Decision Support Systems 55 (2013) 359–363

Contents lists available at SciVerse ScienceDirect

Decision Support Systems

journal homepage: www.elsevier.com/locate/dss

Data, information and analytics as services

Dursun Delen [a,*], Haluk Demirkan [b]

[a] Department of Management Science and Information Systems, Spears School of Business, Oklahoma State University, United States
[b] The Milgard School of Business, University of Washington Tacoma, United States

ARTICLE INFO

Available online 29 May 2012

Keywords:
Service-orientation
Cloud computing
Data-as-a-service
Information-as-a-service
Analytics-as-a-service
Agile analytics
Business analytics

ABSTRACT

While organizations are trying to become more agile to better respond to market changes in the midst of rapidly globalizing competition by adopting service orientation—commoditization of business processes, architectures, software, infrastructures and platforms—they are also facing new challenges. In this article, we provide a conceptual framework for service oriented managerial decision making process, and briefly explain the potential impact of service oriented architecture (SOA) and cloud computing on data, information and analytics. Today, SOA, cloud computing, Web 2.0 and Web 3.0 are converging, and transforming the information technology ecosystem for the better while imposing new complexities. With this convergence, a large amount of structured and unstructured data is being created and shared over disparate networks and virtual communities. To cope and/or to take advantage of these changes, we are in need of finding new and more efficient ways to collect, store, transform, share, utilize and dispose data, information and analytics.

1. Introduction

Service oriented thinking is one of the fastest growing paradigms in today's business world [3]. Most of the organizations have already built or are in the process of building decision support systems that utilize agile data, information and analytics capabilities as services. The concept of data, information and analytics as services advocates the view that—with the emergence of service-oriented business processes, architecture and infrastructure which include standardized processes for accessing data and analytics "where they live"—the actual platform on which the data or analytic tools resides should not matter. Data can reside in a local computer or in a server at a server farm in a cloud computing environment [1]. With data-as-a-service, any business process can access data wherever it resides, and with analytics-as-a-service can make sense out of the data using analytic tools wherever they may be located. Data and information-as-a-service began with the notion that data—wherever they may reside and whatever form they may be in—can be integrated, cleansed and enriched at a centralized location (often on a virtual network infrastructure) and made available to different systems, applications or users. Also, the concept of analytics-as-a-service—often referred to as Agile Analytics—is fueled by the idea of turning utility computing and virtualization into a service model for analytics [12].

This special issue is aimed at soliciting and publishing cutting-edge research to better understand the effects of service orientation on data, information and analytics. Specifically, we wanted to have a collection of articles that provide insight into (1) how data, information and analytic services are different from traditional data access, manipulation and distribution frameworks, (2) what the primary reasons, costs and benefits are in implementing a service oriented architecture for management of data, information and analytics, (3) what the bases are for evaluating relevant technical and managerial approaches to service-oriented data, information and analytics, and (4) what be the prevailing approaches would be for governance mechanisms of such systems. With the papers accepted for this special issue, we think we have shed some light to addressing these issues.

The rest of the paper is organized as follows. In Section 2, we propose a high-level conceptual framework for service-oriented decision support systems. In Section 3, we provide a description of business analytics and ramification of its service-orientation. In Section 4, we summarize the papers accepted for this special issue, and in Section 5 we conclude the paper.

2. Service oriented decision support systems

Service orientation is gaining popularity in decision support systems. Such an architectural structure enables systems developers to rapidly configure/re-configure complex systems using a number of loosely-coupled components representing data, model and user interface as individual services. This type of service-oriented decision support system not only provides a flexible development environment, but also ensures effective and efficient use of computational resources to produce more accurate, complete and timely results. Fig. 1 illustrates our high-level conceptual framework, where the cyclic process of managerial decision making is supported by a service-oriented architecture.

* Corresponding author. Tel.: +1 918 594 8283; fax: +1 918 594 8281.
E-mail address: dursun.delen@okstate.edu (D. Delen).

