Service Science: Research and Innovations in the Service Economy

Haluk Demirkan
James C. Spohrer
Vikas Krishna
*Editors*

# The Science of Service Systems

Foreword by Richard B. Chase

Springer

The Science of Service Systems

## Service Science: Research and Innovations in the Service Economy

### Series Editors

Bill Hefley
Katz Graduate School of Business & College of Business Administration
University of Pittsburgh
Mervis Hall
Pittsburgh, PA 15260 USA
E-mail: wehefley@katz.pitt.edu

Wendy Murphy
IBM c/o
1954 Rocky Cove Lane
Denton, NC 27239
E-mail: wendym@us.ibm.com

For more information and a complete list of titles in this series,
please visit http://www.springer.com/series/8080

Haluk Demirkan • James C. Spohrer
Vikas Krishna
Editors

# The Science of Service Systems

Foreword by Richard B. Chase

Springer

*Editors*
Haluk Demirkan
W. P. Carey School of Business
Department of Information Systems
Main Campus PO BOX 874606
85287 Tempe Arizona
USA
haluk.demirkan@gmail.com

James C. Spohrer
IBM Almaden Research Center
San Jose, CA
USA
spohrer@us.ibm.com

Vikas Krishna
San Jose, CA
USA
vikasconnect@gmail.com

ISBN 978-1-4419-8269-8 e-ISBN 978-1-4419-8270-4
DOI 10.1007/978-1-4419-8270-4
Springer New York Dordrecht Heidelberg London

Library of Congress Control Number: 2011922500



Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

# Foreword

It is with great pleasure that I write the foreword to this exceptional volume of papers on service science. I have found the study of services to be a fascinating endeavor and gladly admit to being a "service junkie" (Chase 1996). Thus, it is particularly exciting to be able to write the foreword to a book that contains contributions from other writers whose efforts also reflect a junkie level passion for the subject.

Service, which is defined as the application of competence and knowledge to create benefit (or value) for another, derives from the interactions of entities known as service systems. Service systems, the focus of this book, exist at multiple scales of organizations, from individual people to businesses and nations, chain together into globally integrated service networks of multiple types: business-to-consumer (B2C), business-to-business (B2B), consumer-to-consumer (C2C), business-to-government (B2G), government-to-consumer/citizen (G2C), as well as other permutations.

While "service systems" is now part of our general business vocabulary it is useful to look briefly at the origins of the term and some of the key writings that have provided a foundation for its use in service science. One of the earliest uses of service systems in a book title is Stochastic Service Systems by John Riordan (1962). This work views service systems as processes where arrivals to the process are served by workers or technology, or both. Other writers on service, though not using the term service systems, were concerned with what a service is and what constituted a service transaction. Economists in particular found this to be a major issue in considering productivity growth (See Fuchs 1968).

Levitt (1970) argued for the industrialization of service processes, which translated directly into a service system design philosophy. Taking inspiration from companies such as McDonald's, he described how high-volume service organizations could apply a production-line approach to service in the same way that manufacturing firms approach goods production (Levitt 1972). The central benefit of this approach was that it reframed our thinking about service as being servitude to one of economic processes that were amenable to engineering approaches to quality and efficiency. Of course even before McDonald's fully rationalized burger production Disneyland was the exemplar of high a volume pure service operation.

Probably the first textbook discussion of service systems in a strategic management context was provided by Sasser, Olsen, and Wycoff (1978). They defined a service delivery system as "a process in which the customer participates." They further argued that this participation by the customer in the service process "requires that the service delivery system be defined in terms of, and as an element of, the total service concept." They showed graphically how the service concept consisting of facilitating goods, explicit intangibles, and implicit intangibles dictate and are defined by the service delivery system. The service delivery system is shown to consist of performance characteristics of materials, service atmosphere and image of facilities, and service attitudes of employees. The effectiveness of the service delivery system is defined in terms of performance or service levels of the materials, facilities and personnel. This structural approach underlies virtually every discussion of service operations strategy.

The service system characteristics of intangibility and customer participation led to researchers to develop classification schemes that reflect the operational implications of these characteristics, particularly as they contrast with manufacturing. Chase (1978, 1981) suggested that most businesses have a front office component and a back office component. For manufacturing firms, the back office is the factory where the core product is created where there is little or no direct customer contact during production. In services, the front office is often the core of the business since by definition this is where service encounters take place. The implications of this are that front office features of a service system such as location, layout, and scheduling must reflect the physical presence of the customer, and as a result, is inherently less efficient than the manufacturing back office or the back office of the service firm itself.

Pine and Gilmore (1998) argued that service organizations are undergoing a transformation from the traditional concept of service transaction to one of an experience. Even for mundane services such as shoes stores and coffee shops need to reflect this in the physical and sensory features of their facilities (Fitzsimmons and Fitzsimmons (2005). More recent work by Voss et al. (2008), develops the strategic requirements needed to make this come about. Chase and Dasu (2001), and Dasu and Chase (2010) emphasized how psychological factors such as creating a positive flow of events in a service encounter and ending on a high note can be engineered into the design of a service interaction.

As we look at contemporary industry, the explosion of telecommunications and virtual service interactions require radically different models and approaches to the design and operation of service systems. Indeed, service science needs to recognize the need to strike out in new directions in its basic research and develop more effective ways linking service systems to the organizations and larger communities of which they are a part. This volume is an important step in addressing these requirements.

Los Angeles, CA Richard B. Chase

## References

Chase, R.B. (1978).”Where Does the Customer Fit In a Service Operation?”, *Harvard Business Review* 56 (6), 137–142.

Chase, R.B. (1981). “The Customer Contact Approach to Services: Theoretical Bases and Practical Extensions,” *Operations Research*, 21 (4), 698–705.

Chase, R. B. (1996) “The Mall Is My Factory: Reflections of A Service Junkie,” *Production and Operations Management* 5, (4) 298–308.

Chase, R. B., and S.Dasu (2001). “Want to Perfect Your Company’s Service? Use behavioral Science,” *Harvard Business Review*, 78 (6) 78 – 85.

Dasu, S., and R. B.Chase (2010). “Designing the Soft Side of Customer Service,” *Sloan Management Review*. In Press.

Fitzsimmons, J.A. and M.J Fitzsimmons (2005). *Service Management: Operations, Strategy, and Information Technology*, 5th ed. McGraw-Hill/Irwin, New York, NY.

Fuchs, V. (1968). *The Service Economy. National Bureau of Economic Research*, New York

Levitt, T. (1970). “The Industrialization of Service,” *Harvard Business Review* 48 (5) 63–74.

Levitt, T. (1972). “Production Approach to Service,” *Harvard Business Review* 50(5) 32–43.

Pine, J., and J. Gilmore, (1998). “Welcome to the Experience Economy,” *Harvard Business Review* 76 (4), 97–105.

Riordan, J.(1962) *Stochastic Service Systems*. Wiley, New York.

Sasser, W.E., Olsen, R. P., and Wyckoff, D.D.(1978). *Management of Service Operations, Text, Cases, and Readings*. Allyn and Bacon, Boston.

Voss, C., Roth, A., Chase, R.B. (2008). Experience, Destination Services and Service Operations Strategy: Foundations and Exploratory Investigation, *Production & Operations Management Journal*, 17, (3). 247–266.

## Professor Richard B. Chase

Richard B. Chase is co-author with R. Jacobs of *Operations Management and Supply Chain Management* (13th edition), which has been one of the top three sellers since its first edition in 1973. Two of his *Harvard Business Review* articles, “Where Does the Customer Fit in a Service Operation?” and “The Service Factory” (with D. Garvin) have been cited as classics. In 2009, he was honored as a major contributor to the field of service operations management in the January issue of the *POMS Journal*, and received a Lifetime Achievement Award from the American Marketing Association’s Service Interest Group. In 2006 he received a lifetime achievement award from the POM Society and in 2004 the Scholar of the in Year by the OM Division of the Academy of Management. His recent publications include “Designing the Soft Side of Customer Service” (with S. Dasu), *Sloan Management Review*, in press; “Revisiting ‘Where does the Customer Fit in a Service Operation?’ Background and Future Development of Contact Theory”, in P. Maglio et al., *Handbook of Service Science,* 2010, “Experience, Destination Services and Service Operations Strategy” (with A. Roth and C. Voss), *POMS Journal*, 2008.

# Preface

We live in and interact with many service systems in our daily life. As it matures, the service science community is gradually becoming increasingly focused on the study of holistic service systems, such as cities, universities, hospitals, luxury resort hotels, cruise ships, and the like, that can be described as somewhat self-contained entities that are an integrated system of systems. In each of these somewhat self-contained entities, one finds a range of systems including transportation, water, food, energy, communications, buildings, retail, finance, health, education, and governance. The study of holistic service systems is especially challenging, because local optimization does not necessarily lead to global optimization and small changes in one subsystem can lead to large consequences in other systems (Blomberg 2008; Maglio et al. 2006, 2009; Spohrer et al. 2007).

The concept of a service system is resonating well with academics from diverse disciplines and practitioners from diverse economic sectors. And yet, because this is such a new area, few compilations of the works of academics and practitioners exist. Therefore to fill the gap, these two inter-related peer reviewed volumes of the Service Science: Research and Innovations in the Service Economy Series on Advancement of Services Systems ("The Science of Service Systems" and "Service Systems Implementation") are very specific in nature. They present multidisciplinary and multisectoral perspectives on the nature of service systems, on research and practice in service, and on the future directions to advance service science. *The Science of Service Systems* intends to stimulate discussion and understanding by presenting theory based research with actionable results. *Service Systems Implementation* intends to stimulate discussion and understanding by presenting application-oriented, design science-oriented (artifacts building: constructs, models, methods and instantiations) and case study-oriented research with actionable results.

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 editors would like to thank the Series Editors of the Service Science: Research and Innovations in the Service Economy Series, Bill Hefley and Wendy Murphy, and the Springer co-editors, Melissa Fearon and Jennifer Maurer, for their encouragement and guidance for development of these volumes; and leading thinkers in this field, Richard B. Chase and Richard C. Larson, who wrote forewords, and Mary Jo Bitner, Stephen W. Brown, Andrew Dingjan, Jay Kandampully, Suk Joon KIM, Jeong Hyop Lee, Michael Lyons, Kunihiko Niwa, Miguel Angel Sicilia and J.B. Wood who wrote testimonials.

We had 80 articles and extended abstracts submitted for these two inter-related volumes. With so many submissions reflecting the interest of these topics among scholars and practitioners in our community, it was necessary for us to make some tough decisions as to papers to accept for further development, and those to pass back to submitting authors with indications of the work that they needed to do to put themselves in a better position to contribute to the service science literature. The articles in these volumes issue went through a three-cycle "review and revise" process. From original inception to completion this book project with two inter-related volumes took almost 3 years. We include total 34 chapters (17 chapters in each book) that represent research and practices from almost 20 countries including Amsterdam, Australia, Canada, China, Cypress, Germany, India, Ireland, Italy, Mexico, Netherlands, Singapore, Spain, Taiwan, Turkey, United Arab Emirates, United Kingdom, United States of America, and many others. These researches represent studies and practices from many universities, companies, government offices and public and private institutions.

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 us with development and constructive reviewing that led to the final products that you see in the present edited volume. Finally, we thank the authors, including those whose works we accepted, and those whose efforts did not permit their research and practices 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 systems is. We look forward to the "next generation" of service science and systems research and practices.

San Jose, CA
December 24, 2010

Haluk Demirkan
James C. Spohrer
Vikas Krishna

## References

Blomberg, J. (2008). Negotiating meaning of shared information in service system encounters. *European Management Journal*, 26, 213–222.

Maglio, P. P., Srinivasan, S., Kreulen, J. T., Spohrer, J. (2006). Service systems, service scientists, SSME, and innovation. *Communications of the ACM*, 49(7), 81–85.

Maglio, P. P., Vargo, S. L., Caswell, N., Spohrer, J. (2009). The service system is the basic abstraction of service science. *Information Systems and e-business Management*, 7, 395–406.

Spohrer, J., Maglio, P. P., Bailey, J., Gruhl, D. (2007). Steps toward a science of service systems. *Computer*, 40, 71–77.

# Contents

# Contributors

**Steven Alter** earned his Ph.D. from MIT. Formerly Vice President of the manufacturing software firm Consilium, he teaches at the University of San Francisco. His research emphasizes developing systems analysis concepts and methods that can be used by typical business professionals and can support communication with IT professionals. His 2006 book, The Work System Method: Connecting People, Processes, and IT for Business Results, distills and extends ideas in four editions of his information system textbook, which raised awareness of the role of IT in work systems in organizations. His articles have been published in many leading journals and many conference proceedings.

**Benjamin Blau** is PostDoc and head of the division "Corporate and Cloud Services" at the Institute of Information Systems and Management (IISM) and member of the Karlsruhe Institute of Service Research (KSRI) at the Karlsruhe Institute of Technology (KIT). He studied Information Management and Engineering at the Universität Karlsruhe (TH) and the University of California, Santa Barbara. His majors were in information and knowledge management, artificial intelligence, machine learning, financial management, eFinance, and markets and incentives. In 2007 he finished his diploma thesis in cooperation with the SAP AG Germany and partly abroad at the SAP Labs. Bangalore 2006/2007.

**Martin Böttcher** is the leader of the research group Service Modeling and Engineering at the Institute for Applied Informatics (InfAI) in Leipzig (Germany). Additionally, he works at the University of Leipzig as a senior research assistant at the Department of Business Information Systems. Dr. Böttcher studied Information Management at the University of Leipzig. Subsequently he was member of the doctoral program "knowledge representation" sponsored by the German Research Foundation. Dr. Böttcher received his Ph.D. for his work on Service Modeling. His research topics cover Service Science, Service Engineering, Formal Service Systems Modeling and the industrialization of Service Systems.

**Jayanta Chatterjee** is a renowned practitioner with rigorous academic involvement. He has 10 years of Management teaching experience and 30 years of management experience in different countries. He helped to setup new operations and assisted merger and acquisition projects in Korea, Japan, Singapore and other countries of the region. Simultaneously he continued to pursue his research interests in strategic management of technology and marketing. He is a founder EC member of the Engineering Management Society of IEEE in India and a popular speaker at management conferences. Since 2001, Dr. Chatterjee is in full time academics and a Professor at the Industrial and Management Engineering Department of IIT Kanpur and a visiting professor in 2008–2009 at Aalto University's Design Factory in Helsinki. He is a consultant and coach for several high technology companies and their key executives and continues to be a venture catalyst.

