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Services computing as the foundation of enterprise agility: Overview of recent advances and introduction to the special issue

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Abstract The advancement of web services in the last few years has spurred a number of revolutionary concepts in information technology and management including service-oriented architectures, service-oriented computing, and services science, management and engineering, which can be collectively called as "services computing." Services computing is a new research field that goes beyond traditional computing disciplines as it includes not only architectural, programming, deployment, and other engineering issues, but also management issues such as business component modeling, business process design, and service delivery. In this paper, we provide an overview of emerging research concepts in services computing without attempting to unify them as it will take sometime for the field to become mature. In addition, we take a position that the ultimate goal of services computing is to create the necessary technological and managerial foundation to support enterprise agility. In this short paper, we give an overview of services computing, describe its relationship to enterprise agility, and discuss basic technical and managerial issues. Finally, we introduce the papers that are published in this special issue.

Keywords Agile enterprises · Services computing · Service-oriented architecture · Service-oriented computing · Services science · Service science, management and engineering (SSME) · Web services

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1 Introduction

Web services technology has been embraced by the industry as the new standard for enabling an organization to transact with its partners over the Internet in support of its overall business strategy. The International Data Group estimated that the total software, hardware and services opportunity derived from Web Services will rise from USD1.6 billion in 2004 to USD34 billion by 2007. According to a survey by Delphi Group in 2002, 14% of the organizations surveyed had web services initiatives underway to expose their application programming interfaces to their partners, 8% had initiatives to share software with business partners as web services, and 33% are actively engaged in using web services to support the integration of internal applications (Delphi Group, 2002).

Web services are the new industrial standard for distributed computing and are considered, for the first time, a real opportunity to achieve universal interoperability. Besides enabling such interoperability, web services can also be used as communication protocols for efficient and effective business application integration. At the same time, just with any new technology, these web services also bring with them some computational complexities and business challenges. For instance, while it is easy to generate a few web services, transforming business processes into web services and harnessing the integration of many hundreds of such web services for effective application development and integration remain an open question.

While the web services technology has created a new industrial standard for business application integration, its role in the broader area of services computing is least understood. Before we discuss this, we need to understand the differences between service technology and services computing. In its elemental form, service technology is any information technology that enables a business function or process to act as a "service," which can be called up and executed on demand. Obviously, "web services" is one illustration of a service technology. The goal of services computing, however, is the use of information technology (IT) to allow an enterprise to act like a "service provider." For example, an enterprise may want to offer its procurement functions such as procuring an item as "services on demand." This will require that many business processes (e.g. select a vendor, place an order, and check shipment) to be rendered as "services." This implies that these services must be integrated dynamically to meet changing customer demands. The ability of creating and restructuring these services is also called "business agility" as discussed in the next section.

In summary, service computing covers the entire lifecycle of business processes that are offered as services by an enterprise, and use various service enabling technologies such as web services, service oriented architecture to meet the enterprise needs. In many ways, this is similar to the way information technologies such as data bases, client-server architectures, and application software were used to make business processes become efficient (Stohr & Zhao, 2001).

As illustrated in Fig. 1, services computing has emerged as a new field of research as indicated by a recent surge of publications in this area. Both IEEE Computer and Communications of the ACM published special issues in October 2003 on web services and service-oriented computing. The Communications of the ACM published another special issue on Service Science, Management, and Engineering in July 2006. However, the concept of "service-oriented communication" was mentioned as early as in 1997 (DeVor, Graves, & Mills, 1997). Since services computing is not yet a mature discipline, there are many new concepts that are not yet clearly aligned, leading to certain conceptual confusion. By describing the emerging research concepts in services computing, this paper should help illuminate their relationships, without attempting to unify them.

Next, we take a look at why a service-centric approach is critical to enabling organizations to react quickly to changes in the market place. In the third section, we then define various features of services computing and show how some of the service-oriented technologies, such as web services and service-oriented architectures fit into the field of services computing. The fourth section provides a review of the articles published in this special issue. Finally, we conclude the paper in the last section.

2 Enterprise agility and services computing

Gartner defines enterprise agility as "the ability of an organization to sense environmental change and respond efficiently and effectively to that change" (McCoy & Plummer, 2006). Agility has been embraced as the new manufacturing philosophy for companies seeking to compete successfully in an uncertain and unpredictable business environment (Hooper, Steeple, & Winters, 2001). In a case study, Hooper et al. revealed that the adoption of activity-based costing (i.e. relating each activity to the contribution it makes to corporate profitability) enables a company to become customer centric and more agile, as it allows identification and elimination of waste in the manufacturing process. Among other factors, agility requires flexible human resources, flexible manufacturing systems, and decentralized organizations and external partnerships with suppliers.