0167-9236/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.dss.2012.05.044

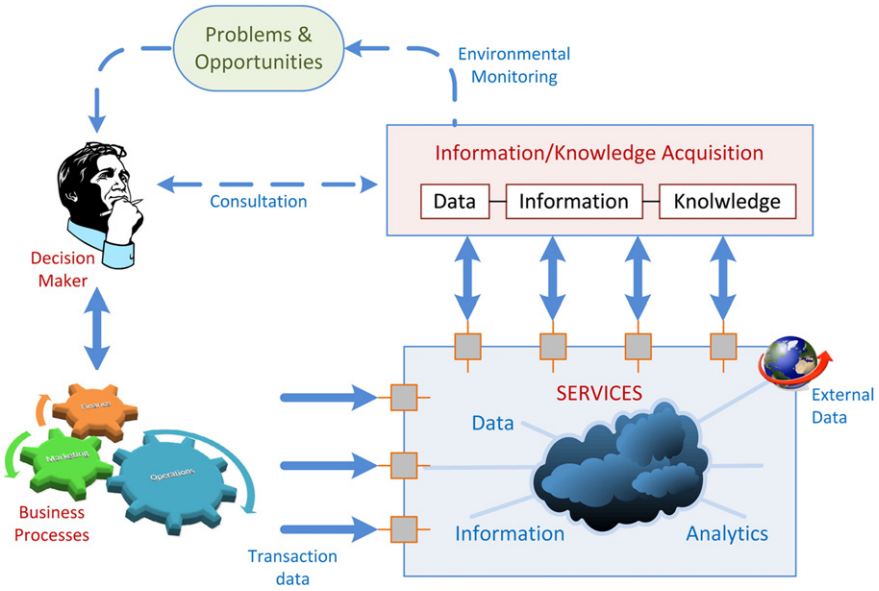

Fig. 1. A conceptual framework for service oriented decision support systems.

As the business world becomes more integrated and open for competition from all angles, the manager's main job (i.e., decision making) becomes an increasingly complex endeavor. Repeatedly making the right decisions in a timely manner becomes a matter of survival. In such an unforgiving environment, decision makers need systems capable of providing them with the accurate and relevant information and knowledge on the fly. As complexity increases, so does the need for more and better data, information and knowledge. Even though it is relatively easy and cost effective to collect and store large datasets nowadays, it is still cost prohibitive to employ highly-capable analytic resources (both hardware and software) to be able to process the data in a timely manner. Service-oriented architecture (SOA) and its enabling extension, cloud computing, make this undertaking a viable option, providing a capable infrastructure at a fraction of the cost. A brief description of analytics-as-a-service is given in the following section.

The concept of SOA is evolving and merging with cloud computing. A graphical depiction of this convergence is shown in Fig. 2 [10]. The OASIS (www.oasis-open.org) describes SOA as a "paradigm" for managing "capabilities" because it can be used to manage any type of distributed competence—whether it is technical (e.g. a Web service), human, or organizational [8]. SOA is constructed on a type of architectural framework that supports the design, development, identification, and consumption of loosely coupled, discoverable, reusable, interoperable services across the enterprises [14]. These services can be executed based on need. The National Institute of Standards and Technology defines cloud computing as "… a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (for example, networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" [4,9]. Basically, cloud computing is reminiscent of the software-as-a-service, infrastructure-as-a-service, platform-as-a-service paradigms, and it expands SOA by adding scalability and grid computing. When data, information, analytics, software and infrastructure are used as services, because of the fact that more services would be instantiated, and more hardware resources would be utilized, scalability would become a requirement [5]. The concept of grid computing brings more processing horse power. And, the term Web 2.0 is associated with web applications that facilitate data and information sharing, interoperability, user-