**Tobias Conte** works as a scientific associate and Ph.D. student at the Research center for information technology (FZI) and at the Institute of Information Systems and Management (IISM). He is work package lead in the large-scale German research project THESEUS/TEXO. Tobias is also associated to the Karlsruhe Service Research Institute (KSRI). His research interest are incentive schemes in service value networks, especially evolving structures and power distribution, as well as the impacts of strategic behavior of individuals on the overall network utility. Tobias Conte studied "Information Engineering and Management" at the Universität Karlsruhe (TH) and the University of California Santa Barbara (UCSB).

**Haluk Demirkan** is a Professor of Information Systems and a Research Faculty of Center for Services Leadership. His doctorate is in Information Systems and Operations Management from University of Florida, and his research in service science, and service-oriented management and technology solutions have included recent industry-sponsored research projects with American Express, Intel, IBM, MicroStrategy and Teradata. He has authored or co-authored almost 50 articles in refereed journals or conference proceedings. He has 15 years of consulting experience in the areas of service-oriented information systems and technology solutions, information supply chain, business intelligence and strategic business engineering with Fortune 100 companies.

**Clemens van Dinther** is temporarily head of the Group "Market and Information Engineering" of the Institute of Information Management and Systems (IISM) and associated member to the Karlsruhe Service Research Institute (KSRI) at the Karlsruhe Institute of Technology (KIT). He is interested in allocation and incentive mechanisms for Service Value Networks and distributed energy networks. From 2005 to 2009 he worked as Department Manager at the Research Center for Information Technology in Karlsruhe. He received his Doctoral degree in economics in 2006 from Universität Karlsruhe (TH). Clemens studied Business Engineering and Management at the Universität Karlsruhe (TH) and the National University of Ireland, Galway.

**Klaus-Peter Fähnrich** is the leader of the Department of Business Information Systems, which he established in 2000 at the University of Leipzig. In addition, he is speaker of the board of directors of the Centre for Information, Knowledge and Service Management, speaker of the Leipzig's Information Society (LIV) and board member and chairman of the board of the Institute for Applied Informatics (InfAI), established in 2006 at the University of Leipzig. His main research areas are Business Information Systems, Software Engineering and Management, E-Business and Services Science. In the past 15 years he has developed the discipline of Service Engineering.

**Ovsei Gelman** is a Senior Researcher at CCADET, a Research Center of the National Autonomous University of Mexico (UNAM). He holds a B.S., M.Sc. and Ph.D. in Physics and Mathematics from the University of Tbilisi, Georgia. In the last 35 years, Dr. Gelman has contributed to the advance of the Systems Science discipline and Interdisciplinary Research through the publication of approximately 250 research papers in books, national and international journals and conference proceedings. Dr. Gelman has also served as advisor in the Engineering Graduate Program at UNAM and realized consulting activities for governmental and private organizations.

**Michael Genesereth** is an associate professor in the Computer Science Department at Stanford University. He is the director of the Stanford Logic Group and founder of several startups such as Teknowledge, CommerceNet and Mergent Systems. He received his Sc.B. in Physics from M.I.T. and his Ph.D. in Applied Mathematics from Harvard University. Genesereth is best known for his work on Artificial Intelligence, especially on Computational Logic. He has published several papers on these research fields in A- and B-ranked journals. In addition, Genesereth is the author of Logical Foundations of Artificial Intelligence, a landmark study on the fundamentals of Artificial Intelligence from the vantage point of logic.

**John Healey** is in the doctoral program in marketing at the Smith School of Business, University of Maryland and holds an undergraduate degree in Economics and Political Science from the University of Florida and a Master's of Science in Management and a Master's of Business Administration from the University of Florida. His research interests include services marketing, innovation, and modeling.

**Axel Hochstein** is a visiting associate professor at the Computer Science Department at Stanford University. His current research focuses on semantics, data mining and pattern recognition and its application to enterprise information systems. He published several journal papers, conference articles, and books, and gained industry praxis in Europe, the USA and China while consulting companies with the implementation and development of innovative enterprise information systems, especially in the area of systems management.

**Juliana Hsuan** is associate professor of operations management at Copenhagen Business School. She obtained her Ph.D. in operations management from CBS and Licentiate of Science degree in logistics from the Helsinki School of Economics, Finland. She serves as an officer for INFORMS–TMS Section, as a member of the board of EurOMA, and as a faculty member of CEMS–Logistics Group. Her teaching and research interests include operations management, modularization strategies, and portfolio management of research and development projects. Her research has been published in the Journal of Product Innovation Management, IEEE Transactions on Engineering Management, Production Planning and Control, Technovation, R&D Management, Supply Chain Management: An International Journal, European Business Review, Creativity, and Innovation Management, among others. She and her colleagues have recently published Managing the Global Supply Chain (3rd ed., CBS Press, 2007).

**David Ing** is a marketing scientist and business architect with a 25-year career at IBM. He is completing his Ph.D. in Industrial Management at Aalto University, with prior degrees from the Kellogg School of Management and the University of Toronto. In professional activities, he has served a variety of roles for the International Society for the Systems Sciences, currently as the Vice-President of Research and Publications. David resides in Toronto, Canada, and is an active blogger at http://www.coevolving.com.

**P.K. Kannan** is Professor of Marketing at the Robert H. Smith School of Business at the University of Maryland and is the Chair of the Department of Marketing. His current research stream focuses on new product/service development, design and pricing digital products and product lines, marketing and product development on the Internet, e-service, and customer relationship management (CRM) and customer loyalty.

**Vikas Krishna** is a senior technical staff member and manager at the IBM Almaden Research Center in San Jose, CA, USA. He leads a team of service researchers and engineers focusing on innovative solutions and service systems for IBM's global services business to provide higher personnel productivity, enabling service personnel to work and deliver service smarter, and higher client value propositions. He is also the recipient of several awards for his outstanding innovative and technical contributions to IBM's services business and that of its clients. He received his Bachelor of Technology degree from the Indian Institute of Technology, India, an M.Eng. degree from Memorial University, Canada and his M.S. degree from Syracuse University, USA.

**Stephen K. Kwan** is a professor of Information Systems at the College of Business, San José State University. He was the founding chair of the department and had served as the Senior Associate Dean of the College. He is currently working on the implementation of a Service Science, Management and Engineering program at his university, and the promotion of education and research about standardization in US universities. He is a member of the American National Standards Institute Committee on Education and The International Community for Education about Standardization. He started the Special Interest Group on Services in the Association for Information Systems and currently serves as the Vice Chair. He worked closely with IBM and was a recipient of IBM Faculty Awards. He received a

B.S. and M.S. in Computer Science from the University of Oregon, and a Ph.D. in Management from UCLA.

**Jos G.A.M. Lemmink** is Professor of Marketing and Dean of Maastricht University School of Business and Economics, Maastricht, The Netherlands. He holds an M.Sc. degree in Business Administration of the University of Groningen and a Ph.D. from the University of Limburg. He was market analyst for Dutch Postal Services and Telecommunication. He serves as a fellow of the Center for Services Leadership, W.P. Carey School of Business, Arizona State University, Tempe, USA and member advisory board of the Latin American Academy of Services Management, ITESM, Monterrey, Mexico. He published extensively on service quality marketing, service management and modeling; seven books and many publications in, e.g., Journal of Marketing, Journal of Economic Psychology, Journal of Service Research, International Journal of Research in Marketing, Journal of Management Studies, Journal of Business Research and Journal of Retailing. He was editor-in-chief of the International Journal of Service Industry Management from 2000 to 2005. At the moment he is scientific director of Maastricht University's Service Science Factory.

**Kelly Lyons** is an Associate Professor in the Faculty of Information at the University of Toronto. Prior to joining the University, she was Program Director of the IBM Toronto Centre for Advanced Studies (CAS). Her research interests include service science, social computing, collaboration, and business intelligence. She is currently studying technologies, work practices, and business models that support human-to-human interactions in service systems. Kelly is cross-appointed to the University of Toronto, Department of Computer Science, is a member of the Knowledge Media Design Institute, an IBM Faculty Fellow, and Member-at-Large of ACM Council. More details can be found at: http://www.individual.utoronto.ca/klyons.

**Roger Maull** is Professor of Management Systems at the University of Exeter Business School. His research focuses on using systems theory to provide insights into the problems of management. In his research Roger has experience of using both qualitative and quantitative research methods and is an enthusiastic supporter of relevant research that informs practitioners. He has published papers in journals such as, Journal of Operations Management, IJOPM, and British Journal of Management and is currently one of the three joint editors of IJOPM.

**Duncan McFarlane** is Professor of Service and Support Engineering at the Cambridge University Engineering Department, and head of the Distributed Information and Automation Laboratory within the Institute for Manufacturing. As Professor of Service and Support Engineering one of his key roles is to examine the role of engineering in services. He is also Director of the Cambridge Auto-ID Lab and is chairman of RFID start up RedBite Solution Professor McFarlane is currently Research Director of two industrially supported activities: the Support Service Solutions: Strategy and Transition Programme [S4T] and the Airport

Operations Programme. His research interests relate to the role and the value of information and automation in service, industrial and environmental areas.

**Cristina Mele** is assistant professor of Quality Management at the Department of Business Economics, University of Naples "Federico II", Italy; Cristina obtained her Ph.D. in Management and Economics in 2000. Her main areas of interest are marketing, quality, and innovation and her most recent studies are about service innovation and value co-creation in a network perspective. She has published over 70 articles in Italian and international journals, including the International Journal of Quality and Reliability Management, Managing Service Quality, Journal of Customer Behaviour and The International Journal of Quality and Service Science. She was one of the co-chairs (with Evert Gummesson and Francesco Polese) of "The 2009 Naples Forum on Service: Service-Dominant Logic, Service Science and Network Theory".

**Irene Ng** is the Professor of Marketing Science at the University of Exeter Business School, the ESRC/Advanced Institute of Management Research Service Fellow and Honorary Senior Visiting Fellow at the University of Cambridge. Her research interests are in service innovation, value-based pricing and revenue management of services, outcome-based contracts in B2B services as well as value-based complex service systems. She has published in numerous international journals in the domain of engineering, management, marketing, information systems, economics, education and sociology and she is the author of the book "The Pricing and Revenue Management of Services: A Strategic Approach".

**Charles Petrie** is a Senior Research Scientist working in the Stanford CS Logic Group. His research topics are concurrent engineering, enterprise management, and collective work. Dr. Petrie was a Founding Member of Technical Staff of the MCC AI Lab, Founding Editor-in-Chief of IEEE Internet Computing, and Founding Executive Director of the Stanford Networking Research Center. He is the Founding Chair of the Semantic Web Services Challenge. He received his Ph.D. in Computer Science from the University of Texas at Austin. A more complete biography is available at: http://www.cdr.stanford.edu/%7Epetrie/bio.html.

**Francesco Polese** is Associate Professor at Cassino University, Italy, where he teaches Business Management. His research interests cover the management of networks and relationships, service, service science, tourism, and R&D management. His most recent article (2009) is "B2B is not an island" (with Evert Gummesson) in the Journal of Business and Industrial Marketing. He is Director of MADILab (University Lab for Innovation Management and Diffusion) [email: polese@unicas.it]. He was one of the co-chairs (with Evert Gummesson and Cristina Mele) of "The 2009 Naples Forum on Service: Service-Dominant Logic, Service Science and Network Theory", see http://www.naplesforumonservice.it.

**Artem Polyvyanyy** is a research assistant and a Ph.D. candidate at Business Process Technology research group at Hasso Plattner Institute of IT Systems Engineering at the University of Potsdam, Germany. His research areas are business process management and service-oriented computing. Artem has published his research results at international conferences on business process management. He has a strong background in computer science, software engineering, and business process management from the National University of Kyiv-Mohyla Academy in Ukraine and Hasso Plattner Institute in Germany. His industry experience includes internships at Wincor-Nixdorf GmbH in Hamburg, Germany and SAP Labs in Palo Alto, USA.

**Stefan Puehl** is a Project Manager and IT Architect with Dell Services. Stefan's consulting work focuses on technology strategy, technology governance, and enterprise architecture management (EAM). He is delivering software solutions, especially SOA and BPM solutions in global service delivery settings. He is a specialist in CRM applications for multi-national corporations. Before joining Perot Systems (now Dell Services) Stefan was a Senior Managing Consultant and Senior IT Architect with IBM Global Business Services.

**Mahesh Raisinghani** is an associate professor in the Executive MBA program at the TWU School of Management. He is a Certified E-Commerce Consultant (CEC) and a Project Management Professional (PMP). Dr. Raisinghani was awarded the 2008 Excellence in Research and Scholarship award and the 2007 G. Ann Uhlir Endowed Fellowship in Higher Education Administration. His research has been published in academic journals such as IEEE-TOEM, Information and Management, IRMJ, and JGITM among others and international/national conferences. Dr. Raisinghani is included in the millennium edition of Who's Who in the World, and Who's Who in Information Technology.

**Miguel Angel Sicilia** obtained a University degree in CSc from the Pontifical University of Salamanca in Madrid, Spain (1996) and a Ph.D. from Carlos III University in Madrid, Spain (2002). From 1997 to 1999 he worked as assistant professor at the Pontifical University, after which he joined the CSc Department of the Carlos III University in Madrid as a lecturer, while working in e-commerce companies. Currently, he works as a full-time associate professor at the CSc Department, University of Alcalá (Madrid). His research interests include learning technology, the Semantic Web and Service Science. He is editor-in-chief of the IJSSMET.

**Laura Smith** is a doctoral candidate at the University of Exeter Business School. Her research interests include service science, service management, customer value in service and value co-creation. Laura has worked on research projects with organizations such as HWC Ltd, the UK National Health Service and Rolls Royce.

**James C. Spohrer** is a Director of IBM Global University Programs since 2009, Jim founded IBM's first Service Research group in 2003 at the Almaden Research Center with a focus on Science Technology Engineering and Math for Service Sector innovations. Working with service research pioneers from many academic disciplines, Jim advocates for Service Science, Management, Engineering, and Design as an integrative extended-STEM framework for global competency development, economic growth, and advancement of science. In 2000, Jim became the founding CTO of IBM's first Venture Capital Relations group in Silicon Valley. In the mid 1990s, he lead Apple Computer's Learning Technologies group, where he received the Distinguished Engineer Scientist and Technologist award. Jim received a Ph.D. in Computer Science/Artificial Intelligence from Yale University and a B.S. in Physics from MIT.

