architecture) by OMG, DCOM (Distributed Common Object Model) by Microsoft. As a result, web services have gained industry-wide acceptance as the universal standard for enterprise integration [8].

Web services consist of a set of universally agreed specifications including XML (eXtensible Markup Language), SOAP (Simple Object Access Protocol), WSDL (Web Services Description Language) and UDDI (Universal Description, Discovery and Integration) [3,20]. The self-describing nature of XML and WSDL allows disparate software components to understand each other. The messaging protocol SOAP supports the interaction between software components via RPC-like communication. UDDI represents a set of protocols for the description, registration, lookup and integration of software components.

In sum, web services provide a new standard for enterprises to build a cost-effective application integration infrastructure and create a universal computing environment where all computer programs can communicate with one another from anywhere at

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[1] We did not include results of 2003 since not all articles of 2003 have been indexed yet when the search was done at the start of 2004.

anytime. The web services standard represents a platform neutral and language independent technology that is capable of enabling new strategic e-business partnerships, creating new service-oriented businesses, and developing a third party software marketplace based on an open standard.

3. The renewed interest in process management research

Process management has been a steady research area for quite a few years as indicated by the number of publications during the last eight years. Table 2 summarizes the results of search on the phrase "process management" that appears in the abstracts of the journal and conference articles indexed in the three reference sources—the IEEE Xplore, the ACM Digital Library, and the INSPEC index database. Interestingly, research in process management shows significant increase, i.e., renewed interest, since 2001 (see the total number of articles in Table 2). Although the articles quoted in INSPEC overlap somewhat with those in IEEE Xplore and ACM Digital Library, the total should still be meaningful as an indicator to the trend of research in process management.

An area of research closely related to business process management is workflow technology. In fact, workflow technology has become the de facto standard for process management [17]. As a research area, workflow technology is arguably narrower than process management, and "process management" includes broader contents than "workflow technology". During our search, we noticed that most of the papers that include "workflow" also contain "process

management". However, we use the two terms interchangeably in this paper wherever appropriate.

As part of the web services development, two recent trends are renewing the research and development efforts in business process management. One such trend is the adoption of process-driven application integration by major e-business middleware vendors, and the other is the web-services-oriented process integration.

Process-driven application integration is a new paradigm for application integration where a workflow engine is utilized as a hub or exchange and a process model is used to drive the flow of applications. This paradigm has been embraced by the software industry, for example by IBM through its WebSphere software, by BEA through its WebLogic platform, and by Oracle through its ERP systems. Because of the reliance on the process model, process-driven application integration is also referred to as model-driven application integration in the industry. Researchers in the area of workflow technology have also been paying attention to application integration recently. For instance, Stroulia and Hatch [19] developed a software framework that integrates services of existing web applications, which was built on an integration workflow that interoperates the domain model, a set of semantic constraints, the end-user profiles, and the existing web applications. Stonebraker [18] suggested the consolidation of a myriad of poorly integrated systems with overlapping functionality. He argued that workflow technology should be integrated into EAI systems to handle application integration. Kwak et al. [9] proposed a framework for workflow-based dynamic enterprise application integration based on four major components, i.e., the workflow engine, adapter, service interface repositories, and XML messages. Based on a case study in telecardiology, Ganguly et al. [5] presented a workflow-based methodology for development and implementation of distributed health care applications in diagnostic instruments, medical expertise, hospital care and other related administrative services.

Most recently, web services are incorporated into the application integration platform by wrapping around existing applications. Ludascher et al. [11] studied web service workflows in scientific computing for compiling "scientist-friendly" abstract workflow specifications into real-world executable work-

Table 2
Number of "process management" articles in three major digital libraries

Year	IEEE Xplore	ACM DL	INSPEC	Total
1995	22	45	58	125
1996	33	47	81	161
1997	55	26	86	167
1998	35	42	76	153
1999	32	38	60	130
2000	36	63	62	161
2001	44	86	72	202
2002	50	106	80	236

flows of web service invocations, using a set of abstract-as-view definitions from a repository of abstract tasks. Staab et al. [16] considered web services as loosely coupled, reusable software components that semantically encapsulate discrete functionality and are programmatically accessible over standard Internet protocols. They also noted that web services per se do not offer a solution to underlying problems in application integration and need to be studied along with workflow and grid computing. Ganesarajah and Lupu [4] noted that companies are competing to provide workflow-based tools for web service integration. They developed a prototype workflow management system for building new web services from a workflow of existing web services. Preuner and Schrefl [13] studied how companies can import and integrate web services from other companies into their own workflows. They presented a design architecture that satisfies service independence and level-specific integration for various business purposes. Yang et al. [22] explored the characteristics of service composition and provided a framework for classifying different scenarios of service composition by extending workflow integration. Shegalov et al. [14] proposed an architecture consisting of an XML mediator that handles the exchange of business and flow control data between workflow and business-object servers on the one hand and client activities on the other via XML messages over HTTP.