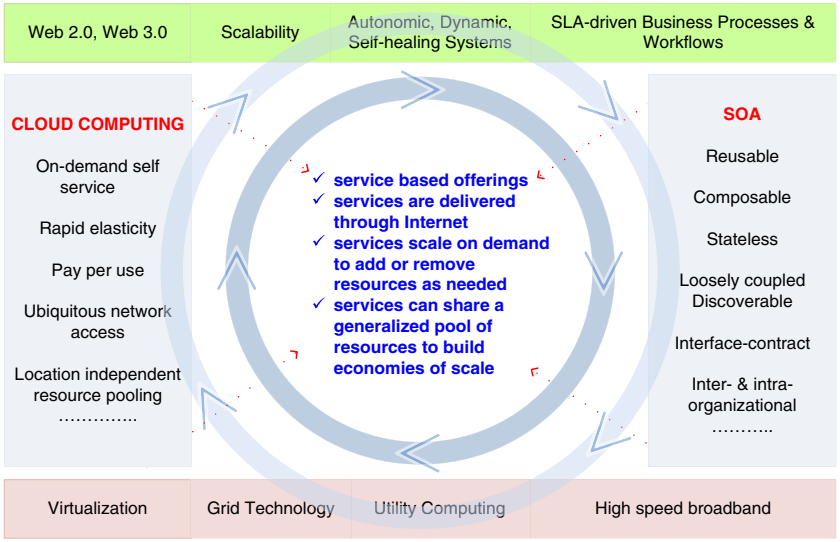

Fig. 2. Convergence of SOA, cloud computing and Web 2.0 and 3.0 (adopted from Modi 2009).

centered design and collaboration on the World Wide Web [5]. A Web 2.0 site allows users to interact and collaborate with each other in virtual environments such as clouds, social networking sites, blogs, wikis, hosted services, mashups and folksonomies [11,13]. According to Agarwal [2] and Hendler [6] Web 2.0 extends to Web 3.0 with semantic web, personalization and computer generated data and information. Today, SOA, cloud computing, Web 2.0 and Web 3.0 are converging, and transforming the information technology ecosystem with new capabilities.

3. Analytics-as-a-service

Compared to data and information-as-a-service, analytics-as-a-service is a relatively newer concept in the business world. Complexity of model management, development of service-based analytic models and standardizing the interfaces between the models are among the unique challenges that made analytics-as-a-service a late-emergent information technology endeavor.

Analytics facilitates realization of business objectives through reporting of data to analyze trends, creating predictive models to foresee future problems and opportunities and analyzing/optimizing business processes to enhance organizational performance [7]. From a taxonomical view, there are three main categories under analytics: descriptive, predictive and prescriptive. Fig. 3 illustrates this simple taxonomy of analytics.

Descriptive analytics, also called business reporting, uses the data to answer the question of "what happened and/or what is happening?" It includes simple standard/periodic business reporting, ad-hoc/on-demand reporting as well as dynamic/interactive reporting (OLAP, slice/dice, drill-down/roll-up, etc.). The main output of descriptive analytics is the identification of business opportunities and problems.

Predictive analytics uses data and mathematical techniques to discover explanatory and predictive patterns (trends, associations, affinities, etc.) representing the inherent relationships between data inputs and outputs. In essence, it answers the question of "what will happen and/or why will it happen?" Enablers of predictive analytics include data mining, text mining, Web/media mining and statistical time-series forecasting. The main outcome of predictive modeling is an accurate projection of the future happenings and the reasoning as to why.

Prescriptive analytics uses data and mathematical algorithms to determine a set of high-value alternative courses-of-actions or decisions given a complex set of objectives, requirements, and constraints, with the goal of improving business performance. These algorithms may rely solely on data, solely on expert knowledge, or a combination of both. Enablers of prescriptive analytics include optimization modeling, simulation modeling, multi-criteria decision modeling, expert systems and group support systems. The main outcome of prescriptive modeling is either the best course of action for a given situation, or a rich set of information and expert opinions provided to a decision maker that could lead to the best possible course of action.

