Editorial: Special Section on Services Computing Management for Artificial Intelligence and Machine Learning

I. Introduction

FIFTEEN years ago, few would have imagined that employees could work entirely remotely or that an entire business infrastructure could exist on the Internet. With the adoption of services computing, a service that allows companies to access processing and data storage through the Internet, these business models are becoming a reality. Services computing requires a multidisciplinary lens that integrates science and technology to bridge the gap between business services and information technology (IT) services [item 1) in the Appendix]. Services computing management involves 1) ensuring services computing strategy which is allied with how the organization manages IT and how IT is aligned with organizational strategy, 2) designing, building, sourcing, and deploying resilient computing solutions, trusted, efficient, and address quality of service (QoS) expectations, and 3) overseeing all matters related to business and IT services operations and resources both across business domains and within domains such as retail, finance, healthcare, logistics, and others [item 2) in the Appendix].

The goal of services computing is to enable IT services and computing technology to perform business services more efficiently and effectively [item 3) in the Appendix]. The pervasive nature of services computing management is exhibited in almost all industry settings [item 4) in the Appendix]. In everyday life, new business service innovations will give rise to an emergent data- and information-focused economy that will only pick up steam as both consumer and business utilization of Internet of Things are advanced.

Concomitantly, we are moving toward an era of artificially intelligent (AI) (e.g., cognitive computing) services, which are deployed in multiscale, complex distributed architectures. Cognitive computing is the use of computerized models to simulate the human thought process in complex situations where the answers may be ambiguous and uncertain. Computers are increasingly capable of doing things that humans could once do exclusively. Today smart machines are becoming like humans by recognizing voices, processing natural language, learning, and interacting and learning with the physical world through their vision, smell, touch, and other senses, mobility, and motor control. In some cases, they do a much faster and better job than humans at recognizing patterns, performing rule-based analysis on a very large amount of data, and solving both structured and unstructured problems [item 5) in the Appendix].

These AI services can be formed from high-level computational intelligence that leverages emerging analytical techniques associated with big data, web analytics, data and text mining, ontology engineering, semantic web, and many other advances. At the same time, it becomes increasingly important to anticipate technical and practical challenges and to identify best practices learned through experience. Also, researchers, businesses, and policymakers have seized on machine learning (ML) services to support their decisions. ML services will catalyze smart application areas such as drones and robotic computing [item 6) in the Appendix]. ML services will continue to improve with analytics discipline advancements in areas such as data/text mining, predictive analytics, and algorithms that model high-level abstractions in data by using multiple processing layers with complex structures or nonlinear transformations. At the same time, the design, development, and deployment of ML services present novel methodological and technological challenges.

This special section of the IEEE Transactions on Engineering Management seeks to provide readers with an overview of the current issues and practices related to managerial and technical challenges of services computing for AI. Also, new and compelling service computing technologies are of interest. The authors' contributions in all of the articles have implications for services computing that go beyond the immediate application settings on which they report. These papers also showcase the application of an array of research methods, including surveys, experiments, and design science. In the remainder of our Guest Editors' Introduction, we will briefly discuss each of the articles in the special issue to identify their main thrust of the authors' investigation and the relevant findings for theory and practice.

II. Papers in This Special Section

This special section contains seven papers.

The first contribution is "A Deep Neural Network With Multiplex Interactions for Cold-Start Service Recommendation" by Ma *et al*. This paper presents a multiplex interaction-oriented service recommendation approach by deep learning to extract hidden structures and features from different types of interactions between mashups and services.

Next, the second paper "QoS-Aware Data Placement for MapReduce Applications in Geo-Distributed Data Centers" by Chen *et al*. presents an efficient data-placement technique by a heuristic algorithm considering traffic flows in the network topology of data centers with QoS guarantees.