Process-driven web services have been considered as the technological foundation for service-oriented computing. Service-oriented computing means that services offered by different enterprises can communicate with one another over the Internet, leading to a distributed, open computing infrastructure for both intra- and cross-enterprise application integration and collaboration. Papazoglou and Georgakopoulos [12] defined services as ''self-describing, open components that support rapid, low-cost composition of distributed applications.'' Service-oriented computing also means that services must advertise their service capabilities, interface, behavior, and quality such that users can discover, select, bind, and compose services efficiently. Other metrics that must be given to the users include the behavior, quality of service, security, integrity, reliability, scalability and availability. Casati and Shan [1] argued that under service-oriented computing, there is a closer relationship between IT and

business operations. This is because web services are typically at a higher level of abstraction in comparison to traditional middleware objects such as CORBA objects, and are often used to support business-to-business interactions. The authors developed a framework known as Web Service Manager based on existing web service standards, which can facilitate the specification of business properties and enable the definition and computation of business-level metrics.

In summary, workflow and web services are being merged into a new research area, called web services composition, or web services choreography, particularly in the context of service-oriented computing. In many ways, this has made process management a more prominent research area in recent years.

4. Web services and process management: the relationship revealed

4.1. The web services effects

We envision three types of effects resulting from the application of web services:

- *Interoperation effect*: the universal standard for remote invocation. Clearly, by taking advantage of the two universal standards, namely, HTTP protocol and the XML language, the SOAP protocol enables the remote invocation of any programs running in any computing environment. This allows the communication of any two programs on the Internet regardless the programming language and the operating system on which the programs are built. We call this as the interoperation effect because it represents the most basic value of web services.
- *Architecture effect*: the simplification of application architecture with standard APIs. Given that web services allow the interoperation of any two programs using a single standard, i.e., SOAP based on HTTP and XML, companies can now integrate up and down the supply chain and within the organization without having to develop various interfacing methods based on proprietary APIs. To the developer of an application, web services make it possible to ''develop once and use anywhere and on any platform''. This reduces the dependency of

various development efforts and therefore simplifies the system architecture.

- *Infrastructure effect*: the enablement of service-oriented computing. Web services not only provide a universal standard for remote invocation that leads to simplified system interoperation, but also enable a new type of computing infrastructure, namely, service-oriented computing. Service-oriented computing promises to revolutionize the way software components are developed and used. Under service-oriented computing, software development will become more collaborative since the system architecture will include many services provided by numerous providers. Therefore, the concepts and techniques of process management are instrumental to service-oriented computing, including role specification, process coordination, activity monitoring, and process integrity control [12].

4.2. A union of mutual benefits

There appears to be an intimate coupling between the web services technology and process management in terms of both research and development. The question is whether this coupling is a temporary convenience or a long-term union. The answer is the latter because the three web services effects discussed above give rise to new ways of developing the next generation of process management systems. The interoperation effect of web services applies to workflow systems because it makes easier the development of distributed workflow systems. Until now, distributed workflow systems have not been researched extensively in the literature because of difficulties of interoperating heterogeneous workflow systems [23]. For instance, interoperating a workflow system from Oracle and one from IBM can prove to be a challenge. The architecture effect of web services is pronounced in workflow technology because the very nature of workflow is to coordinate among many resources that are either Information Systems or human agents. The business process execution language (BPEL) as part of the web services standard makes it possible to design workflow systems with an open architecture [7]. The infrastructure effect of web services also permeates into the workflow systems. Based on the

service-oriented computing philosophy, process management can be provided as a service to the business partners. For instance, an e-market can provide e-services to support dynamic trading processes [15]. With web services, it is much more cost-effective to support dynamic trading services because the trading partners can speak the same process language and possibly use the same process interfaces across companies and electronic markets.