Agile manufacturing has long been recognized as a new expression for an enterprise that states it has the ability to produce goods and services in the presence of continuous change. If an organization is to remain agile to meet continual change of customer demand, not only does it need agility in its ability to manufacture a product with minimal waste, but it also needs agility in its entire value chain—from the time an order is received to the time it is fulfilled, including product configuration, manufacturing, procurement and distribution. In fact, many electronic firms (such as Dell) are meeting these agility challenges by leveraging Internet technology for communication and inter-organizational process integration. Both "information architecture adaptability" and "service-based communication" (DeVor et al., 1997) are key to support manufacturing agility. The goal of services computing is to enhance the information architecture adaptability and service-based communication of an organization so it can become more agile along its entire value chain.

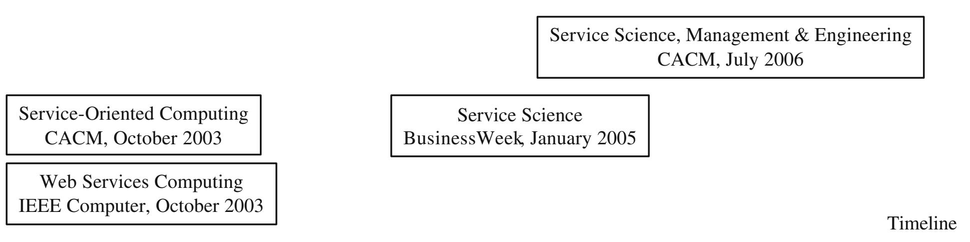

Fig. 1 Some important events in services computing publications

One key factor that influences an enterprise's agility is its ability to sense environmental change and respond readily (Overby, Bharadwaj, & Sambamurthy, 2006). While many customer relationship management technologies can help a firm sense changing customer preferences on product content and delivery expectations (service needs), an organization's ability to react to these changes is often impeded by poorly architected information systems and technologies. For example, monolithic IT architectures limit the range of responses available to an organization to adjust its processes, thus resulting in high costs when new strategies are pursued (Daniel & Wilson, 2003). Consequently, advances in services computing are essential to make an enterprise agile.

Recently, Tsourveloudis and Valavanis (2002) have tried to measure enterprise agility in four areas: production, market, people, and information infrastructures. They argued that the overall enterprise agility requires agility in all these four areas and, information infrastructure agility plays a critical role for global enterprises. They identified two variables, i.e., interoperability and networking, that constitute information infrastructure agility. Interoperability is a measure of the level of standardization for application integration, and networking is a measure of the communication capability for information exchange.

To understand the relationship between enterprise agility and services computing, let us look at an example in which an automotive firm responds to a request for quotation (RFQ) about an automotive part. Once its response to the RFQ is accepted, it engages in the following processes: *tool design process, procurement process for materials to make the tool, bill of material process to make the part, procurement process for materials to make the part, manufacturing process to make the part with the tool, and shipment processes*. Given the distributed nature of automotive business, the firm may have to consider each process described above as a "business service" and let each service react quickly to changes to its inputs. The bottom line is, if the enterprise views itself as a collection of "business services" that are integrated to meet a changing customer demand, then the agility with which these business services integrate their operations becomes essential and "service-oriented computing" is to support this agility.

3 Service oriented computing, service technologies and service science

3.1 Service technologies—web services

Web services provide the latest approach to address the integration of applications, a core challenge of corporate information technology departments today (Leymann, Roller, & Schmidt, 2002). W3C (2002) defines web service as a "software application, identified by a Uniform Resource Identifier (URI), whose interfaces and bindings are capable of being defined, described and discovered by eXtensible Markup Language (XML) artifacts, and supports direct interactions with other software applications using XML-based messages via internet-based protocols." The web services technology is intended to help streamline business processes by creating an open and distributed system environment, and reduce the cost of business process management by enabling dynamic process integration without "hardwiring" the code (Gottschalk, Graham, Kreger, & Snell, 2002). As a result, web services have gained industry-wide acceptance as the universal standard for enterprise application integration (Kreger, 2003).