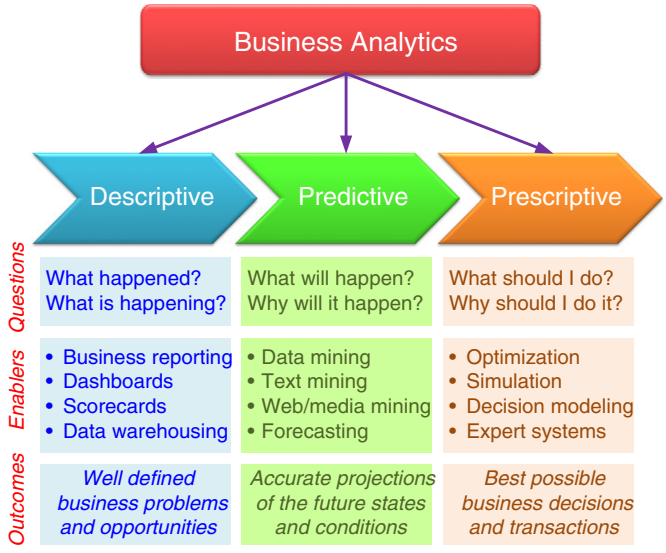

Fig. 3. A simple taxonomy of business analytics.

Business analytics is gaining popularity more rapidly than any other managerial paradigms that we have witnessed in recent years. The main reason is that it promises to provide decision makers with much needed information and knowledge. Effectiveness of business analytics systems depends largely on the quality/quantity of the data (volume and representational richness); accuracy, integrity and timeliness of the data management system; and the capabilities and sophistication of the analytical tools and procedures used in the process. Service oriented architecture and cloud infrastructure provide the capabilities and flexibility business analytics systems need to live up to their promise.

4. Introduction of the papers

This section provides a short description of the papers included in the special issue. These papers serve as a good representation of the diversity of research topics in service-oriented decision support systems.

The paper by Dong and Sirinivasan is about agent-enabled service-oriented decision support systems. In their paper, as part of the motivation for their study, they argue that the recent emphasis on web enablement as the next step in design improvements for decision support system applications, by itself, is not sufficient to address the need for adaptability in providing support for decision makers. Instead of solely focusing on automation in decision making, they believe that it is also necessary to pay close attention to the interplay between decision makers and organizational processes. The service oriented view of organizations recognizes the need to accommodate the changing reality of organizational dynamics. For example, the service science approach focuses on interactions between service providers, their clients, and consumers as important interacting components of a service system.

They argue that the current approaches to DSS design are constrained in terms of their ability to adapt to changes in user requirements and to provide support for the evolution of systems. This situation worsens when resources are distributed at different locations across organizations; decision making processes are required to be integrated at different points in time; and when collaboration is needed among decision makers. According to the authors, agent based implementation offers a superior design approach capable of addressing the four underlying dimensions (i.e., resource, location, time and lifecycle) that are necessary to adaptability. They define a service oriented system as an interactive computerized system that uses services to flexibly integrate components between service providers and service clients across a network to help decision makers solve semi-structured and unstructured problems. To support their emphasis on system adaptability, they propose an agent-based service-oriented framework for core DSS functions.

To illustrate the potential of their architecture, they developed a prototype system for Collaborative Planning, Forecasting and Replenishment (CPFR) problems in Supply Chain Management. Within the context of this prototype, they explained the details about individual components, model lifecycle, software agents and the DSS system. They claim that such a system can be used to enable collaboration of retailers and manufacturers to exchange information/knowledge and work together in executing plans across organizational boundaries.

The paper by Deokar, El-Gayar and Aljafari is about development of a semantic-web-based distributed model management system. In the paper, they provide the need for such a system, design requirements

of the proposed solution, an overview of their development effort, and discuss their experiences and lessons learned. The prime motivation behind model management is to reuse models that were originally developed for a specific decision situation in other but similar decision settings in the future. By doing so, one would save time and effort while increasing the changes of using validated and verified models. Even though motivation behind model management systems is a no-brainer, implementation of such systems has been challenging.

Authors define distributed model management systems (DMMSs) as a particular class of decision support systems with the focus on managing decision models throughout their lifecycle. DMMSs focus on supporting model management functionalities so that decision making models can be shared and reused in distributed work environments, both on the inter-organizational and intra-organizational levels. They argue that facilitating sharing and reusing models require properly capturing the underlying semantics for model representation and reasoning. For that, they propose a solution that utilizes semantic web technologies which not only overcome many of the challenges associated with information exchange but also are further enhanced by the standardization offered by the World Wide Web consortium.