However, what makes process management unique since any area of software technology can benefit from the three effects of web services? The answer lies in the unique capability of workflow as a coordination technology. As aforementioned, web services can be integrated into composite web services. However, because of the various quality-of-service, reliability, and availability issues, the integration of web services has to be done dynamically to allow real-time management of services. This is a perfect task for workflow technology since it is designed for coordinating the access of resources by means of role resolution and late binding. Therefore, workflow technology plays a unique role in the development of web services-based applications. Consequently, we can declare that the close relationship between web services and process management is a union of mutual benefits.

4.3. Research directions in web services and process management

We view the intersection of web services and process management as a hybrid area of research because of the natural union between the two research domains. For simplicity, we refer this intersection as "process web services", or simply process services. We envision three types of research in the area of process web services, namely, technical foundation, architecture and application development, and strategic analysis. Naturally, we must admit our MIS bias in our analysis here since our computer science counterpart will most likely ignore the strategic analysis as it is outside the scope of science or engineering.

- *Technical foundation*. While the basic components of web services are in place such as SOAP, WSDL, UDDI, and BPEL, many fundamental issues remain unresolved such as security, reliability, quality-of-

service, payment mechanisms, and composition. Therefore, research is needed to bring these issues of standards into the context of process management to support business process automation.

- *Architecture and application development.* New system architectures need to be designed and experimented that will support significant business areas such as e-market, supply chain automation, and customer relationship management. Many potential business applications can be developed by a combination of web service and process management techniques. This line of research may focus on a particular type of applications.

- *Strategic analysis.* Companies will need to know the costs and potential impact of adopting process services. For instance, while the technique of combining two web services into one service is readily available, a company must know whether or not integrating two web services will be beneficial to the business. Therefore, research is needed to examine the various conditions under which company might form alliance. In addition, it is also beneficial to study the best practices and the necessary conditions for a company to adopt process web services successfully.

5. Conclusions

In this paper, we examined the surge of research interests in web services and those in process management. We found that web services and process management are easily blended into a hybrid area of research because not only web services give new meaning to various existing workflow issues but also workflow is a natural candidate technology for web services choreography.

This special issue includes seven fine research articles that were selected among 36 submissions after several rounds of reviews by the guest editors and other reviewers. These articles can be categorized into the three research directions, namely, technical foundation, architecture and application development, and strategic analysis.

- zur Muehlen et al. examined the development of process management standards in the context of workflow development based on web services. They investigated two opposing types of standards: those based on SOAP, with tightly coupled designs similar to remote procedure calls, and those based on REST, with loosely coupled designs similar to the navigating of web links. In the context of SOAP versus REST, the authors illustrated the standardization process, clarified the technical underpinnings of the conflict, and analyzed the interests of stakeholders.

- Five of the seven articles fall into the direction of architectural design and application development. Blake and Comaa proposed a workflow-driven methodology for composing web services that span multiple, distributed web-accessible locations. In their paper, the authors investigated how to support evolvable service-based workflow composition, focusing on the internal coordination and control of software agents. Chiu et al. proposed a systematic way to perform negotiation activities over the Internet, namely, e-Negotiation. They developed a meta-model of e-Negotiation to allow flexible negotiation support for a variety of negotiation processes such as bargaining, auction, and request for proposals. Kim and Segev believed that insufficient consideration of process management aspects such as process design, description, and deployment has hindered the automation of business negotiations. In their paper, the authors studied system support and automation of business-to-business negotiations from the process management perspective and proposed a web-service-enabled marketplace architecture for negotiation process management. Kumar and Werner described an exception handling framework based on events, states, and a new kind of process called meta-workflow. They illustrated how to implement such a framework using the web services technology and argued that the framework is useful wherever coordination requirements are complex and demand flexible and adaptable processes. Sayah and Zhang introduced a web service based model for on-demand process based business collaboration, referred to as Extended Business Collaboration (eBC), and presented the major characteristics of the eBC model, including modeling, solution stack, and configurable business protocol enabling framework.

- Tang and Cheng studied the optimal pricing and location strategy of a Web service intermediary. Their analyses showed that the optimal strategy is determined by delay cost, integration cost, and prices of the constituent Web services. They concluded that the

Web service intermediary is optimally located between the Web service providers and charges a penetration price if the delay cost is low.

We sincerely hope that these seven articles will give readers some concrete idea on the research trend in web services and process management and this special issue will stimulate more research activities in this important and interesting domain. We would like to thank all the reviewers who have contributed to this special issue. Without their generous help, this special issue would not have been possible.

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