**Chris Voss** is professor emeritus of operations management at London Business School, where he has served as deputy dean, and is a senior fellow at the UK's Advanced Institute for Management Research. He obtained his Ph.D. from London Business School. He is a fellow of Decision Sciences Institute (DSI) and Production and Operations Management Society (POMS) and was elected distinguished scholar by the Operations Management (OM) division of the Academy of Management in 2008. He has researched and written extensively in the area of service operations and is founder and leader of the International Service Study, a multicountry study of service operations, and was president of the POMS College of Service Operations from 2006 to 2009. His research has been published in the Journal of Operations Management, Production and Operations Management, Journal of Service Research, and Journal of Product Innovation Management, among others. He was founder and long-term chairman of the European Operations Management Association, is a board member of the Production and Operations Management Society (POMS) and serves on several editorial boards.

**Christof Weinhardt** is full professor and head of the Institute of Information Management and Systems (IISM) at the Karlsruhe Institute of Technology (KIT). He is member of the board of directors at FZI – Research Center for Information Technologies in Karlsruhe and founding member of the Karlsruhe Service Research Institute (KSRI) at KIT. Christof Weinhardt received his diploma in Business Engineering and Management and his Ph.D. in Economics from Universität Karlsruhe (TH). Between 1994 and 2000 he held positions as professor at the University of Bielefeld and the University of Giessen as head of the Department for Information Systems.

**Mathias Weske** is professor and a chair of the Business Process Technology research group at Hasso Plattner Institute of IT Systems Engineering at the University of Potsdam, Germany. His research interests include process choreographies, process modeling methodologies, and service science. He leads Oryx, an open source business process management framework on the Web. Dr. Weske has published 12 books and over 80 scientific papers. He is on the steering committee of the BPM conference series. Dr. Weske has published a textbook on business process management, and he is co-author of The Process, a narrative on using the Business Process Modeling Notation.

**Soe-Tsyr Yuan** received her Ph.D. degree in Computer Science from Oregon State University in 1994. She is a Professor of MIS Department and Director of Service Science Research Center in National Chengchi University. Her research interests include Service Science, Management and Engineering, Service System

Design, Service-Oriented Computing, Electronic and Mobile Commerce, Strategic Information Systems and Multi-agent Systems and Data Mining. She has been on the editorial boards for several international journals including International Journal of Web Services Research, Service Oriented Computing and Applications, International Journal of E-Business Research, International Journal of Information Systems and Management, etc.

# Testimonials

"*Drawing on relevant theory and cutting edge practices, the editors have compiled an outstanding snapshot of present knowledge on the science of service systems. From a multi disciplinary and global perspective, the chapters successfully demystify the numerous nascent and much debated concepts and practices, resulting in an invaluable resource for both researchers and practitioners*."
Jay Kandampully, Ph.D.
Professor of Services Management
The Ohio State University, USA
Editor in Chief of Journal of Service Management

"*The most comprehensive text yet on Service Systems and underpinning science: how it works and why it matters across business, government and society. This is a 'must have' reference for any professional responsible for value creation and innovation within the interconnected systems of the modern service economy*."
Andrew Dingjan
Leader of Services Science Network
The Commonwealth Scientific and Industrial Research Organisation
Melbourne Area, Australia

"*This is a comprehensive and stimulating compilation devoted to service science, and by pioneering this new area they are creating the future world of improved service*."
Jeong Hyop Lee, Ph.D.
Director of Division of Research Planning and Administration
Science & Technology Policy Institute
South Korea

"*The books are filled with rich fundamental concepts and noble ideas that leverage government officials, policy researchers, and scholars toward the development of new service R&D and service science related policy to enhance the international competitiveness of advanced countries as well as developing countries*."
Suk Joon KIM, Ph.D.
President of Science & Technology Policy Institute
South Korea

"*This timely volume brings together a wide range of experts from different disciplines and demonstrates the richness of the concept of a service system. It gives an excellent overview of the current state of theory underpinning Service Science, presenting a comprehensive foundation for future development*."
Michael Lyons, Ph.D.
Chief Researcher of Service Systems
British Telecom Innovate & Design
London, UK

"*This collection of papers represents a critical step forward in beginning a dialog on the science of service and service systems. I believe we will look back on this book as representing a key moment in time for the discipline.*

*This volume presents a critical collection of papers that begins an important journey to define and develop the science of service systems*."
Mary Jo Bitner, Ph.D.
PetSmart Chair in Services Leadership
Professor and Academic Director
Center for Services Leadership
W. P. Carey School of Business
Arizona State University, USA

"*This ground breaking book successfully aligns disciplinary and sector research and practice around the concept of service systems. The papers help the reader build their own service systems for use as scholars and students, as well as for their application as providers and consumers of services*."
Stephen W. Brown, Ph.D.
Edward M. Carson Chair in Services Marketing
Professor and Executive Director
Center for Services Leadership
W. P. Carey School of Business
Arizona State University, USA

"*A must-read for researchers and practitioners approaching service science. The selected chapters provide a balanced walkthrough on the theory and practice of devising and building service systems*"

"*Service science is one of the cornerstones of our future societies, which demands new ways of looking at common problems and approaches that boldly cross disciplines. This book faces that challenge by offering an insightful look at the design and practical deployment of service systems*"

"*The book represents an impressive, serious attempt to compile the best theory and practice on service system design and deployment*"
Miguel Angel Sicilia, Ph.D.
University of Alcala at Henares, Spain
Editor in Chief of International Journal of Service Science, Management, Engineering and Technology

"*Service science is at the intersection of natural, social and human sciences. It is a challenge to integrate these existing sciences. This volume, which compiled interdisciplinary and theory-based papers, will contribute to build the theoretical backbone on service science*."
Kunihiko Niwa, Ph.D.
Principal Fellow of Center for Research and Development Strategy
Japan Science and Technology Agency, Japan

# Introduction of the Science of Service Systems

**Haluk Demirkan, James C. Spohrer, and Vikas Krishna**

## 1 Why the Science of Service Systems?

Why do we need these two books on the science of service systems? The short answer is because the concept of a service system is resonating well with academics from diverse disciplines and practitioners from diverse economic sectors. And yet, because this is such a new area, few compilations of the works of academics and practitioners exist. Therefore to fill the gap, these two inter-related volumes of the Service Science: Research and Innovations in the Service Economy Series (SSRI), "*The Science of Service Systems*" and "*Service Systems Implementation*," present multidisciplinary and multisectoral perspectives on the nature of service systems, on research and practice in service, and on the future directions to advance service science. These two volumes compile a collection of papers by thinkers ready to contribute to creating the emerging area known as service science, and ready to connect it into their own areas of expertise and experience. The Science of Service Systems intends to stimulate discussion and understanding by presenting theory based research with actionable results.

## 2 Service Systems Are the Basic Abstraction

What types of entities interact to co-create value? Service systems are such entities, be they individuals, firms, or nations. Service science is a transdisciplinary approach to study, improve, create, scale, and innovate in service (Spohrer & Maglio, 2008, 2009). We think of service as *value cocreation* – broadly speaking, as useful change that results from communication, planning, or other purposeful and knowledge-intensive interactions between distinct *service system entities*, such as individuals, firms, and nations (Spohrer & Maglio, 2009). And so we think of

H. Demirkan (✉)
Arizona State University, Tempe, AZ, USA
e-mail: haluk.demirkan@gmail.com

H. Demirkan et al. (eds.), *The Science of Service Systems*,
Service Science: Research and Innovations in the Service Economy,
DOI 10.1007/978-1-4419-8270-4_1, 

service science as the systematic search for principles and approaches that can help understand and improve all kinds of value cocreation between interacting service systems (Spohrer & Maglio, 2009). Value cocreation interactions fall into two categories. Value-proposition-based interactions deal with access rights to resources that measurable benefit stakeholders, while governance-mechanism-based interactions deal with dispute resolution mechanisms needed to clean-up failures and debug shortcomings of the first type of interactions. Figure 1 summarizes the core concepts of service science.

The road to establishing a science of service system will be a long one, spanning decades. There is simply no easy way for academics from many disciplines and practitioners from many sectors to quickly adopt and consistently use the emerging vocabulary about service systems.

However, it is very encouraging that academics and practitioners are stepping up to the challenge. These chapters reflect early efforts to define a science of service systems. In general, there are still many rough edges. However, all the chapters represent progress.

From the formal (ontologies, representation specifications, decision-making and maturity models) to the informal (analysis frameworks, design heuristics, anecdotal observations), these papers provide a snapshot in time of the gradually emerging scientific understanding of service systems. The progress is reflected in the diversity of backgrounds of the authors, all of whom have something to contribute to a more holistic perspective on service systems. Service systems are too complex to be fully understood from any single perspective.

Our goal in this volume is not to present the end product, a fully formed science of service systems, but instead to present a useful beginning and process to make progress. The process consists of connecting people with diverse backgrounds, who all appreciate the opportunity at hand. The opportunity is to contribute to an

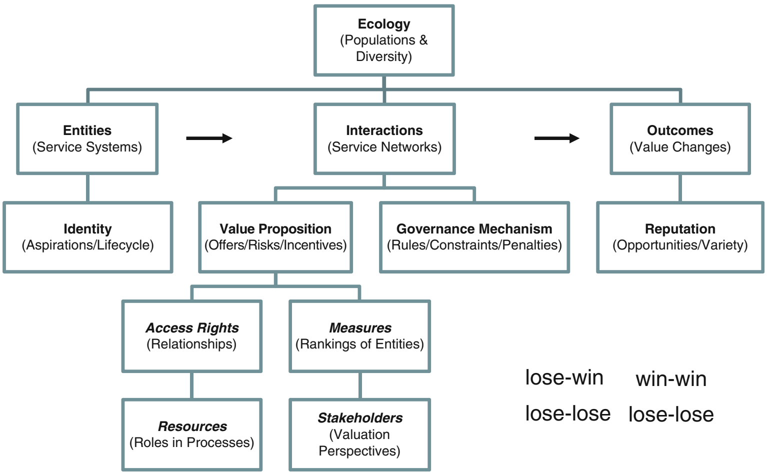



**Fig. 1** Ten core concepts of service science (Adapted from Spohrer & Maglio, 2009)

emerging systematic understanding of service and service systems. We hope this admittedly humble beginning and simple process will inspire others to contribute to this emerging area.

Service research is not a new area (Maglio et al. 2009). However, what is new is augmenting decades of traditional service research views, based in disciplinary (marketing, operations, etc.) and economic sectoral (service sector, as residual of agriculture and manufacturing) reductionism. To see all major discipline areas as equally relevant to the study of service systems, and to see all major sectoral areas as composed of interacting service system entities, is our novel perspective, which is in fact a hybrid reductionist and systems perspective. Furthermore, to invite representatives of multiple disciplines and sectors to transcend existing boundaries, and create something new and holistic, united by the concept of service system, is the goal of these two volumes.

In sum, service science builds on traditional service research, while seeking to create a complementary holistic systems perspective based on coordinating deeper traditional disciplinary and sectoral research and practice components. This will not be easy. Nevertheless, to improve quality of life and sustainability of existing and future service systems, it is necessary. The alignment of traditional disciplinary and sectoral research and practice around the concept of service system is our starting point.

While no boundary between theory and practice is clean cut, we have collected most of the articles that focus on formalizing the theoretical foundations for a science of service systems in this volume – The Science of Service Systems. The papers that we have chosen for this book examine a wide range of substantive issues and implementations related to service science in various perspectives. The authors of these papers are more likely to review and advance formal definitions of service and service systems, or methods to formally analyze and design service systems. Given that, what we have striven to do in this volume is compile a series of service system theories, concepts, models and frameworks that help understand real world services systems, their performance, and their behaviors upon introduction of changes, and hopefully provide the reader with insights and guidelines to help in building their own service systems towards a more favorable service experience as viewed by the customer and the provider. In the remainder of our Editors' Introduction, we will briefly discuss each of the articles in the book to identify their main thrust of the authors' investigation and the relevant findings for research and practice.

In the next chapter, Ng, Maull, and Smith in "Embedding the new Discipline of Service Science" ask how the new discipline of service science should approach the understanding of service systems. Science offers at least two different perspectives: (1) reductionism, which is widely adopted and is implicit in many of the disciplines that combine to make up service science, and (2) systems thinking, which is less used but has the potential to offer a different set of insights for research. The two approaches are not in competition, but are in fact quite complementary. Their conceptual discourse argues for service science to be free of the paradigmatic research influences of existing disciplines and proposes service science as an integrative discipline of engineering, technological and, social sciences (including business and law) for the *purpose of value cocreation with customers*, much like medicine is an integrative discipline of physical and biological sciences for the purpose of healing. The vision of service science is to discover the underlying principles of complex service systems and the value propositions that interconnect them. Service science is a distinctive field of study that places the co-creation of value between service provider and customer at its core. In sum, they conclude that service science will not emerge from any singular discipline but rather from the integration of research across these disciplines, that is, it should be transdisciplinary.

Mele and Polese in "Key dimensions of Service systems in value-creating networks" describe how service systems interact in the process of value co-creation and network formation. The four key dimensions identified in the analysis are: customers, people, information, and technology. They describe the value-creation process in service systems as consisting of three related stages: value proposition, acceptance, and fulfillment. The work has implications for understanding the formation of social networks and technological networks.

Alter in "Making a Science of Service Systems Practical: Seeking Usefulness and Understandability while Avoiding Unnecessary Assumptions and Restrictions" argues for practical definitions of service and service systems that will be easier to teach to business students. He argues that the initial development of service science did not use straightforward definitions that are understandable, useful, broadly applicable, and teachable. Services are acts performed for someone else, including the provision of resources that someone else will use. A service system is a work system that produces services for customers. A work system is a system in which human participants and/or machines perform work using information, technology, and other resources to produce products and/or services for internal or external customers.

Polyvyanyy and Weske in "Flexible Service Systems" introduce an approach to model service systems using flexible process graphs (FPG). FPG is a method for modeling business processes with a limited degree of structuring. They argue that once the modeling technique for capturing service systems and their environments is in place, they can be studied, analyzed, compared, classified, and researched more systematically. This work makes the connection to service computing and service oriented architectures (SOA) as a new way of designing complex software systems consisting of service components. However, they next argue that the technical point of view, taken alone, is too narrow to provide a solid understanding of service environments. Therefore, they integrate disciplines that investigate not only technical aspects of services, but also their economical and organizational foundations.