Web services consist of a set of universally agreed specifications including XML, Simple Object Access Protocol (SOAP), Web Services Description Language (WSDL) and Universal Description, Discovery and Integration (UDDI) (Ferris & Farrell, 2003; Tsalgatidou & Pilioura, 2002). 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 Remote Procedure Call (RPC). UDDI represents a set of protocols for the description, registration, lookup and integration of software components.

In summary, web services provide a new standard for enterprises to build a cost-effective application integration infrastructure where all computer programs can communicate with one another from anywhere at 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.

3.2 Service technologies—service-oriented architectures

According to wikipedia (en.wiki.org), *service-oriented architecture* (SOA) is a software architecture that allows the use of loosely-coupled software services to meet the needs of business processes and users. In an SOA environment, network resources are made as independent services that can be accessed without any knowledge of their underlying implementation platform. A service-oriented architecture defined by IBM contains four core components including business services, integration services, enterprise service bus, and infrastructure services, which work together to provide the capability for on-demand business (Keen et al., 2004). A service-oriented architecture does not depend on a specific technology such as web services and can be implemented using many interoperability standards such as the Distributed Component Object Model (DCOM).

Service-oriented architectures use process driven application integration, with a workflow engine operating as a hub or exchange, and a process model driving the flow of applications (Ganguly, Ray, & Lovell, 2000; Kwak, Han, & Shim, 2002; Stroulia & Hatch, 2003). This paradigm has been embraced by the software industry, for example by IBM through its WebSphere software, BEA through its WebLogic platform, and 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.

3.3 Service-oriented computing (SOC)

SOC is referred to as the computing paradigm that utilizes services as fundamental elements for developing applications (Huhns & Singh, 2005; Papazoglou & Georgakopoulos, 2003). Some researchers have described service-oriented computing as the use of service-oriented architecture for implementing web services. They conceptualize three types of services: basic services, composite services, and managed services. Services are self-describing and open components that support low-cost composition of distributed applications rapidly.

In the IEEE Computer special issue on Web Services Computing, Chung, Lin, and Mathieu (2003) define web services as “Web-based applications composed of coarse-grained business functions accessed through the Internet.” They believed that “With the strong support most major market players are providing, Web services may achieve what Corba and DCOM could not. Web services use document style messages that offer the flexibility and pervasiveness that Corba and DCOM cannot provide.” The special issue contains four interesting articles that push the envelope of web services computing. Turner, Budgen, and Brereton (2003) describe a software market in which businesses can assemble systems from component Web services, leading to the software-as-a-service concept. Peltz (2003) introduces the concept of web services orchestration as an executable business process that spans applications and organizations. Thompson, Weil, and Wood (2003) describe an industry initiative that leverages the web services paradigm to serve the electronic photographic services market. Tsai et al. (2003) describe a web-services-based smart office task automation framework that uses web services, ontology, and agent components to increase interoperability and offer user-centric support for automating intranet office tasks.

The Communications of the ACM October 2003 publication (Papazoglou & Georgakopoulos, 2003) identified several issues of service-oriented computing, including (1) composition of basic web services to support robust business interactions (Curbera, Khalaf, Mukhi, Tai, & Weerawarana, 2003), (2) the concept of service abstraction in web service composition (Yang, 2003), (3) the complexity of distributed heterogeneous applications (Meredith & Bjorg, 2003), (4) an extended transaction model that negotiates cross-enterprise transactional guarantees (Little, 2003), and (5) management of web services by optimizing service executions based on stated business objectives (Casati, Shan, Dayal, & Shan, 2003).

3.4 From service-oriented computing to service science

In a two-day session in May of 2004, starting with the theme of “the architecture of on demand business,” over 60 researchers from universities and IBM discussed a bold undertaking: develop and introduce a new academic discipline. A 120-page report, titled “Services Science: a New Academic Discipline?” is structured along a business model involving business strategy, people/workforce, business process, and underlying technology. The core message of the white paper is “Services have matured as a business as software once did, and there is a science underlying services that must be explored.” The government and companies need to invest in the research and development needed to “move services out of the realm of art and into the realm of science.” Service Science is defined as a new discipline “to merge technology with an understanding of business processes and organization and to understand how that capability can be delivered in an efficient and profitable way” (Horn, 2005).

The services sector dominates economic activities in most advanced industrial economies today and “Web Services” and “Service Oriented Architectures” are important techniques and concepts, as services are increasingly delivered over the Internet. But, our scientific understanding of services is in a rather rudimentary state and the methods for designing and deploying them are ad hoc.