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TABLE I
SERVICE ORIENTATION AND TRANSFORMATION OF COMPUTING (ADAPTED FROM MICROSOFT)

From (traditional)	To (agile)
Function oriented	Coordinated oriented
Build to last	Build to change
Prolonged development cycles	Incrementally built and deployed
Application silos	Enterprise solutions
Tightly coupled	Loosely coupled
Object oriented	Message oriented
Known implementation	Abstraction
Governance models	Federated
Approval process	Judge common needs but allow for innovation
Value calculation	Hedging options for flexibility

Then Chaturvedi *et al*. present a service change classifier-based interface slicing algorithm that mines change information from two versions of an evolving distributed system by an intelligent tool named Automatic Web Service Change Management in the third paper "Service Evolution Analytics: Change and Evolution Mining of a Distributed System."

Referring to the fourth paper "Enabling Secure Trustworthiness Assessment and Privacy Protection in Integrating Data for Trading Person-Specific Information," Hussain Khokhar *et al*. present information entropy-based trust computation algorithm to detect the covert behavior of a dishonest data provider and select the qualified providers for a data mashup.

Further, the fifth paper "Ant Colony Optimization Based Quality of Service Aware Energy Balancing Secure Routing Algorithm for Wireless Sensor Networks" by Rathee *et al*. discuss an ant colony optimization based QoS-aware energy balancing secure routing algorithm for wireless sensor networks by calculating the end-to-end delay of transmission and the trust factor of the nodes on the routing path.

Next, "Comparison of Artificial Intelligence Techniques for Project Conceptual Cost Prediction: A Case Study and Comparative Analysis," by Elmousalami *et al.*, investigates 20 AI techniques for developing conceptual cost modeling such as fuzzy logic, artificial neural networks, multiple regression analysis, case-based reasoning, and hybrid models.

The last paper, "Tensor-Train-Based High Order Dominant Eigen Decomposition for Multi-modal Prediction Services," by Liu *et al.*, focuses on proposing a tensor-trained (TT) -based computation approach with its scalable implementation for high order dominant eigen decomposition (HODED) in multivariate Markov models. Themain idea is to equivalently convert the original hig order tensor operation to a series of lower-order TT-core based operations and then implement these lightweight operations in a distributed or parallel manner, which is different from the traditional block-based parallelism.

In summary, these papers provide clear proof that AI and ML are playing a more and more important and critical role in supporting various applications in services computing. It is also believed that the papers will further research new best practices and directions in this emerging research discipline.

Taken together, the seven exemplar papers selected in this special issue highlight the increasing need for research on managerial and technical challenges of services computing for AI and ML and seek answers to some of the important questions for the service orientation and transformation.

III. CONCLUSION

This special section shares research and related the practical experience to benefit readers, and it provides clear proof that services computing management is playing an ever-increasing important and critical role in supporting computational intelligence—especially in exciting new cross-discipline research topics in computer science, information systems, and the management sciences.

A fundamental premise of services computing is that by using service orientation, organizations can break siloed business processes into modular independent services that can be reused on-the-fly in loosely coupled dynamic business service choreographies, and they can source those choreographies by using virtual computing resources. And services computing is the core of any smart services such as AI and ML. For services computing and smart services, there has been a transformation from traditional system development to agile thinking (Table I).

Service orientation and transformation are enabling organizations to be agile and flexible, and to respond market changes much faster than used to [item 7) in the Appendix]. Organizations' IT is becoming much more flexible to join their value chain partners' IT networks to cocreate value to the consumers (e.g., federated service oriented technology framework) [item 8) in the Appendix]. Organizations are able to collect and process so much data they have never dreamed for with unstructured (e.g., Hadoop) and structured big data solutions (e.g., Big SQL).

We like to highlight few more topics that need further research.

1) Integration of Services: Almost all AI and ML services need multiple loosely coupled services that are being provided from multiple federated service computing environments. For example, an organization can use voice to text AI service from AWS, text to voice AI service from Azure, and visual analytics AI service from Google. Integration of these services is a complex problem.