In this paper they explain the design and implementation specifics of a semantic web-based DMMS. They talk about the key issues and lessons learned, along with a variety of technical and organizational issues encountered. Based on their experiences in this project, they also provide interesting future research directions. They claim that, from a technical perspective, future research will need to explore the viability of tools specifically designed to facilitate the semantic annotation of models, specify and validate SA-SMML, and extend the white-box approach presented in this paper to other model types not amenable to structured modeling. From an organizational perspective, further research is needed in the areas of adoption issues and business models that would ensure the sustainable support for such systems in the service enterprise.

The paper by Fabiana and his colleagues is about secure federation of semantic information services. Focusing mainly on the security aspects, the authors propose a holistic approach to organizational and technical measures of the semantic information federation services. They define a semantic information service as a web service that provides capabilities to query semantic repositories and returns information in a semantic data format.

In order to establish the motivation for their study, the authors claim that a fundamental challenge for product-lifecycle management in collaborative value networks is to utilize the vast amount of product information available from heterogeneous sources in order to improve business analytics, decision support, and processes. This phenomenon becomes even more challenging if those sources are distributed across multiple organizations. Federations of semantic information services, combining service-orientation and semantic technologies, provide a promising solution to this problem. However, without proper measures to establish information security, companies will be reluctant to join an information federation, which could lead to serious adoption barriers.

Following the design science paradigm, this paper's authors present general objectives and a process for designing a secure federation of semantic information services. Their contributions include (1) an access-control enforcement system for semantic information services and a process for modeling access-control policies across organizations, (2) a comprehensive security architecture, and (3) an implementation of the architecture in the context of an application scenario and several performance experiments to demonstrate the practical viability of the proposed approach.

The paper by Zorrilla and García-Saiz is about a service-oriented architecture to provide data mining services to non-expert data miners. They argue that in a market as competitive and global as today's information/knowledge is one of the main organizational assets for effective and efficient managerial decision making. Regardless of the size or the nature of the company, the need for having an accurate and reliable knowledge of what is affecting the business, and discovering novel and useful information hidden in the large data repositories for accurate and timely decision making is crucial for success (or mere survival). Information systems that provide such capabilities are often called business intelligence (BI) tools nowadays. These systems encompass a wide range of techniques and technologies that are used to gather, provide access to and analyze data from the operational systems of the organization and other external sources (for instance surveys, information from competitors or data from the web, among others) with the aim of offering decision makers a more comprehensive knowledge of the factors affecting their business and, in this way, help them to take more accurate and effective managerial actions.

The authors argue that the development and use of today's business intelligence systems, especially the ones that provide in-depth predictive and prescriptive capabilities, require an incredible amount of expertise on the part of the users/developers. They also argue that the knowledge discovery process requires large storage and processing capabilities and therefore propose a cloud-type architecture to bolster the underlying analytic process. In their research, they claim to have addressed both of these issues. Their proposed solution is an architecture that uses a collection of data mining services designed to address the needs of non-expert data miners, which can be delivered as software-as-a-service on the cloud. They present the viability of their architecture with a prototype implementation where they designed and implemented a web-based application that uses the data mining service configured for an educational context to help instructors involved in virtual teaching to discover their students' profile and their behavior in the course. In the paper they also outline the shortcomings of their proposed architecture and list potential improvement ideas and future research directions.

The last paper in this special issue—authored by Demirkan and Delen—is about leveraging the capabilities of service-oriented decision support systems in the cloud. The authors aimed to provide a general description of the past and present of services and service orientation, and their use in information systems, and propose a number of future research directions. According to the authors, using service-oriented decision support systems (DSS in cloud) is one of the major trends for many organizations in hopes of becoming an agile business. There are many opportunities, and means to mitigate challenges and risks (that may harm organizations in the long term) if they are assessed and addressed correctly. After defining a list of requirements for service-oriented DSS, they propose and discuss the details of a conceptual framework for DSS in cloud.

After presenting a compelling motivation for service orientation for decision support systems, they briefly describe the foundation for "services paradigm," and identify the key requirements for service-oriented decision support systems. In the following chapters they conceptualize the service-oriented DSS, and review the relevant and leading methods, model and theories, and discuss where foundational knowledge of the emerging service-oriented (in cloud type environment) can be developed.