On July 12, 2005, an industry and academic panel was held at the joint IEEE International Conferences on Web Services and Services Computing (Brown et al., 2005) to address some of the research challenges. The panel believed that study of services need to include not only computing infrastructure that provides services (e.g. online product ordering), but also human workforce involved in providing the services, and the metrics needed to define and optimize services. As enterprises engage in e-business, particularly in the area of supply chain management, they need to view internal processes as elements of a collaborative value chain across a federation of enterprises. In the automotive industry, some of the business activities may be automated, others completed by engineers and people in the assembly line, and still others by external parties such as vendors. If services computing is to address a customer need, it needs to consider the interplay of technologies that support external processes (e.g. web services) with internal processes (automated as well as non-automated) to develop both organizational level and individual level metrics (e.g. quality of service, responsiveness). Understanding what a customer views as "quality of service" and how it changes over time is critical, if we are to develop ways to link the inter- and intra-organizational processes and make them respond to changing customer expectations.

An area of research that can help stimulate ideas for modeling services is cybernetic management. Cybernetics is the science of feedback and control in biological and mechanical systems. Although it was developed a long time ago by Wiener (1948), cybernetic management is still relevant today as we make systems react to changes through measurement and feedback control. The Viable System Model based on cybernetic management has adopted many of the cybernetics principles in support of business decision making (Beer, 1981), and cybernetic management may help us gain a better understanding of the dependencies across a business value chain and possibly provide one potential theoretical foundation for Service Science.

The Communications of the ACM published a special issue on Services Science in July 2006 intended to broaden and challenge traditional thinking about services and service innovation. The editors of the special issue believe that "the opportunity to innovate in services, to realize business and societal value from knowledge about service, to research, develop, and deliver new information services and business services, has never been greater. The challenges are both the multidisciplinary nature of service innovation, which combines business, technology, social-organizational, and demand innovation as well as the lack of formal representations of service systems" (Spohrer & Riecken, 2006). The special issue included several interesting results such as:

- The co-production of value between client and provider organizations requires the formalization and codification of tacit knowledge embedded in the organization, people and processes (Chesbrough & Spohrer, 2006).
- The analysis of firm-level data across multiple nations is needed to better understand the distinctive characteristics of service innovation (Sheehan, 2006).
- Service systems may be outlined semantically to include people, technologies, and organizations, as well as their capabilities, goals, rights, and value (Sheth, Verma, & Gomadam, 2006).
- Labor-intensive services in both manufacturing firms and service firms present an interesting array of new modeling challenges (Dietrich, 2006).
- Understanding innovative and sustainable business transformation requires a deeper theoretical foundation of socio-technical systems to model service systems (Rouse & Baba, 2006).
- A new academic discipline of Services Sciences, Management, and Engineering (SSME) has been proposed to solve complex, real-world problems in service systems (Maglio, Srinivasan, Kreulen, & Spohrer, 2006).

The panel at the IEEE Conference (SCC, 2005) also pointed out that services now account for over 70% of the GDP of most industrialized nations. Industrial research at IBM and HP is leading the effort to address the growing service needs of their clients, and new types of business services are emerging (e.g. virtual organizations are formed by integrating many services on the fly to meet one-time or changing customer needs). Yet, most academic curricula in the US do not cover unique issues of service science and management. It is our belief that multiple fields such as computer science and engineering, marketing, and Management Information Systems (MIS) are a key to further develop the service science concept. While the first three fields have been involved in developing technologies and applying them to business process automation and integration, marketing has been studying the field of customer preference models and services innovation, which hold the key to drive requirements for service computing in organizations. It is, hence, incumbent upon the academic community to bring together many underlying theoretical foundations from fields such as service-driven marketing, innovation, cybernetic management and software engineering to develop theoretical foundations for service science and guide the development of applications in a service computing environment.

3.5 Summary

In this section, we examined the recent advances in several areas of services computing discussed in the literature and showed how services computing is essential if firms need to remain agile to meet changing market needs. We noted that services computing goes beyond web services and SOA and must look at the broader requirements of an enterprise to combine the customer needs and partner capabilities with its own internal process and technology capabilities. To further develop services computing as a field of study, we may need to better understand the concept of "service science and innovation," and engage in academic initiatives such as those proposed by IBM, e.g., service science, management and engineering (SSME). They may provide a starting point for multiple colleges and disciplines in the area of computer science and engineering, MIS, marketing

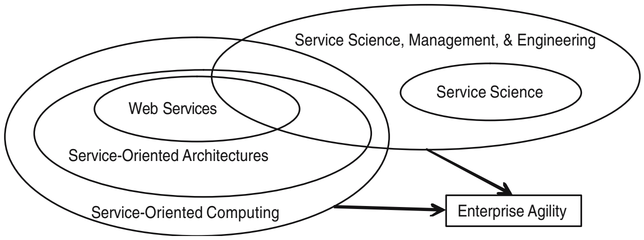

Fig. 2 The relationships among various concepts in services computing

and general business management to engage in fruitful discussion and seek partnerships to move aggressively on this front.