Petrie, Hochstein and Genesereth in "Semantics for Smart Services" apply the situational calculus of artificial intelligence planning systems to the domain of modeling and composing service systems. They focus on well-defined service descriptions that can be reasoned about prior to execution and support dynamic changes and contingency planning. They examine the discrepancy between the manufacturing industry, having adapted concepts such as standardization, automation or modularization for many decades, which service enterprises have only recently started considering. The more the service descriptions can be used to analyze and combine the service components for new purposes, the more useful they will be. The more that they are declarative and tied to formal constraints, the more useful they will be. The more the descriptions are formally described so that the meaning is tightly constrained among different systems and uses, the more they term them semantic descriptions.

Van Dinther, Blau, Conte and Weinhardt in "Designing Auctions for Coordination in Service Networks" introduce market engineering as a cornerstone for a science of service systems. They note that service providers tend to engage in networked value creation in ecology-like environments. This reflects the economic trend to a horizontal specialization in service offerings which in turn calls for new cooperation forms in loosely-coupled configurations of legally independent firms. Partners in such ecologies can leverage the know-how and capital assets of partners, at the same time spreading risk, sharing investment cost, and retain flexibility. Market engineering provides a structured approach to the design of coordination mechanisms which can be used to engineer service value networks. Their process consists of the four stages (1) Task Clarification, (2) Design and Implementation, (3) Testing, and (4) Introduction.

Böttcher and Fähnrich in "Service Systems Modeling: Concepts, Formalized Meta-Model and Technical Concretion" explore modeling and meta-modeling of service systems. The modeling and formalized description of service systems form a part of service engineering. Unlike other disciplines such as product engineering and software engineering, service engineering lacks an adequate modeling approach. As it is based on a broad literature analysis and on an analysis of existing modeling approaches, it covers a fairly wide range of the current state of the art in service systems modeling. The development approach of the meta-model (extracting concepts, a formalized meta-model and technical concretion) allows a continuous enhancement because further concepts can be added or changes of the actual meta-model can be made. The evaluation of the meta-model (in different use cases) has shown that the concepts provided are sufficient, yet the meta-model might be too expressive.

Mora, Raisinghani, Gelman and Sicilia in "Onto-ServSys: A Service System Ontology" construct an initial ontology for a science of service systems. An extensive literature review provides the foundation to construct an ontology that is based on an integrative systems approach. The literature review spans marketing, operations, and management of information systems areas. These discipline areas reflect the importance of understanding customer-provider interactions enhanced by increasingly sophisticated information systems.

Lyons in "A Framework that Situates Technology Research within the Field of Service Science" observes that academic and industry researchers from separate and currently mostly isolated disciplines are each approaching the field of service science from their own perspectives. Her chapter presents a conceptual framework that technology researchers can use to understand and articulate how their research relates to the field of service science. The framework aims to better enable technology researchers to relate to and engage with other researchers in the interdisciplinary field of service science. This is a tall order, as service science strives to bring together many disciplines (including computer science, cognitive science, economics, organizational behavior, human resources management, marketing, operations research, and others) in an attempt to study service systems in the following ways: understanding what service systems are and how they evolve; studying how to invest in order to improve management practices in service systems; determining how to create new technologies that increase the scaling of service systems; and, establishing a basis for assessing and relating relevant inter-disciplinary knowledge to a deeper understanding of the nature of service systems.

Kwan and Yuan in "Customer-Driven Value Co-Creation in Service Networks" provide a framework to connect the macro view of Service Dominant Logic (Vargo 2009; Vargo and Lusch 2004, 2008; Vargo et al. 2008) to the system view of Service Science in creating a framework of Service Value Network that accounts for both provider and customer driven value co-creation. They investigate four primary questions: (1) What are the determinants of value co-creation considering both the provider and the consumer versus customer driven value co-creation? (2) What are the determinants and elements of customer driven-service value networks? (3) How should service value networks be described? and (4) What are the incentives and the methods for service providers to embrace customer-driven SVNs? Because, they state that Service Dominant Logic takes a very high level perspective of provider-customer interaction. The role of the customers in value creation is emphasized but their role in the creation of the value proposition choice sets is not explicitly considered. From another perspective, the notion of value co-creation addressed in existing Service Science studies often assumes the value proposition to be static – i.e., proposition/acceptance happens before the start of service and is not visited again during the service.

Puehl in "Towards Service System Governance – Leveraging Service System Grammar to Empower Value Co-Creation" examines governance at both the enterprise level (business architecture) and project level (technology design). Governance in practice is about ownership. Service system governance is about service system ownership. If a person is the service system, ownership translates to accountability. The challenge lies not simply in formally modeling the technology or organizational interactions, but in modeling the people and their roles as knowledge workers in the system. Standard knowledge management is failing – making the knowing-doing gap worse – because they treat knowledge as a tangible. Service system governance has to respect the intangible.

Voss and Hsuan in "Services Science: The opportunity to re-think what we know about service design" investigate rather service design is a product or service. They argue that for much of the area of service design a manufacturing-based, product development paradigm is inappropriate. Given that the process is the product in many services, people should still draw on their knowledge from products, but adapt it. They have proposed that service product and process architecture, service platforms together with. A service system can be analysed at each level from the industry level down to what one might think of as the discrete service module. In exploring the architecture of services they illustrate through four levels, even though it may be possible to subdivide into many more than these four. These levels are industry, service company/supply chain, service bundle and lastly service package/component. In the dynamics of services, sustained competitive advantage is hard to achieve. Within the frameworks of service architecture and modularity, there are three areas that can contribute to competitiveness. The first is the possession of unique service modules or elements that are not easily copied in the short term by competitors. The second is the ability to exploit these through replication across multiple services or multiple sites. The third is the possession of a degree of modularity, which in turn supports both customisation and rapid new product development.

Lemmink and Chatterjee in "Service Science Learning: Exploring the Challenge of Cross Disciplinary and Academia-Company Collaboration" discuss about why multidisciplinary and cross disciplinary work in service science, management and innovation needed, why it is done very limited in today's world. They also provide guidelines how academia – company interaction can be improved for multi- and cross-disciplinary research. Their assessment about the academia-industry research is correct. As academia cannot bridge the gap alone with their traditional curricula, there is a most important role for new learning approaches incorporating cross disciplinary and academia-company learning at the group level. They state that problem based learning seems to be an approach that provides the necessary structure for systematic goal oriented collaboration while encouraging new paradigms to emerge. Perhaps the development of more socially inspired and thematically integrated choices for inter-disciplinary topics and new experiments on learning methods can create the agile SSMED professionals who can bring about the new era of service innovation by moving easily from abstraction to analysis and then to synthesis.

McFarlane in "An Engineering Perspective on Service Science" focuses on the way in which engineering as a discipline can most effectively interact with the services sectors generally and with service science in particular. This perspective is proposed in order to balance the relatively limited recognition of both engineering as a contributor to service science and also services as application area for engineering developments. McFarlane investigates five very important questions in this research, as following: (1) How can the engineering discipline – and academic engineering departments in particular – best prepare graduates for a vocation in the services sector? (2) To what extents are existing service science courses relevant to engineering and engineers? (3) Are engineering tools and techniques widely used in the design, operation or evaluation of services, computer aided design: information models and architectures, manufacturing engineering tools, process modelling and simulation? (4) Is there sufficient research of an engineering nature being applied to service sectors? and (5) What role can engineering play in service models of the future? This article has taken a pragmatic approach to increasing the involvement of the engineering discipline in the support of the service sectors that dominate our economy.

Ing in "Service Systems in Changing Paradigms: An Inquiry through the Systems Sciences" proposes the development of a body of knowledge on services systems, based on foundations in the systems sciences. The approach includes the design of the systems of inquiry, acknowledging that body of knowledge on twenty-first century service systems is relatively nascent. A program of action science is pro-posed, with an emphasis on multiple realities and knowledge development through dialectic. The outcome pursued is an increased number of T-shaped people with depth and breadth in service systems, in communities of inquiry of researchers and practitioners.

Kannan and Healey "Service Customization Research: A Review and Future Directions" propose a framework to provides the building blocks for such paradigm shifts in design for service customization. The critical component to target is the service product, which along with the service environment determines the scope of service customization that is feasible within the service system. The service at the service delivery stage can be customized only to the extent that service product is flexible enough to accommodate the customization in response to customer variability. Thus, front-line service employees or self-service technologies or the combination of the two can be as effective as what the service product (the processes that allow customers to obtain their preferred product or service) can allow. It is clear that with advancing technology and methodologies, service customization is going to much more important in the coming years. It will be a critical strategy that will separate winners from losers. In order that it provides a competitive edge to a firm, it is imperative that it is not viewed as a service attribute that can be traded-off against other attributes, but rather viewed as an objective where the bar should be set increasingly higher over time. It is necessary that firms have a learning mind-set when initiating service customization strategies. The strategy is best implemented with the selection of a niche segment of customers, for whom service customization is offered, either through co-creation or through other means.

In the last chapter, Spohrer, Demirkan and Krishna in "[17] Service and Science" seek to answer What is service? and Where is the science (in service science)? , and discuss universal patterns that can possibly occur when abstract entities interact and produce outcomes, or Abstract Entity-Interaction-Outcome Universals (AEIOU Theory). AEIOU Theory proposes a sequence of binary conditions that can be used to connect generalized systems science to service science and service dominant logic. They state that service science seeks to be a science based on reliable mechanisms, just as natural science is based on reliable mechanisms. From a human perspective, sometimes natural mechanisms (seemingly) fail to act reliably. This may be because assumptions are invalid, or other mechanisms are at work (e.g., a plane fails to fall from the sky). The same is true of service (value cocreation) mechanisms. If assumptions are invalid or other mechanisms are at work, then predictions may not be reliable. For example, when a computer program does not operate as predicted, we know it is because of invalid assumptions or other mechanisms at work. Science works to discover mechanisms, and to expose invalid assumptions and other mechanisms at work.

## 3 Concluding Remarks

As we conclude this project, we recognize that the research and practitioner work that we have included in this edited volume only scratches the surface of the issues that need to be studied and practices that need to be presented. We expect researchers and practitioners to pursue interdisciplinary research agendas in service science and service systems. We expect them to produce rich fundamental and applied work that leverages organizational and behavioural, economics and management science, and technical and design science research approaches toward the development of new managerial knowledge for service systems. If, as our colleagues at IBM, Jim Spohrer, Paul Maglio, and others have averred, we truly are moving to a world involving a "new science for services" for organizations large and small, then the time that we have spent will be a sentinel effort for what is to come. By participating in the beginning of the development of a new paradigm, we – authors, editors and readers alike – will have front row seats at the "table of innovation."

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 editors would like to thank the Series Editors of the Service Science: Research and Innovations in the Service Economy Series, Bill Hefley and Wendy Murphy, and the Springer Senior Editor, Melissa Fearon, for their encouragement and guidance for development of this volume. We actually had 80 articles and extended abstracts submitted on the topics of "*The Science of Service Systems*" and "*Service Systems Implementation*" for these two inter-related volumes of the Service Science: Research and Innovations in the Service Economy Series (SSRI). With so many submissions reflecting the interest of these topics among scholars and practitioners in our community, it was necessary for us to make some tough decisions as to papers to accept for further development, and those to pass back to submitting authors with indications of the work that they needed to do to put themselves in a better position to contribute to the service science literature. The articles in these volumes issue went through a three-cycle "review and revise" process. These two inter-related peer reviewed volumes of SSRI on Advancement of Services Systems ("The Science of Service Systems" and "Service Systems Implementation") are very specific in nature. The Science of Service Systems intends to stimulate discussion and understanding by presenting theory based research with actionable results. Service Systems Implementation intends to stimulate discussion and understanding by presenting application-oriented, design science-oriented (artifacts building: constructs, models, methods and instantiations) and case study-oriented research with actionable results.

We include total 34 chapters (17 chapters in each book) that represent research and practices from almost 20 countries including Amsterdam, Australia, Canada, China, Cypress, Germany, India, Ireland, Italy, Mexico, Netherlands, Singapore, Spain, Taiwan, Turkey, United Arab Emirates, United Kingdom, United States of America, and many others. These researches represent studies and practices from many universities, companies, government offices and public and private institutions.

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 us with development and constructive reviewing that led to the final products that you see in the present edited volume. Finally, we thank the authors, including those whose works we accepted, and those whose efforts did not permit their research and practices 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 systems. We look forward to the “next generation” of service science and systems research and practices.

## References

Maglio, P. P., Vargo, S. L., Caswell, N. & Spohrer, J. (2009). The service system is the basic abstraction of service science. *Information Systems and e-business Management*, 7, 395–406.

Spohrer, J. & Maglio, P. P. (2008). The emergence of service science: Toward systematic service innovations to accelerate co-creation of value. *Production and Operations Management*, 17, 1–9.

Spohrer, J. & Maglio, P. P. (2009). Service science: Toward a smarter planet. In W. Karwowski & G. Salvendy (Eds.), *Introduction to service engineering*. New York: Wiley

Vargo, S. L. (2009). Toward a transcending conceptualization of relationship: a service-dominant logic perspective. *The Journal of Business and Industrial Marketing*, 24(5–6), 373–379.

Vargo, S. L. & Lusch, R. F. (2004). Evolving to a New Dominant Logic for Marketing. *Journal of Marketing*, 68, 1–17.

Vargo, S. L. & Lusch, R. F. (2008). Service-Dominant Logic: Continuing the Evolution. Journal of the Academy of Marketing Science. 36(1). Pp. 1–10.

Vargo, S. L., Maglio, P. P., & Akaka, M. A. (2008). On value and value co-creation: A service systems and service logic perspective. *European Management Journal,* 26(3), 145–152.

## Editors

**Haluk Demirkan** is a Professor of Information Systems and a Research Faculty of Center for Services Leadership. His doctorate is in Information Systems and Operations Management from University of Florida, and his research in service science, and service-oriented management and technology solutions have included recent industry-sponsored research projects with American Express, Intel, IBM, MicroStrategy and Teradata. His research appears in a number of journals, including Journal of Information Management Systems, Journal of the Association for Information Systems, Journal of Service Research, European Journal of Operational Research, IEEE Transactions on Systems, Man and Cybernetics, Electronic Commerce Research and Applications, Communications of ACM, and many other leading journals. He has authored or co-authored almost 50 articles in refereed journals or conference proceedings. He has 15 years of consulting experience in the areas of service-oriented information systems and technology solutions, information supply chain, business intelligence and strategic business engineering with Fortune 100 companies. He is the recent recipient of the IBM Faculty Award for a research project titled "Design Science for Self-Service Systems."