Taken together, the five exemplar papers selected in this special issue highlight the increasing need for research on service oriented data, information and analytics, and seek answers to some of the important questions for the service orientation and convergence of SOA, cloud computing and Web 2.0 and 3.0.

5. Concluding remarks

Today, utilization of service orientation, cloud computing and Web 2.0 and 3.0 are growing exponentially. As part of this utilization process, organizations generate and share more data and information than ever before. Owing to the increasing computational capabilities coupled with decreasing acquisition and operational costs,

organizations are building capabilities to collect and store more structured and unstructured data and to transform them to meaningful information about their customers, competitors and changing market conditions. Some of these organizations choose to use external service providers to collect and process their data, and return the information to them as services.

It is a growing belief that tomorrow's enterprises will not compete solely based on price differentiations, but they will enhance their competitive posture with the way they generate, collect and transform their data to actionable knowledge using advanced analytics. Such an engagement will provide organizations with more innovative products and services, and hence improve their competitive position.

The articles included in this special issue clearly only scratch the surface of the possibilities for research in the data, information and analytics domain of service science. What we hope they have demonstrated, however, is the fertile ground available for further research. We believe that this new approach to service-oriented data, information and analytics in cloud will create great opportunities as well as many challenges.

Announcement of this special issue on decision support systems and electronic commerce has attracted a large number of research paper submissions. During the review process, the referees looked at the relevance of the research, rigor of methods used, scientific contribution of the research and managerial implications of the manuscript to the practitioners. We followed multiple phases of reviews and revisions to ensure that the selected papers meet the recognized standards for scholarly research and make contributions to management practice.

As the guest editors we would like to extend our thanks to the anonymous reviewers of these articles. They contributed much invaluable time and effort to help us assess these research publications; their ideas, suggestions and critiques were central to the success of the final products. We also would like to thank the Editor-in-Chief, Dr. Andrew B. Whinston for his encouragement, support and guidance on this special issue project. We further would like to acknowledge the commitment that the authors of the articles in this special issue have made to produce high quality work on an expedited schedule. Their cooperation and commitment to address the reviewers' comments and incorporate reviewers' suggestions produced high quality manuscripts. Finally, we hope that this special issue will encourage the authors whose papers did not make it into the special issue to continue their research stream, publish their papers in high impact journals, and hence make new contributions to the body of knowledge in service oriented decision support systems.

References

[1] D.J. Abadi, Data management in the cloud: limitations and opportunities, IEEE Data Engineering Bulletin 32 (1) (March 2009) 3–12.
[2] A. Agarwal, Web 3.0 concepts explained in plain English, digital inspiration, 2009. Available at http://www.labnol.org/internet/web-3-concepts-explained/8908/ Last accessed on December 25, 2011.
[3] H. Demirkan, R.J. Kauffman, J.A. Vayghan, H.-G. Fill, D. Karagiannis, P.P. Maglio, Service-oriented technology and management: perspectives on research and practice for the coming decade, The Electronic Commerce Research and Applications Journal 7 (4) (Fall 2008) 356–376.
[4] H. Demirkan, M. Goul, Taking value-networks to the cloud services: security services, semantics and service level agreements, Information Systems and e-Business Management (forthcoming).
[5] H. Demirkan, R. Harmon, M. Goul, Service-oriented Web application framework: utility-grade instrumentation of emergent Web applications, The Special Issue of the IEEE IT Professional on the Future of Web Applications: Strategies and Design 13 (5) (September/October 2011) 15–21.
[6] J. Hendler, Web 3.0 emerging, IEEE Computer 42 (1) (January 2009) 111–113.
[7] I. Lustig, B. Dietrich, C. Johnson, C. Dziekan, The analytics journey, Analytics Magazine, INFORMS, Atlanta, GA, November/December 2010, pp. 11–18.
[8] C.M. MacKenzie, K. Laskey, F. McCage, P.R. Brown, R. Metz, Oasis Reference Model for Service Oriented Architecture 1.0, 2006 OASIS.
[9] P. Mell, T. Grance, The NIST definition of cloud, recommendations of the National Institute of Standards and Technology, 2011. Available at http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf.
[10] T. Modi, The cloud SOA ecosystem, ebiZ the insider's guide to next generation BPM, 2011. Available at http://www.ebizq.net/topics/soa_management/features/11787.html?page=2. Last accessed on September 22, 2011.
[11] T. Oreilly, What is Web 2.0: design patterns and business models for the next generation of software, Communications and Strategies 1 (17) (First Quarter 2007).
[12] O. Ratzesberger, Analytics as a service, xlmppAvailable at, http://www.xlmpp.com/articles/16-articles/39-analytics-as-a-serviceFebruary 12 2011Last accessed on September 22, 2011.
[13] P. Sharma, Core characteristics of Web 2.0 services, Techpluto, 2009. Available at http://www.techpluto.com/web-20-services/. Last accessed on December 25, 2011.
[14] M. Singh, M. Huhns, Service-Oriented Computing: Semantics, Processes, Agents, J. Wiley, 2004.