2) Management of Services: When all these AI and ML services are being provided from federated service computing,

service level agreements with performance requirements, resource allocations, negotiations and governance of services, etc. become very complex.

3) Change Management and Version Control: When organizations are building their service ecosystem (e.g., service computing, AI services, and ML services) based on "build the change," change management and version control need to be managed very carefully. Traditional operation management key performance metrics (such as budget, schedule, and requirements) are not sufficient enough any longer.

4) Knowledge Management: One of the many other success factors for AI services is having a reliable knowledge management system. Knowledge is the core of any AI and ML services to train and improve these smart services.

5) Security: Of course, when organizations are using smart services from multiple organizations to increase their efficiency, security of data, information, and knowledge become another important area to study for research.

6) Ethics and Privacy: There have been many comments about how these smart services can manage ethics and privacy [item 9) in the Appendix]. Of course, with the right design, management, technology, and training these smart services can behave unbiased.

Changes will be required in employee workforce, corporate culture, partner ecosystems, law, and regulations. As we conclude this project, we recognize that the research work that we have included in this special issue only scratches the surface of the issues and possibilities for research in management of services computing for AI and ML. What we hope they have demonstrated, however, is the fertile ground available for further research. We expect enterprising future doctoral students and faculty to establish names for them by pursuing research agendas in services computing. We expect them to produce rich fundamental and applied work that leverages organizational and behavioral, economics and management science, and technical and design science research approaches toward the development of new managerial knowledge for services computing.

We know the importance of having to start "somewhere" to get the new ideas moving, and finding the appropriate collaborators to make some initial steps and advances in new knowledge possible. The guest editors would like to thank the Editor-in-Chief, Tugrul Daim, for the vision he shared with us. We also was fortunate to be able to assemble a highly committed group of authors whose papers were selected from among the many presented at conferences. 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.

We would especially like to acknowledge the anonymous reviewers, who so generously offered their time, effort, and helpful insights for us to make the hard choice and for helping me with development and constructive reviewing that led to the final products that you see in the present special issue. Finally, we thank the authors, including those whose works we accepted, and those whose efforts did not permit their research to go the final distance to publication. They all were diligent and careful and gave us private lessons along the way about what vibrant and creative research on service science already looks like in the present. We look forward to the "next generation" of submissions to the IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT and hope that future authors will build on the foundations that we have established here.

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This special issue is dedicated to our wonderful deeply missed Prof. Michael Goul who was one of the guest editors in this special issue. Forever Prof. Goul remains in our memory.[1]

PATRICK C. K. HUNG, *Guest Editor*
Faculty of Business and Information Technology
Ontario Tech University
Oshawa, ON L1G 0C5, Canada
patrick.hung@uoit.ca

HALUK DEMIRKAN, *Guest Editor*
Milgard School of Business
University of Washington Tacoma
Tacoma, WA 98402 USA
haluk@uw.edu

SHIH-CHIA HUANG, *Guest Editor*
Department of Electronic Engineering
National Taipei University of Technology
Taipei 106, Taiwan
schuang@ntut.edu.tw

APPENDIX
RELATED WORK

1) H. Demirkan *et al.*, "Service-oriented technology and management: Perspectives on research and practice for the coming decade," *Electron. Commerce Res. Appl. J.*, vol. 7, 2008, Art. no. 20.
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4) L.-J. Zhang *et al.*, *Services Computing*. Beijing: Tsinghua Univ. Press, 2007.
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8) H. Demirkan and J. Spohrer, "Emerging service orientations & transformations (SOT)," *Inform. Syst. Frontiers*, vol. 18, pp. 407–411, 2016.
9) S. Karnouskos, "Self-driving car acceptance and the role of ethics," *IEEE Trans. Eng. Manage.*, vol. 67, no. 2, pp. 252–265, May 2020.