**James C. Spohrer** is a Director of IBM Global University Programs since 2009, Jim founded IBM's first Service Research group in 2003 at the Almaden Research Center with a focus on STEM (Science Technology Engineering and Math) for Service Sector innovations. He led this group to attain ten times return on investment with four IBM outstanding and 11 accomplishment awards. Working with service research pioneers from many academic disciplines, Jim advocates for Service Science, Management, Engineering, and Design (SSMED) as an integrative extended-STEM framework for global competency development, economic growth, and advancement of science. In 2000, Jim became the founding CTO of IBM's first Venture Capital Relations group in Silicon Valley. In the mid 1990s, he lead Apple Computer's Learning Technologies group, where he received the DEST (Distinguished Engineer Scientist and Technologist) award. Jim received a Ph.D. in Computer Science/ Artificial Intelligence from Yale University and a B.S. in Physics from MIT.

**Vikas Krishna** is a senior technical staff member and manager at the IBM Almaden Research Center in San Jose, CA, USA. He leads a team of service researchers and engineers focussing on innovative solutions and service systems for IBM's global services business to provide higher personnel productivity, enabling service personnel to work and deliver service smarter, and higher client value propositions. Since joining IBM in 1997, he has led the design and development of systems for net mining, web-based service delivery, business-to-business information exchange, integrated analysis of text and data, managed business processes services, and next generation contact centers holding several patents in these areas. He is also the recipient of several awards for his outstanding innovative and technical contributions to IBM's services business and that of its clients. He received his Bachelor of Technology degree from the Indian Institute of Technology, India, an M.Eng. degree from Memorial University, Canada and his M.S. degree from Syracuse University, USA.

# Embedding the New Discipline of Service Science

**Irene Ng, Roger Maull, and Laura Smith**

**Abstract** This chapter presents a conceptual discourse for embedding the new discipline of service science. It argues for service science to be free of paradigmatic research influences of existing disciplines, proposing service science as an integrative discipline of engineering, technological and, social sciences for the *purpose of value cocreation with customers*. The chapter argues that thinking of a service organisation from a systems perspective will complement the traditional reductionist position and that together they will provide a sound foundation for the discipline of service science. The chapter then goes on to put forward a research agenda for service science, considering five salient issues for knowledge production. The argument for service science knowledge production is located alongside disciplinary knowledge of service, in so doing, suggesting that service science is not a logical development within any discipline and that the time is right for it to emerge into a discipline of its own.

**Keywords** Service science · Systems theory · Complex service systems · Viable systems model · Value-in-use · Value co-creation

## 1 Introduction

Today's world economy is going through the largest labor force migration ever known to mankind. With globalization spurred on by rapid technological innovation, business growth has been phenomenal in providing employment particularly in the service sector. Indeed, this sector now accounts for more than 50 percent of the labor force in Brazil, Russia, Japan and Germany, as well as 75 percent in the United States and the United Kingdom.[1]

[1] IBM SSME website, http://www.research.ibm.com/ssme/

L. Smith (✉)
University of Exeter, Exeter, Devon, UK
e-mail: L.A.Smith@exeter.ac.uk

H. Demirkan et al. (eds.), *The Science of Service Systems*,
Service Science: Research and Innovations in the Service Economy,
DOI 10.1007/978-1-4419-8270-4_2, 

The growth of the service sector is changing the nature of the organization, and it is becoming apparent that there is a lack of research and knowledge in service with most academics working within a manufacturing rather than a service paradigm (Spohrer and Maglio 2008, 2009). For historically, research has supported the manufacturing sector (e.g. in engineering, management, technology etc.), but with economies shifting to service economies, research needs to focus on the technology and techniques that will enable organizations in the service economy to function effectively and productively. Even traditional manufacturing companies (e.g. Kone, Rolls Royce) now attribute more than 50% of their revenues to service. Yet, the technology, knowledge and expertise required for an organization to deliver a *service* which may include intangible value being delivered that is perishable by nature and heterogeneous in characteristic, are clearly deficient. It is widely recognized that service research has not kept up with the demands of the economy (Grönroos 2001).

In 2006, Chesbrough and Spohrer published a manifesto for research in service science. The article was a "call to action" for academia, industry and government to create and pursue a shared agenda of service research. Chesbrough & Spohrer put forward the "Grand Challenge" of service science, a common set of research problems meant to unite multiple groups in a common cause. Through the pursuit of these problems and by the means of a systematic, interdisciplinary approach, common terminology and methods they proposed the way forward for reconnecting theory with the needs of the service economy.

What began as a "call to action" has now become a global initiative in service science or SSMED research, which is short for Service Science, Management, Engineering and Design. This emerging discipline advocates an interdisciplinary approach to the study, design, and implementation of service systems, that is complex systems in which specific arrangements of people and technologies take actions that provide value for others. As one might expect extant research in SSMED has focused on the description of core problems and outline concepts behind the phenomena of service science (see for example, Maglio et al. 2006; Chesbrough and Spohrer 2006; Spohrer et al. 2007; IfM and IBM 2008). For it is through shared problems and concepts that foundations for interdisciplinary research are built.

Spohrer et al (2007) followed the manifesto with a general theory of service systems, which presented service science as an emerging field that should "tap into" and integrate science, management and engineering for the advancement of three primary goals; to understand service systems, how they improve and how they scale. In doing so they called for interdisciplinary, scientifically rigorous research into the three types of resource that make up all service, namely people, technology and shared information. IfM & IBM's (2008) report "Succeeding through Service Innovation" drew upon the expertise and experience of leading academics and senior practitioners to propose a set of recommendations for key stakeholders of service science. The report set out the following recommendations for researchers intending to formulate service innovation action plans: to develop an interdisciplinary and intercultural approach to service research; to build bridges between disciplines through grand research challenges; to establish *service system* and *value proposition* as foundational concepts; to work with practitioners to create data sets to understand the nature and behaviour of service systems and to create modeling and simulation tools for service systems. Both of these articles set out an agenda for the advancement of service science, through the assimilation of interdisciplinary knowledge and skill that exists between the stakeholders of service science towards a shared set of issues.

Extant literature has provided us with a manifesto, a common cause and a set of questions from which to base the integrative discipline of service science. Thus, agendas have been presented which address the "what" and the "why". In this chapter we develop the conversation on the fundamentals behind the "how". It is commonly noted that integration of disciplines requires a common purpose and the development of common language, platforms, units of analysis and research philosophies towards that purpose (Wild et al. 2009). Yet, the vision of service science is to discover the underlying principles of complex service systems and the value propositions that interconnect them. This will not be achieved through traditional approaches to scientific research alone; the answers lie deeper than interdisciplinary collaboration towards a shared cause. Certain aspects of the way we approach research need to be addressed if we are to produce new knowledge in service research.

This chapter begins by presenting service science as a distinctive field of study that places the co-creation of value between service provider and customer at its core. This definition means that service science has many founding disciplines including business, engineering and many of the social sciences. However we would argue that the development of service science will not emerge from any singular discipline but rather from the integration of research across these disciplines, that is, it should be trans-disciplinary. This in itself is not new, for Spohrer (2009) has called for

> an integrated approach that spans not only existing discipline-based silos within academic organizations (i.e., marketing, operations, and human resource management within a business school) but also across academic organizations (i.e., business, engineering, and liberal arts)
>
> (Spohrer 2009)

In our view the approach we take to this new discipline is crucial. We set out the case that there are two alternative but complementary scientific perspectives from which we can conceive of the new discipline. The first and historically dominant perspective is based on reductionism, the second takes a systems perspective. It is our view that thinking of a service organisation from a systems perspective offers many insights into integration that will complement the reductionist position and that together they will provide a sound foundation for the development and embedding of the new discipline of service science. We then move on to set out a research agenda for producing new knowledge in service, incorporating the implications of the two approaches presented. Finally, we provide the argument for service science as an emerging discipline and how it is conceptually located with service research within disciplines plus implications of the proposed agenda for research and practice.

## 2 Service Science and Its Distinctiveness

Service, as it was traditionally understood, comprised of activities, deeds and performances (Berry and Parasuraman 1993; Zeithaml et al. 2006). However, the new understanding of service is now broader, one where service "*is the application of competences (skills and knowledge) for the benefit of another party*" and such competencies could be manifested in a complex combination of goods, money, activities and institutions within a service system (Vargo and Lusch 2008). This service-dominant logic embraces the concept of value co-creation, where the value is no longer *value-in-exchange* (i.e. a tangible product solely created within the firm and exchanged with the customer), but *value-in-use*, i.e. jointly co-created between the customer and the firm for benefits (Ng et al. 2008; Payne et al. 2008; Prahalad and Ramaswamy 2003). The concept of value co-creation subsumes previous service research that have emphasized the role of the customer within a service system such as the customer contact model (Chase and Apte 2007; Chase and Tansik 1983), customer interactions (Johnson et al. 2005), value co-production with the customer (Ramirez 1999). The understanding of "customer" here is taken in the broadest sense of the word e.g. the end customers who actually pay and receive the service or organizations/customers in public services and even customers who use the service and do not directly "pay" for it (e.g. Broadcasting and Google).

Despite subsuming previous literature on customer centricity, the new concept of value co-creation in service systems extends the ideas further with two major implications for the design, delivery, evaluation and purchase of service. The first is the notion that customers are an integral part of the service system and they contribute the resources accessible to themselves into the system to achieve the outcomes just as firms deploy resources into the service system to deliver the service. This implies customers' *abilities* to co-create value i.e. *their* resources (e.g. in knowing how to use an ATM, informing the hairdresser how s/he would like his hair cut, understanding how to get around an airport, or a leasing company's ability to operate aircraft) is now *part* of the organization's service capability to deliver, particularly if it aims to achieve service excellence (Ng et al. 2008). This also implies a far more proportionate view of a service system, where equal emphasis on customer and the firm's systems is needed in understanding value co-creation. Second, as an extension of the first, is that firm's competency to deliver on a service, and perhaps its potential source of competitive advantage, includes the customer "as the source of competence", and the firm has to find ways to harness the competency (or improve the lack of competency) of the customer in the service system (Prahalad and Ramaswamy 2000). Seen in this light, value co-creation thus demands a major rethink of traditional disciplines from management and technology to the engineering and manufacturing of tangible products. Traditional disciplines are strongly goods-based, more often involving linear supply chain models and linear models from design to manufacture. This may impede organizations' potential to construct optimal systems for value co-creation since, in contrast to linear models, service often involves "value constellations" (Normann and

Ramarez 1993) which are networked and complex (Demirkan and Goul 2006) and which suggest a multi-faceted and iterative approach with the customer system within the whole system. The move towards that understanding is a process commonly known as *service transformation* (Ng et al. 2009a, b). With newer technologies such as computing and web-based technologies in which such IT-related capabilities could be provided "as a service", the time has come to allow service to emerge as its own discipline of service science, which will enable it to focus on producing knowledge on how best value could be co-created, and how a service system of people, technologies and products could be configured in order to integrate the best from all disciplines.

The understanding of value co-creation also compels the firm to better understand customer needs and usage requirements across differing environmental conditions so that customers are able to realize the firm's value proposition through their part in the co-creation process. In so doing, customers' use and achievement of outcomes could result in changing the firm's business model (Ng et al. 2009a, b). Customer usage could result in different types of access rights to tangible goods and intangible activities within a service system for example hybrid revenue models of ownership/lease of goods and privileged access to activities and physical locations.

How, then should the new discipline of service science approach the understanding of service systems? Science proposes two different perspectives. The first is reductionism which is widely adopted and is implicit in many of the disciplines that combine to make up service science. The second is systems thinking, which we would argue is much less used but has the potential to offer a different set of insights for research. In no sense are these two approaches in competition. Rather, they are complementary and both provide insights into the study of service organizations. We shall now consider the features of both perspectives.

## 3 Reductionism

It has notably been argued that the standard scientific approach is based around the 3 R's of reduction, repeatability and refutation (Popper 1972). That is we reduce the world through the selection of variables and we run repeated experiments until exceptions occur (refutation). Checkland (1981) points out the three ways in which much of scientific thinking throughout history has been reductionist (Checkland 1981).

1. Because many problems are highly complex and messy scientists focus their effort and select some aspects of a problem from all those that are possible for further detailed investigation.
2. Science progresses by applying the principle of Occams razor: the removal of all extraneous factors for a parsimonious explanation of the facts.
3. Science follows Descartes' advice to analyze problems piecemeal, that is, breaking down a phenomena into its elemental parts. Accordingly, scientific thinking is very closely associated with analytical (divided into its constituent elements) thinking.

This approach to scientific thinking strongly influences the manner in which management academics approach their research. For example, Schroeder (2008) in his recent article on theory in operations management states that "*not only should theory be parsimonious, but it should be falsifiable*". He then calls on operations management scholars to develop *"good" theory that can be tested and possibly refuted, confirmed, or refined*. Clearly for Schroeder, good theory is closely associated with reduction.

Yet we would argue that the reductionist approach is based on a number of assumptions that we should consider before applying it to the problems of service research.

## *3.1 Assumptions in Reductionist Thinking*

The first and most crucial assumption, the division of the complex problem into separate parts, is that the elements of the whole are the same when examined independently of the whole as when they are examined as a whole. This needs careful consideration. If the elements are loosely connected then we can take them apart, analyze them, improve or change them and then put them back together and the whole will be improved. Whilst this may be true for the problems of physics at the atomic level, does this assumption hold for complex wholes? For example can we take out a part of the body e.g. heart, modify it replace it back within the body and not expect effects elsewhere?

It is also not just that the parts of the whole in service that are interconnected, their relationships are also highly complex and non-linear. Forrester (2003) in his seminal work on organizational dynamics points to the importance of time delays, amplification and structure on the dynamic behaviour of the system (Forrester 2003). These can occur across supply chains (the Forrester or Bullwhip effect) or within organizations. Akkermans and Vos (2003) provide an excellent example of a Telco implementing a new customer service process that includes four separate activities, selling, installing, provisioning and billing each of which is carried out by a different department. The interactions between the departments led to enormous amplification where a 10% increase in sales order volumes leads to a 250% increase in provisioning, 140% in installing and 175% in billing (Akkermans and Vos 2003).