Dr. Dursun Delen is the William S. Spears Chair in Business Administration and Associate Professor of Management Science and Information Systems in the Spears School of Business at Oklahoma State University (OSU). He received his Ph.D. in Industrial Engineering and Management from OSU in 1997. Prior to his appointment as an Assistant Professor at OSU in 2001, he worked for a private consultancy company, Knowledge Based Systems Inc., in College Station, Texas, as a research scientist for five years, during which he led a number of decision support and other information systems related research projects funded by federal agencies such as DoD, NASA, NIST and DOE. His research has appeared in major journals including Decision Support Systems, Communications of the ACM, Computers and Operations Research, Computers in Industry, Journal of Production Operations Management, Artificial Intelligence in Medicine, Expert Systems with Applications, among others. He recently published three books on business intelligence, decision support systems and advanced data mining techniques. He is often invited to national and international conferences for keynote addresses on topics related to business intelligence, decision support systems, knowledge management and data mining. He served as the general co-chair for the 4th International Conference on Network Computing and Advanced Information Management (September 2–4, 2008 in Soul, South Korea), and regularly chairs tracks and mini-tracks at various information systems conferences. He is the associate editor-in-chief for International Journal of Experimental Algorithms, associate editor for International Journal of RF Technologies, and is on editorial boards of five other technical journals. His research and teaching interests are in decision support systems, data and text mining, knowledge management, business intelligence and enterprise modeling.

Dr. Haluk Demirkan is a Professor of information systems, and a Research Faculty of the Center for Services Leadership. His research and teaching interests are on service science and sustainable innovations, business-, social- and cloud services-intelligence and analytics, service supply chain management and commoditized service-oriented information systems. He has authored or co-authored almost 100 publications. Some of his articles appeared in Decision Support Systems, Journal of Service Research, Journal of Management Information Systems, Journal of the Association for Information Systems, IEEE Transactions Systems, Man & Cybernetics, European Journal of Operational Research, the Electronic Commerce Research & Applications Journal, and Communications of the ACM. He has recently co-edited two research books titled "The Science of Service Systems" and "Implementation of Service Systems." Most recently, in 2011, he was ranked 50th in Top-100 Rankings of World-wide Researchers according to the Association for Information Systems sanctioned Research Rankings. He also received the IBM Faculty Award. He has more than fifteen years of professional work experience on how to maximize the return on companies' resources by effectively implementing enterprise business intelligence solutions with companies such as American Express, Bank of America, IBM, Intel, Premier Healthcare, MicroStrategy, Darden Restaurants, Eckerd Corporation and Lending Tree among others. He is a board member for Teradata University Network; Service Research and Innovation Institute; INFORMS and AIS Service Science Sections, and Global Text Project. Dr. Demirkan holds a Ph.D. in the Department of Information Systems & Operations Management; Post Master of Engineering and Master of Engineering in Industrial & Systems Engineering from the University of Florida, and BS in Mechanical Engineering from Istanbul Technical University.