Patrick C. K. Hung received the bachelor's degree in computer science from the University of New South Wales, Kensington, Australia, in 1993, and the master's and Ph.D. degrees in computer science from the Hong Kong University of Science and Technology, Hong Kong, in 1995 and 2001, respectively, and the master's degree in management sciences from the University of Waterloo, Waterloo, Canada, in 2002.

He is a Professor and Director of International Programs with the Faculty of Business and Information Technology, Ontario Tech University (formerly called University of Ontario Institute of Technology), Oshawa, Canada. He is currently working with the College of Technological Innovation, Zayed University, Dubai, United Arab Emirates, on smart city and cyber security research projects. He is also a Visiting Professor with the University of São Paulo, São Paulo, Brazil, an Honorary International Chair Professor with National Taipei University of Technology, Taipei, Taiwan, and an Honorable Guest Professor with Shizuoka University, Shizuoka, Japan. He has worked with Boeing Research and Technology, Seattle, WA, USA, on aviation services related research with two US patents on mobile network dynamic workflow system. Before that, he was a Research Scientist with the Commonwealth Scientific and Industrial Research Organization (CSIRO), Canberra, Australia.

Dr. Hung is a Founding Member of the IEEE Technical Committee on Services Computing and the IEEE TRANSACTIONS ON SERVICES COMPUTING. He is a Co-ordinating Editor of the *Information Systems Frontiers*. He also Chairs the Social Robots—Robotics and Toy Computing Mini-Track and Computing in Companion Robots and Smart Toys Symposium in the *Hawaii International Conference on System Sciences (HICSS)*.

Haluk Demirkan received the B.S. degree in mechanical engineering from Istanbul Technical University, Istanbul, Turkey, in 1991, and the M.E. and P.E. degrees in industrial and systems engineering, in 1995 and 1997, respectively, and the Ph.D. degree in information systems and operations management from the University of Florida, Gainesville, USA, in 2002.

He is the Milgard Professor of Service Innovation and Business Analytics. He is the Founding Director of Master of Science in Business Analytics, Undergraduate Minor in Business Data Analytics and Center for Business Analytics, Milgard School of Business, University of Washington Tacoma, Tacoma, WA, USA. Currently, he is assisting organizations to transform themselves with collaborative intelligence (humans + AI + process).

Dr. Demirkan is an innovation and analytics evangelist, maestro, data gig, recognized leader, experienced practitioner (20+ years), awarded consultant, accomplished scholar (~20 years), active applied researcher, cross-disciplinary teacher, effective mentor, invited speaker, productive author (150+ pubs), and professional student. His achievements brought him a global leadership and reputation in cocreation of value and service innovation with automation, out-tasking, complex data, analytics, artificial intelligence, intelligence augmentation, micro services, design- and service-oriented technology, and management.

Shih-Chia Huang received the B.S. degree from National Taiwan Normal University, Taipei, Taiwan, the M.S. degree from National Chiao Tung University, Hsinchu City, Taiwan, and the Doctorate degree in electrical engineering from National Taiwan University, Taipei, in 2009.

He is currently a Professor with the Department of Electronic Engineering, National Taipei University of Technology, Taipei, Taiwan, and an International Adjunct Professor with the Faculty of Business and Information Technology, Ontario Tech University, Oshawa, Canada. He has authored or coauthored more than 50 journal and conference papers and holds more than 40 patents in the United States, Europe, Taiwan, and China. His research interests include intelligent multimedia systems, image processing, and video coding, video surveillance systems, cloud computing and big data analytics, and mobile applications and systems.

Prof. Huang is currently the Chair of the IEEE Taipei Section Broadcast Technology Society. He is an associate editor of the *Journal of Artificial Intelligence* and a Guest Editor of the *Information Systems Frontiers* and *International Journal of Web Services Research*. He is also the Applications Track Chair and the Program Committee Chair of the IEEE BigData Congress and IEEE BigData Taipei Satellite Session in 2015, and was the Program Committee Chair of the IEEE BigData Taipei Satellite Session in 2014.