Finally, Lipsey and Lancaster (1956) and Goldratt (1994) have identified implications for the performance of parts where there is a close relationship. Lipsey and Lancaster in their theory of the second best showed that if one optimality condition is not satisfied, it is possible that the next-best solution will involve changing other variables away from their positions of optimality (Lipsey and Lancaster 1956). Similarly Goldratt pointed out the implications of optimizing one part of a whole process that was not the limiting step. In his theory of constraints he points out that optimizing the performance of a process step upstream of the bottleneck will only increase work in progress and working harder downstream is limited by the output of the bottleneck (Goldratt 1994). Sprague (2007) sums this up by neatly proposing that *"Optimizing the supply chain" means convincing elements within that system to accept local sub optimums for the good of the whole (Sprague 2007)*. We would simply add that this holds for any system not just supply chains. Thus, if we want to understand the performance of the whole service system and if we have begun the understanding by following the method of reduction we are making three highly questionable assumptions; First, the connections between the parts must be very weak; second, the relationship between the parts must be linear so that the parts can be summed together to make the whole; and third, optimizing each part will optimize the whole.

To address the problems caused by these assumptions an approach is required that begins with the whole and concentrates on the relationship of the parts in the whole. This is the perspective taken by systems thinkers which we will now consider in some detail.

## 4 Systems Thinking

In the introduction to Systems Thinking, Systems Practice, Peter Checkland (1981) states that;

> the central concept of a system embodies the idea of a set of elements connected together which form a whole this showing properties which are properties of the whole rather than properties of its component parts.

There are a number of important ideas in here that need to be drawn out. Firstly, the definition draws attention to elements (other systems writers use words such as components or parts) which are interdependent, that is elements which affect one another, system thinking is particularly associated with the study of elements that have strong connections (Weinberg 1975) as problems with weak connections are amenable to reduction. Secondly, there is the notion of the study of "wholes". Thirdly, there is the idea that there are properties which occur in the whole not in the component parts, which is of course the essence of the famous phrase attributed to Aristotle that "the whole is greater than the sum of its parts". In short systems thinking is concerned with the study of wholes that exhibit strong interconnections and that as a result of these interconnections properties emerge at the level of the whole that are not present in the elements.

### *4.1 Emergence*

Of central importance to seeing the world from a systems perspective is this concept of emergence which is probably the most important and challenging idea in systems thinking. Understanding emergence sheds light on what appears as a paradox; that the whole is made up of a set of elements, yet the whole is also different from the elemental parts. Take for example the harmony of a group of musicians.

The property harmony is not found in the component parts, e.g. the vocalist and guitar, but only occurs when they interact. Other frequently used examples include color (a phenomenon that can only occur because of the arrangement of the constituent parts in an atom) the swarming of bees, hurricanes, traffic jams and many would argue, life itself.

A fundamental principle is that emergent properties are essentially unpredictable, indeed one well used definition of emergence is that it cannot be predicted (otherwise it would be deterministic) and that it is "subjectively surprising" (Klüver 2000). Henle (1942) argues that "*where there is an emergent there is unpredictability* and that *we have emergence where a new form appears and where the causes of the appearance are unable to explain the form*" (P488).

This does not mean that everything that is unpredictable is emergent for it may mean we have not as yet developed the model that explains the underlying relationships. The argument here is that given a known starting position and knowledge of the components of the system we may not know what the outcome of the system could be.

Emergence is clearly a deeply challenging concept and one that is at the heart of studying wholes not parts. We can provide three insights that might help.

1. What we are observing in complex systems is circular causal chains (Buckley 1980) where the effect of one element on a second element returns to influence the original effect perhaps directly or through some intermediate effect. In organizational life, it is often difficult to point to one-way causality.
2. Emergence is very hard to predict because of the number of elements that interact to produce the property. Seen from one perspective this is a combinatorial problem: identifying all the potential outcomes with many millions of interacting elements (all the potential states of the system) is incredibly challenging and if we take into consideration the non-linear relationships and multiple potential feedback loops, then the results are impossible to predict.
3. There is coupling between the elements so that something is produced in the interaction of the two elements which is a product of the interaction. An analogy might be a win–win game where both parties gain and therefore the new relationship produces an outcome that is greater than the parts.

## *4.2 Core Systems Ideas*

Building on the notion of a system this section will consider some of the main features of systems thinking that can contribute to the development and embedding of service science as a new discipline.

1. Systems characteristics.
   One of the advantages provided by systems thinking is that there is an established language of systems characteristics. As a meta discipline systems thinking has over the past 50 years developed, across many disciplines, an established set

of terms that can provide insights into any discipline. Some authors e.g. Kast and Rosenzweig (1972) have applied these terms into identifying some basic characteristics of a management system which include; boundaries, interfaces, hierarchy, feedback and adaptation to which most systems writers would add emergence, input, output and transformation (Kast and Rosenzweig 1972). These terms may be used as a basis for a research agenda for the consideration of a service system.

2. Law of requisite Variety
   How a system behaves is a key question for those systems researchers working within the general field of cybernetics. One of the most important ideas for service systems research is Ashby's law of requisite variety. The law states that at a minimum there needs to be as much variety in the responses available to the regulator (manager) as in the disturbances that emerge from the environment. If there is not then the manager cannot guarantee acceptable outcomes and therefore keep the system viable. Ashby summarizes the law as *only variety can destroy variety*.

3. Viable Systems Model
   Beer (1984) applied Ashby's law of requisite variety in his Viable Systems Model (VSM) where the term viable is used to assess whether an organisation is able to survive in its environment. The paramount viable system in an organisation (VSM has 5 sub-systems) is its *producer system*, which is the system which generates the income on which the organisation depends for its survival (Beer 1984). Producer systems are threatened with overwhelming variety from the environment and have two potential options which Beer terms variety engineering.

   1. Attenuation; limiting the amount of variety on offer e.g. a fast food restaurant like MacDonald's has a very limited range of offerings on its menu. If what customers want is something outside the fixed menu then the attenuator (the systems designer) has reduced operations response below the threshold and the producer system does not have sufficient variety to respond.
   2. Amplification; for example in a producer systems that only offers one choice of color, for example black, we could amplify variety by offering the customer price promotions that emphasize the value in buying black or we could develop an advertising strategy that promotes black as "cool".

4. Socio-Technical Systems
   A major part of the systems movement that was based around the view of an organisation as an open system was the socio-technical systems school developed during the 1960s at London's Tavistock Institute. Emery and Trist (1960) in their famous work on socio-technical systems were interested in the open systems notions of input-throughput-output and how a system maintained a quai-stationary equilibrium despite changes in the environment (Emery and Trist 1960).

   The Socio-Technical school drew a general conclusion that the social and psychological aspects of work needed to be understood in the context of the task and the way in which "the technological system as a whole behaves". The technology system here is taken to include not only the hardware, machines etc. but the methods and procedures of work and how that work is organized in a process. Thus the Tavistock research identified the technology component of the system as playing an important part in the organisation of the system and that it was no longer possible to talk of purely social systems composed of people and their relationships but to consider the enterprise as a combination of human and technology in a socio-technical system.

5. Open and Closed systems
   The notion of an open system is associated with the early work of the biologist and general systems thinker Von Bertalanffy. He describes open systems as a system which has an *exchange of matter with the environment*, (Bertalanffy 1972). Closed systems, on the other hand, are systems where *no material enters of leaves it* and are typically found in the realm of physics and physical chemistry.

   The discussion on whether a system is open or closed has particular application in the management of service systems. Consider the implications of taking a closed or relatively closed system view of an organization or department in an organization. Such a system would be deterministic and optimizable. However, taking an open systems view would suggest a complex and dynamic interaction of the organization and its environment with undeterminable results. The consequences of closing the system in a technical core are considered by Mills and Moberg (Mills and Moberg 1982).

# 5 Revisiting Reductionism

A systems view does not, however, conflict with the reductionist view; it should be considered as complementary. The traditional thinking behind the reductionist view is if we can get the right simplifications, we will then understand all. If this is true, by logical extension, the right simplification has to be particle physics, since that is what all matter consists of. Clearly, knowledge of particle physics would not be particularly helpful in understanding sociology, economics or psychology. Such a notion as Dennett (1995) puts it, is "greedy reductionism". Also, as Anderson (1972) points out, reductionism does not mean constructionism i.e. just because we could reduce it, does not mean we could construct the system (Anderson 1972). The key question is what the system should be reduced to and for what purpose. The important consideration for a reductionist approach is to weigh the potential to generate insights against the cost of being less exact. Being less exact might be acceptable, but being inappropriate could warp what needs to be understood. Thus, service science has to embrace the notion that whatever the reductionist approach taken, what is lost in reduction is merely resolution, and not the understanding of the whole.

One example of reductionism from a systems perspective is research in computational modeling of agent-based complex systems and developing work in the science of complexity (Wolfram 2002; Epstein 1999). Agent-based objects could be people, organisms, and such objects are capable of change, interacting, thinking and are intelligent but not brilliant in their deliberations. Using agent-based objects in modeling provides a more flexible, dynamic and networked approach that is process oriented and allows for adaptive and emergent properties (Miller and Page 2007). Research in this area has provided insights into why some systems are stable while others are constantly in a flux (Tiebout 1956) by modeling elements, their interactions and analyzing feedback into the system. Thus, from the reductionist view of a complex service systems, a system could be reduced but only if all interactions are modeled as well. Miller and Page (2007) proposed that when reducing systems to agent-based objects, there are eight interconnections to model so as to ensure the representation of the system is appropriate; the agents' information and connections, goals, communication among the agents, action (interaction), payoffs, strategies and actions, cognition and the model focus and heterogeneity. Yet, even as all eight are modeled within one or more agent, the resultant system could result in unpredictable emergent properties – both of the stable and unstable variety. This is because even if we completely specify all interactions and components of the system and its probabilities of occurrence, it is acknowledged amongst researchers in the field that there is still no simple way to understand the macro-level outcomes. This emphasizes the crucial aspect of reductionism in service systems, which is to create models that could go beyond our own understanding, and to build in framework for emergence within the model, and to explore the notion of *organized complexity* (Weaver 1948, Weinberg 1975) that could be invaluable when designing future service systems.

We recognize that the division of approaches to science into reductionism and systems is to some extent artificial. It would be better, perhaps, to recognize them as different positions on a continuum. For problems of relatively low complexity with low randomness, termed *organized simplicity* by Weinberg (1975) then deterministic closed systems models are appropriate i.e. we can understand how the factors inter-relate and we can predict the end result with accuracy. These are the problems that are suitable for reduction into components. For those problems that have greater complexity and that exhibit higher levels of randomness in their behaviour (emergence) then this is the domain of systems thinking. Here the problems are of large numbers of variables with many combinations that are not amenable to varying one factor at a time. This makes the problems too difficult for the traditional reductionist method. Weinberg (1975) and Weaver (1948) term these problems *organized complexity*. Any reductionism would have to incorporate interactions and would be a reduction of the whole system into a prototypical or representative equivalence.

Systems thinking provides an important platform for the development of a "how" research agenda. The division of academia into subject silos contributes to the challenges in engaging in businesses where problems tend to be complex and deeply integrative. One simple example serves to illustrate the point, in what we term the potato case. In this example a company was making French fries from potatoes. However its purchasing department was having problems buying potatoes that fitted their size requirement (they had a minimum and maximum specification). The types of potato that fitted the specification had high demand and were being sold at a premium price. The purchasing department was regularly exceeding its price target and consequently received lots of pressure from their senior managers to improve their performance. Without consulting anyone, the purchasing department removed the maximum size specification of the potato thereby allowing them to buy larger potatoes and at a cheaper price. However, the potatoes were now too big for the chipping machines and at Christmas the company was unable to fill their order from a major retailer. A minor modification to one part i.e. changing the maximum size specification had huge implications across the business. This is often termed the law of unintended consequences.

This simple and true story illustrates the interactive effect of change in business. If academia reduces problems to, for example, the level of a pricing strategy or performance measurement it then risks providing sub-optimal solutions at the level of the whole. Research in service systems needs to include models that show the interactive effects at the level of large "wholes" be they individual companies or across supply networks.

The above presentation has highlighted the approaches towards research in service science. Following on, we propose a research agenda for service science and key issues in producing new knowledge in service.

## 6 Service Science Research Agenda: Issues for Knowledge Production

### *6.1 The Need for More Appropriate Simplification in Service*

There is a pressing need for service to be understood across sectors. *Abstraction* is necessary to discern the tacit knowledge in service for the purpose of *transferability* of knowledge across industry sectors and academic disciplines as well. Abstraction is also needed for *replicability* so that future service design could be systemic, structured and deliberate to ensure sustainable service excellence. Finally, abstraction is needed for the *scalability* of service for growth. Service needs to find a set of simplifications that is able to preserve the essence of the whole while being able to achieve transferability, replicability and scalability. Service science could provide not merely fundamental understanding, but also better tools and mechanisms for discovery and abstraction. Even at the very least, service needs better measurement, analytics and identification of what is performance success. For most of the past three decades, social scientists have tried to find ways to classify and disassemble service in a meaningful manner that would aid practice and provide understanding. This has been without any noticeable success in part due to the analysis being not sufficiently fundamental (the periodic table would be a good analogy of achieving a framework for fundamental understanding so as to classify, systematize and compare all the many different forms of chemical behaviour). In addition, we argue that existing research of this nature has been conducted through narrow disciplinary lenses. Hence, much of service research to abstract service typologies use words such as "complex", "system" and "relationships" (see (Liu et al. 2008) for a historical account of service typologies), an indication of a knowledge gap. Just as science provided ways forward for Physics and Chemistry from "Alchemy and Occult", service science research is challenged to find its abstraction and properties that would subsume all sectors. Service, like color in the early days, is currently alchemistic.[2]

### *6.2 The Need to Look Forward*

The Janus face of science suggests that science has two faces where one looks back at the current state and evidence (ready-made science) while the other looks for the way forward (Latour and Biezunski 1988). For the sake of publications, service research in the past has had to be conducted through the lenses of one or another existing discipline. The current state of service research could then be a reflection of the way it has been influenced by whichever disciplinary regime in which it currently sits, which may not be the best way to look forward. There is a need to take the lessons from the other disciplines, but without the hegemony. When disciplines come together to understand value co-creation with the customer, there would be new impetus for service innovation and service excellence. Yet, while service science is tasked to be able to both look back for the best technologies and look forward to progress knowledge, it must acknowledge the strength and weaknesses of current disciplinary-based knowledge and methodologies. In researching service systems, the technology to capture the range of data (particularly behavioral data) may be beyond the current conventional collection methods and possible observations are far more expansive than what current methodologies can capture. When Copernicus first thought about the possibility of the Earth revolving around the sun, it was not based on measurements or data (although he was clearly motivated to find a theory that could simplify measurement since the Ptolemaic system was very cumbersome empirically). Instead, Copernicus indulged in what is termed as "thought experiments" (Brown 1993; Cohen 2005), breakthrough ways of seeing the world, instead of merely looking at new methods or tools to "measure" what is existing. Indeed, as contemporary philosopher Cohen puts it, "much of modern physics is built not upon measurement but on thought experimentation". Hence, current knowledge and methodologies may be

[2] As Newton wrote, "A Naturalist would scearce [sic] expect to see ye science of [colours] become mathematicall, and yet I dare affirm that there is a much certainty in it as in any part of Opticks" (The correspondence of Isaac Newton ed. HW Turnbull, JP Scott, A Rupert Hall, Laura Tilling, 7 volumes, Cambridge: Cambridge University Press, 1959-177 1:96)

inadequate for service systems. Rather than apply legacy knowledge towards service systems, researchers must also open their minds to opportunities to produce new knowledge, new methodologies and new ways of seeing the world, brought upon by intrinsic characteristics of the service system. The act of focusing on what exists now should not draw attention away from “what can be” (Alvesson and Skoldberg 2000). Work by Vargo and Lusch (2004, 2008), although incorporating themes of what has been iterated for the past 30 years, is a start towards viewing the service domain through a different logic but service researchers the world over need to feel much more empowered to challenge conventional thinking and legacy knowledge (Vargo and Lusch 2004; Vargo and Lusch 2008). Finally, the interactions and the interplay between processes and outcomes within a service system which are non-linear and multi-directional in nature, suggests that the instrument of analysis may not yet be scientifically reproducible in any meaningful manner by conventional methods. Indeed, techniques traditionally used could be, as Miller and Page (2007) puts it, “understand running water by catching it in a bucket”. Future techniques and tools for service system would also need to emphasize dynamic processes and states of equilibrium; much of these ignored by current researchers that research within a static environment.