While it is difficult to clarify the differences and similarities of the various concepts surrounding services computing as introduced in this article, it is useful to have some idea on how they relate to one another. Figure 2 illustrates our attempt to make more sense out of these emerging concepts. Essentially, web services are at the core of services computing, and service-oriented computing includes service-oriented architectures, which in turn contains web services. Service oriented computing is the overall methodology used for achieving enterprise agility. Service science, management and engineering is an academic discipline that influences the development of research and education needed to address both the managerial and technological issues in the development of web services, service-oriented architectures, and service-oriented computing. These relationships should be relatively stable although the various concepts will continue to evolve over time. Figure 2 also shows the relationship between services computing and enterprise agility. The arrows indicate that service-oriented computing and service science, management & engineering should enable better enterprise agility.

4 Introduction to papers in this special issue

This special issue consists of seven fine articles that were selected among fifteen submissions after several rounds of reviews by the guest editors and invited reviewers. These articles can be categorized roughly into three groups, i.e., web service standards, business process management, and service-oriented computing.

Two articles in this special issue deal with *theoretical and practical issues of emerging web service standards*. Umapathy and Purao (2007) investigated the emerging standards for web services from a theory perspective based on "Language-Action Theories" for the purpose of defining, assessing and refining web service standards. The authors developed a reference framework based on theories of Language-Action for understanding web services standards and used the framework to assess the three existing web service standardization initiatives. Gosain (2007) studied strategies for dealing with imperfect standards. The author developed a conceptual framework outlining three approaches for organizations to deal with changing standards: bridging dependencies across components through mediation services, minimizing dependencies across components through loose coupling, and rapidly reconfigure the relevant components when a relevant standard changes.

The next two papers in this special issue focus on *process management in the context of web services*. Hung et al. (2007) proposed a multi-layered web service integration approach to privacy control in service outsourcing of human intensive processes. They illustrated how web services along with several other techniques can provide a suitable interoperation platform for service outsourcing. A telemarketing case study is presented to show how to integrate an outsourced call center with the web services of a bank to protect privacy. Rhee et al. (2007) studied how to enhance the efficiency of supply chain processes through web services. They proposed a method to detect critical paths in a process and reduce the slack time of each task in order to efficiently execute global supply chain processes. A web-service-based system is implemented to support the coordination among processes in a heterogeneous environment.

The remaining three articles present *innovative techniques in service-oriented computing*. The article by Bell et al. (2007) focuses on semantic web services. The authors argued that currently languages such as the Web Services Description Language (WSDL) provide the syntactic means to describe web services, but lack in providing a semantic underpinning. In order to harvest all the benefits of web services technology, they proposed a framework for deriving business semantics from syntactic descriptions of web services, which provides a way to gradually construct domain ontologies from previously defined technical services. Oaks and Hofstede (2007) proposed an approach for guided interaction mechanism to enable ad hoc service interaction, which is designed to enable clients without prior knowledge of programmatic interfaces to be assisted to a successful outcome. The mechanism is grounded in core computing primitives and based on a dialogue model. A key technique of the proposed approach is the use of an interpreter to generate and interpret messages in the exchange language and to manage the path of the dialogue. Madhusudan (2007) presented a web services framework for distributed model management based on an approach for web services integration called Integrated Service Planning and Execution. An important component of the proposed framework is model composition by means of "hierarchical task networks." A prototype is implemented to illustrate how the framework enables distributed model management and knowledge integration.

5 Conclusions

In this paper, we examined the recent advances in several areas surrounding the field of "services computing" by reviewing the recent articles in the literature. We showed that services computing is essentially another step in the continued pursuit of enterprise agility to meet changing customer needs. We also recognize that services computing goes beyond the issues in traditional computer science to include issues in the management of services.

We hope that the seven articles included in the special issue will give readers a sense about the research trends in web services and services computing and will stimulate others to do more research in this important and exciting domain. We would like to thank all the reviewers who have contributed to the review process of this special issue. Without their generous help, this special issue would not have been possible.

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