## *6.3 The Role of Technology Changes the Service System and Vice Versa*

Real/virtual interaction is playing an increasingly prominent role in the service economy and there is a need to better understand virtual worlds as a medium, virtual companies, brick-and-click delivery, multiple-channels, and web 2.0 in value co-creation of service systems. In the field of management, technology is beginning to gain traction in changing business models, for example, in the field of management 2.0® (Breen and Hamel 2007). Leaps in computing power have resulted in newer technologies with greater capability, from the ability to sense facial expressions and stress levels to a fully liberated cyberspace where autonomous and intelligent entities or virtual objects can act in full inter-operability and auto-organize themselves to deliver services, based on the concept of the *internet of things* attributed to the original Auto-ID Center, based at MIT (with continuing research with Cambridge, UK). The service system and the notion of value co-creation are starting to change research in technology as well. More studies are being conducted in the technological sphere that includes customer behaviors and processes, informing research in service-oriented architectures (Papazoglou and Heuvel 2007), User Centred Design (UCD) and Human-Computer Interaction (HCI) which views design for and from the customer, termed as user in the literature. A socio-technical systems view of service could challenge the assumptions surrounding customer types in software modularity and mechanistic designs, compelling research in this area to bring the customer into design issues for greater innovation in value co-creation. This is clearly evident in healthcare, where the digitization of medical records is not merely leading to a convergence of biology and engineering, resulting in the health care service systems and clinical practice becoming much more an information industry, but also allowing customers access and control into their own information and letting them take responsibility for their health through intelligent sharing network of records (The Economist, April 16, 2009).

## *6.4 The Need to Integrate Social Sciences (and Business), Engineering and Technology for Customer Value Co-creation*

It would be a mistake to think that basic research in service science is disciplinary specific and the applied research of service is where interdisciplinarity and integration sits just as it would be a mistake to think that the practice of service is where integration occurs. Precisely because the unit of analysis is the whole service system, basic research is needed into understanding what patterns and orders exist at a systemic level whilst *at the same time* at the analytical level research is needed into how elemental parts of the service system behave, all within an interdisciplinary context. However, interdisciplinarity is one of the biggest challenges in research. As an analogy, one does not leave sodium and chlorine in a beaker and expect them to naturally react and deliver salt. More often in the real world context, the sodiums would have retired to their rooms while the chlorines would have gone down to the pub. Integration of disciplines requires *a common purpose* and the development of a common language, platforms, units of analysis and research philosophies towards that purpose (Wild et al. 2009). Thus, our emphasis on value co-creation with the customer explicitly identifies the purpose towards inter-disciplinary collaborations. The focus on value co-creation, much like the focus on *healing* for medicine as a discipline, should therefore be the central theme of service science and is also the unifying focus towards which knowledge from various disciplines can contribute. By explicitly bringing in the value co-creation, we believe service science can achieve a constructive collaboration for the betterment of knowledge to deliver and innovate on service in the modern economy. In addition, the focus on value co-creation conceptually differentiates service science from service research within other disciplines which would still thrive, particularly in light of the dominance of the service economy. The theme of customer value co-creation is echoed in several papers and presentations on service science (Spohrer 2009; Spohrer and Maglio 2005):

> Service science is emerging as the study of value co-creation phenomena in a globally integrated and connected world, which has the potential to become significantly smarter and more sustainable. In a service world, diverse entities create, abandon, utilize, ignore, configure, reconfigure, specialize, integrate, protect, and share resources and relationships to co-create benefits with and for each other, both as individuals and collectives, both for the short-term and the long-term.

### 6.5 Service Science Could Be a Disruptive Science

We have previously presented how the introduction of a customer system within a service system is a requirement in the study of service. It would therefore not be surprising to find that traditional disciplines that are strongly goods-based may find service technologies rather disruptive (Bower and Christensen 1995) although the disruption might provide opportunities for innovation. In the service context, the move towards a service orientation could lead to the ability to define new "spaces" for doing business that were previously non-existent but of which the profitability is uncertain (e.g. Youtube or Google). With value less "contained" within the vessel of a tangible product, value co-creation could happen everywhere within a service system, often between employees, customers, tangible products and technology (Ng and Yip 2009a). Traditional manufacturing and engineering technologies that propose the optimization of a system that does not include the customer system is now challenged. Similarly, the notion that costs could be minimized and efficiency gains could be attained within a service system without controlling for the loss of value co-created with the customer suggests that many tangible product-based technologies need to be seriously re-evaluated and service science technologies could possibly be disruptive to existing ways of thinking (Ng and Yip 2009b). The industrial era has accumulated more than a 100 years of knowledge in the managing, manufacturing, and engineering of tangible products, often within silo-ed disciplinary domains. Thus, the advancement towards a technologically fast-paced globalized world where the service system is a constellation of amorphous value co-creation with the customer, integrating several disciplinary approaches is bound to create severe discomfort, not least amongst the knowledge producers of the old. As the world moves towards a service era, serious questions need to be posed about the legacy knowledge and while the best technologies to advance knowledge in the service era will eventually be adopted, adapted and improved, the initial task of embedding the discipline of service science will encounter political difficulties.

Those with the most to gain from a trans-disciplinary approach would be expected to be most enthusiastic. These include researchers who recognize knowledge transfer through a plurality of mechanisms rather than merely through publications; those who are marginalized by their own disciplines or who labored under the patronizing attitudes of the "purer" or more "basic" disciplines, as well as policy makers who are motivated to create better links between science and innovation. Those who are most threatened by a trans-disciplinary approach would predictably be most skeptical; they would argue that the quality of research would be eroded through trans-disciplinarity or feel that their autonomy might be jeopardized. Most alarming to such researchers is the possibility that those who subscribe to product-based technologies may find themselves obsolete in a service system-dominated world. For these researchers, a natural reaction is to reject and refuse to participate. This would be disappointing as the reality is usually far less threatening. What is required of researchers is the willingness to share and adapt existing knowledge, particularly in light of increasing complexity of research problems, and recognizing interdependencies in the production of new knowledge, a fact that has been widely acknowledged (Gibbons et al. 1994; Nilsson 2001; Nowotny et al. 2003). Ziman (2000) describes the transformation of knowledge production processes in what is commonly known as "post academic" as:

> "…marked by an increasing degree of collectivization as a response to the growing complexity of research problems, [and] the increasing costs of scientific equipment, but also the growing potential for research collaboration that is offered by information technology."
>
> (Ziman 2000)

What is needed for service science is for knowledge from all relevant disciplines to be presented to inform customer value co-creation. In doing so, we believe that the gains from the interactions would inform and contribute in return to the production of their own disciplinary knowledge, which is still much desired.

In our endeavor to embed the discipline of service science, our chapter has presented system and reductionist approaches to research as well as the research agenda for the discipline. We now put forward an argument for why service science is an emerging discipline.

## *6.6 Service Science as an Emerging Discipline*

As a result of disciplinary inter-dependency, we propose that service science is not a logical development within any existing discipline. As long as it sits within a discipline, it shall remain a subset of that discipline and more drastically, oppressed by the discipline's agenda, whether intentionally or otherwise. High level mainstream journals are disciplinary-focused, and these gatekeepers will often not allow their power bases to be diluted by a trans-disciplinary approach. The current climate of service research therefore behaves as though most of the answers are there to be applied, albeit it depends on whether it is a technology, marketing, operations, organization behavior, strategy or engineering perspective of service. As such, we argue that service research is currently studying service very much in context. A research article in a service sector often does not address how relevant it is towards other service sectors and as long as service is relegated to "sectors" and does not sit as a "discipline", it would be impossible to progress the learning. Hence, we contend that service needs to *emerge* into a discipline of its own; an integrative discipline of the business, engineering and social sciences for value co-creation with the customer, much like medicine is an integrative discipline of physical and biological sciences for healing.

Our thesis is incomplete unless we conceptually locate where disciplinary knowledge of service, what we define as serviceX (e.g. service marketing, service engineering, service operations, etc.), sits vis-à-vis service science. Disciplinary knowledge in service is still very much desired due to the depth of analysis within that domain. To achieve that depth, many disciplines such as engineering, operations and ICT, while striving to be customer focused, have had to assume customer characteristics to be exogenous to study problems in service design, architecture, engineering and delivery. This is necessary for research questions to be defined and solutions to be tractable. The knowledge produced within such disciplinary domains would still be valuable to service science. Marketing, which brings the customer endogenously into its discipline (in terms of understanding customer choices and needs) is conversely less inclined to evaluate design and delivery issues in service for the obvious reason that design and delivery requires exogenous customer characteristics to design and deliver around. Yet, marketing research in service would also contribute to service science, for example in the understanding of value-in-use and customer needs. Consequently, to use again the analogy of medicine, research in genomics should still continue even while the discipline of medicine continues to seek the best technologies for healing.

Those who currently conduct service research would recount two major movements to push the service agenda – once in the seventies and another in the late eighties/early nineties and both led by Americans (Fisk et al. 1993). Concurrently in Europe, there was also a movement in support of service research. The most notable were by the Nordic Schools (Gronroos and Gummesson 1985) and among its proponents include works by Gronroos and Gummesson. Unfortunately, these movements lacked traction and a tenure-track system of rewarding academics only if they publish in top-tier (disciplinary-focused) journals led to the quiet withdrawal of many service researchers back to their parent disciplines. The creation of the new *Journal of Service Research* in the early 2000 by Roland Rust, who subsequently became the editor of *Journal of Marketing*, was the start of a new initiative in customer-focused service research in this millennium which has finally begun to gain momentum.

Our proposal for service science as an emerging discipline is facilitated by two further major events in 2004. First, the publication of Vargo and Lusch's Service-Dominant Logic in the *Journal of Marketing* (Vargo and Lusch 2004) and its follow-up article in Vargo and Lusch (2008) served to propel service into the forefront and has had a big influence on at least one other discipline, operations management; and second, the growing service science movement initiated by IBM. Led by these two events, service researchers have become more empowered to challenge the status quo and to push journal editors for more interdisciplinary special issues in service. While the current state of empowerment is laudable, it falls short of true liberation. Hence, service science, as a catalyst for change (Davis and Berdow 2008) and as an emerging discipline, would complete the task necessary to push the frontiers of service research.

Large manufacturing, telecommunication and engineering organizations such as Kone, Rolls Royce, BAE Systems, BT and HP have started to take a greater interest in service, bringing along researchers from engineering and manufacturing and increasing the credibility of conducting service research. However, it also poses new research challenges for service researchers who have been based in business schools often researching in traditional service industries such as hospitality, healthcare, transportation, leisure and banking. The arrival of engineering and technology researchers threatens to create a schism in service research, polarizing it into the IPS$^2$ (Industrial Product-Service-System[3]) and service support engineering research that caters to the engineering-types; the IT-based research on service oriented architecture, HCI, cloud computing or "Everything as a Service" (EaaS)[4] that cater to the technology-types; and the traditional service research of the social science and business variety. We argue that the timing is therefore right for service science to emerge as its own integrative discipline.

## 7 Conclusion

This chapter has presented a conceptual discourse for embedding and advancing knowledge production in the new discipline of service science. Agendas have been presented throughout service science literature addressing the "why" and the "what" of research into service science, the aim of this chapter is to build on conceptual discussion of the "how". Through the perspective of systems thinking insights are offered into integration that will complement the traditional reductionist position and that together will provide a sound foundation for the development and embedding of the new discipline of service science. The paper also considers five salient issues for knowledge production as part of the wider research agenda for service science – (1) the need for more appropriate simplification in service; (2) The need to look forward; (3) the role of technology changes the service system and vice versa; (4) The need to integrate social sciences (and business), engineering and technology for value co-creation; and (5) service science could be a disruptive science. The chapter locates the argument for service science knowledge production alongside disciplinary knowledge of service and in so doing, suggests that service science is not a logical development within any discipline and proposes that the time is right for it to emerge into a discipline of its own. Thus, developing conceptual thought through future directions into how researchers should approach knowledge advancement in the discipline of service science.

[3] IPS$^2$ comprises the integrated and mutually determined planning, development, provision and use including the option of partial substitution of products and services over the lifecycle. IPS$^2$ working group was founded by the International Academy for Production Engineering and is a community of 550 members from 41 countries with a strict limitation of membership. See http://www.lps.rub.de/schwerpunkt/cirp/

[4] Cloud computing is the development and usage of Internet-based (hence, "*cloud*") computer technology (hence "computing"). Cloud computing signifies IT-related capabilities that are provided "as a service", allowing users to access technology-enabled services from the Internet with little knowledge of, expertise with, or control over the technology infrastructure that supports them.

## 8 Implications for Research and Practice

As Chesbrough & Spohrer (2006) noted, productivity gains arise from research and development and at the heart of this R&D system is the academic university, and the academic community of scholars, students, and alumni that comprise the greater academic community. Whilst there is a growing initiative to understand and advance the roots of the service economy, organizations are still left without a solid theoretical framework. Without such theory, service providers are left with legacy tools and the challenge of providing effective, scalable delivery of service offerings. In today's economy, service means employment and growth, but the companies who have been leading the charge lack a strong theoretical foundation for their practices and are now reaching out to academics (Chesbrough and Spohrer 2006).

The research agenda presented in this chapter has a number of implications for generating abstracted theory of service which can be understood and implemented across sectors. The five salient issues for knowledge production which are presented call for abstraction for the purpose of transferability, replicability and scalability. To do this, rather than apply legacy knowledge towards service systems, researchers must also open their minds to opportunities to produce new knowledge, new methodologies and new ways of seeing the world, brought upon by intrinsic characteristics of the service system. The research community needs to embrace the challenges of knowledge production in service and the disruption it will inevitably bring if we are to improve the basis for understanding service systems. This is essential in order that theory is generalisable to all service providers so that they can apply that understanding for advancing our ability to design, develop, improve and scale service systems for practical business and societal purposes.

In terms of practice, managers are increasingly called to develop solutions in service that can be de-contextualized, so that firms could be more efficient in rolling out new services and employ better management practices, rather than re-inventing the wheel for each context. Too often, service practices fall easily into the trap that service is "common sense" and the notion of "merely coping" seem sufficient. Such tacit practices do not lend itself well to the scalability of the service and service management, even though may seem intuitive, is in need of sound engineering design that must also incorporate behavioral issues. The capability to deliver service excellence, like the capability to deliver a new technology, should not be lost in the fact that many others have a similar tacit capability to deliver mediocrity.

## References

Akkermans, H. and Vos B. (2003). "Amplification in service supply chains: An exploratory case study from the telecom industry," *Production & Operations Management*, 12 (2), 204–23.

Alvesson, M. and Skoldberg, K. (2000). *Reflexive Methodology: New Vistas for Qualitative Research*. London: Sage.

Anderson, R. C. (1972). "How to construct achievement tests to assess comprehension," *Review of Educational Research*, 42 (2), 145–70.

Beer, S. (1984). "The viable system model: Its provenance, development, methodology and pathology," *The Journal of the Operational Research Society*, 35 (1), 7–25.

Berry, L. L. and Parasuraman, A. (1993). "Building a new academic field – The case of services marketing," *Journal of Retailing*, 69 (1), 13.

Bertalanffy, L. V. (1972). "The history and status of general systems theory," *The Academy of Management Journal*, 15 (4), 407–26.

Bower, J. L. and Christensen, C. M. (1995). "Disruptive technologies: Catching the wave," *Harvard Business Review*, 73 (1), 43–53.

Breen, B. and Hamel, G. (2007). *The Future Of Management*. Boston: Harvard Business School Press.

Brown, S. (1993). "Postmodernism ... The End of Marketing?," in *Rethinking Marketing*, D. Brownlie et al, Ed. Coventry: Warwick Business School Research Bureau.

Buckley, W. (1980). Systems. In: M. Lockett and R. Spear (eds.) *Organisations as Systems*. Milton Keynes: OU Press.

Chase, R. B. and Apte, U. M. (2007). "A history of research in service operations: What's the big idea?," *Journal of Operations Management*, 25 (2), 375–86.

Chase, R. B. and Tansik, D. A. (1983). "The customer contact model for organisation design," *Management Science*, 29 (9), 1037–50.

Checkland, P. B. (1981). *Systems Thinking, Systems Practice*. Chichester, England: John Wiley and Sons.

Chesbrough, H. and Spohrer, J. (2006). "A research manifesto for service science," *Communications of the ACM*, 49 (7), 35–40.

Cohen, E. G. D. (2005). "Boltzmann and Einstein: Statistics and dynamics – An unsolved problem," *Pramana*, 64 (5), 635–43.

Davis, M. M. and Berdow, I. (2008). "Service science: Catalyst for change in business school curricula," *IBM Systems Journal*, 47 (1), 29–39.

Demirkan, H. and Goul, M. (2006). "Service oriented technology management to improve organizational agility," *International Journal of Innovation and Technology Management*, 6(1), 1–16.

Dennett, D. C. (1995). *Darwin's Dangerous Idea: Evolution and the Meanings of Life*. New York: Simon & Schuster.

Emery, F. E. and Trist, E. L. (1960). "Socio-Technical Systems," in *Management Sciences, Models and Technique*, C.W. Churchman et al, Ed. London: Pergamon.

Epstein, J. M. (1999). "Agent-based computational models and generative social science," *Complexity,* 4, 41–60.

Fisk, R. P., Brown, S. W. and Bitner, M. J. (1993). "Tracking the evolution of services marketing literature," *Journal of Retailing*, 69 (1), 61.

Forrester, J. W. (2003). "Dynamic models of economic systems and industrial organizations (archive paper from 1956)," *System Dynamics Review*, 19 (4), 331–45.

Gibbons, M. , Limoges, C., Nowotny, H., Schwartzman, S., Scott, P. and Trow. M. (1994). *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies.*. London: Sage.

Goldratt, E. M. (1994). *Theory of Constraints*. Aldershot, Hampshire: Gower Publications.

Grönroos, C. (2001). "The perceived service quality concept – A mistake," *Managing Service Quality*, 11 (3), 150–52.

Gronroos, C. and Gummesson, E. (1985). *Services Marketing: Nordic School Perspectives*. Stockholm: University of Stockholm.

Henle, P. (1942). "The status of emergence," *Journal of Philosophy*, 39: 486–93.

IfM and IBM. (2008). *Succeeding Through Service Innovation: A Service Perspective for Education, Research, Business and Government*. Cambridge, United Kingdom: University of Cambridge Institute for Manufacturing.

Johnson, B. C., Manyika, J. M. and Yee, L. A. (2005). "The next revolution in interactions," *McKinsey Quarterly,* (4), 20–33.

Kast, F. E. and Rosenzweig, J. E. (1972). "General systems theory: Applications for organization and management," *Academy of Management Journal*, 15 (4), 447–65.

Klüver, J. (2000). *The Dynamics and Evolution of Social Systems: New Foundations of a Mathematical Sociology*. Boston: Kluwer Academic Publishers.

Latour, B. and Biezunski, M. (1988). *Science in Action*. Cambridge, MA.: Harvard University Press.

Lipsey, R. G. and Lancaster, K. (1956). "The general theory of second best," *The Review of Economic Studies*, 24 (1), 11–32.

Liu, C., Wang, C. and Lee, Y. (2008). "Revisit service classification to construct a customer-oriented integrative service model," *International Journal of Service Industry Management*, 19 (5), 639–61.

Maglio, P. P., Srinivasan S., Kreulen, J. T. and Spohrer, J. (2006). "Service systems, service scientists, SSME, and innovation," *Communications of the ACM,* 49 (7), 81–85

Miller, J. H. and Page, S. E. (2007). *Complex Adaptive Systems: An Introduction to Computational Models of Social Life*. Princeton: Princeton University Press.

Mills, P. K. and Moberg, D. J. (1982). "Perspectives on the technology of service operations," *Academy of Management Review*, 7 (3), 467–78.

Ng, I. C. L. and Yip, N. (2009a). "B2B performance-based contracts in services: the attributes of value co-creation," in *11th Quality in Services Symposium* (QUIS 11). Wolfsburg, Germany.

Ng, I. C. L. and Yip, N. (2009b). "Identifying risk and its impact on contracting through a benefit based-model framework in business to business contracting: case of the defence industry," in *CIRP Design Conferenc*e, Cranfield.

Ng, I. C. L., Guo, L., Scott, J. and Yip, N. K. T. (2008). "Towards a benefit-based framework for understanding business to business services and its impact on contract and capability" in *10th International Research Seminar in Services Management: Marketing, Strategy, Economics, Operations & Human Resources*: Insights into Service Activities La Londe, France.

Ng, I. C. L., Nudurupati, S. S. and Tasker, P. (2009). "Value co-creation in the delivery of outcome-based contracts for business-to-business service", *Advanced Institute of Management (AIM) Research Discussion Paper Series*

Ng, I. C. L., Williams, J. and Neely, A. (2009). "Outcome-based contracting: changing the boundaries of B2B customer relationships", *Advanced Institute of Management (AIM) Research Executive Briefing Series*, October 2009, http://www.aimresearch.org/index.php?page=alias-3, ISBN 978-1-906087-22-7

Nilsson, J. (2001). "The future of research: What is the role of the university?," in *Report of the Faculty of Medicine conference*. Trolleholm: Lund University: Available: www.medfak.lu.se/forskning/Conference_report_0425webversion.pdf.

Normann, R. and Ramarez, R. (1993). "From value chain to value constellation: Designing interactive strategy," *Harvard Business Review*, 71 (4), 65–77.

Nowotny, H., Scott, P. and Gibbons, M. (2003). "Introduction: 'Mode 2' revisited: The new production of knowledge," *Minerva: A Review of Science, Learning & Policy*, 41 (3), 179.

Papazoglou, M. and Heuvel, W. v. d. (2007). "Service oriented architectures: approaches, technologies and research issues," *The VLDB Journal The International Journal on Very Large Data Bases*, 16 (3), 389–415.

Payne, A., Kaj, S .and Pennie, F. (2008). "Managing the co-creation of value," *Journal of the Academy of Marketing Science*, 36 (1), 83–96.

Popper, K. R. (1972). *Objective Knowledge; an Evolutionary Approach*. Oxford: Clarendon Press.

Prahalad, C. K. and Ramaswamy, V. (2000). "Co-opting customer competence," *Harvard Business Review*, 78 (1), 79–87.

Prahalad, C. K. and Ramaswamy, V. (2003). "The new frontier of experience innovation," *MIT Sloan Management Review*, 44 (4), 12–8.

Ramirez, R. (1999). "Value co-production: Intellectual origins and implications for practice and research," *Strategic Management Journal*, 20 (1), 49–65.
Schroeder, R. G. (2008). "Introduction to the special issue on theory development in operations management," *POMS,* 17(3): 354–56.
Spohrer, J. (2009). "Welcome to our declaration of interdependence," Service Science, IBM.
Spohrer, J. and Maglio, P. (2005). *Emergence of Service Science: Services Sciences, Management, Engineering (SSME) as the Next Frontier in Innovation*. San Jose, CA: IBM Almaden Research Center.
Spohrer, J. and Maglio, P. P. (2009). *Service science: Toward a smarter planet*. In W. Karwowski & G. Salvendy (Eds.), Service engineering, New York: Wiley.
Spohrer, J. and Maglio, P. P. (2008). "The emergence of service science: Toward systematic service innovations to accelerate co-creation of value," *Production & Operations Management*, 17 (3), 238–46.
Spohrer, J., Maglio, P. P., Bailey, J., and Gruhl, D. (2007). "Steps toward a science of service systems," *IEEE Computer Society*, 40, 71–7, (January).
Sprague, L. G. (2007). "Evolution of the field of operations management," *Journal of Operations Management*, 25 (2), 219–38.
Tiebout, C. M. (1956). "A pure theory of local expenditures," *The Journal of Political Economy*, 64 (5), 416–24.
Weinberg, G. (1975). *An Introduction to General Systems Thinking*. New York: Wiley.
Vargo, S. L. and Lusch, R. F. (2004). "Evolving to a new dominant logic for marketing," *Journal of Marketing*, 68 (1), 1–17.
Vargo, S. L. and Lusch, R. F. (2008). "Service-dominant logic: continuing the evolution," *Journal of the Academy of Marketing Science*, 36 (1), 1–10.
Weaver, W. (1948). "Science and complexity," *American Scientist*, 36: 536
Wolfram, S. (2002). *A New Kind of Science*. Champaign, Illinois: Wolfram Media Inc.
Wild, P. J., Clarkson, P. J. and McFarlane, D. C. (2009). "A Framework for Cross Disciplinary Efforts in Services Research," *CIRP Design Conference*, Cranfield, UK, March.
Ziman, J. (2000). *Real Science: What It Is, and What It Means?* Cambridge, U.K.: Cambridge University Press.
Zeithaml, V. A., Bitner, M. J. and Gremler, D. D. (2006). *Services Marketing*. Singapore: McGraw Hill: International Edition.

# Key Dimensions of Service Systems in Value-Creating Networks

**Cristina Mele and Francesco Polese**

**Abstract** The aim of this chapter is to identify the key dimensions of service systems and to describe how they interact in the process of value co-creation. The four key dimensions identified in the analysis are: customers; people (including employees and other stakeholders); information; and technology. The chapter also characterises the value-creation process in service systems as consisting of three related stages: value proposition; acceptance; and fulfilment. The main conclusion of the chapter is that the four key dimensions interact at all three stages in a network of relationships that co-create value through the integration of resources. In details, the interactions between the key dimensions shape two kinds of nets: (i) a social network; (ii) a technological network. These nets are the basis for a greater value-creating network aimed at increasing stakeholder value. Conclusions have practical implications for managers and theoretical implications for researchers.

**Keywords** Value · Network · Customers · People · Information · Technology

## 1 Introduction

Service science is the study of the creation of value within and among service systems, which are complex adaptive systems, integrating resources and interacting with other service systems via value propositions which may form stable relationships in extended service networks (IfM and IBM 2008; Maglio and Spohrer 2008; Vargo and Akaka 2009). The aim of this chapter is to contribute to the development of service science by analysing the capability of service systems in fostering value creation. In particular, the chapter analyses the interaction of four key dimensions of a service system in building a value-creating network. In doing so, an interactive

F. Polese (✉)
DIAM Dept, University of Cassino, Via S. Angelo, Loc. Folcara,
03043 Cassino (FR), Italy
e-mail: polese@unicas.it

H. Demirkan et al. (eds.), *The Science of Service Systems*,
Service Science: Research and Innovations in the Service Economy,
DOI 10.1007/978-1-4419-8270-4_3, 

research method (Gummesson 2003) was adopted: the work combines literature review, theoretical insights and empirical analysis. The chapter assumes an essentially theoretical perspective, not with a normative orientation, but in terms of a positive basis for service systems and service science; some practical cases are described to provide examples that illustrate the theoretical framework.

The chapter is organised as follows. First, service systems and the concept of value co-creation are described in order to introduce various perspectives on the notion of "value" (such as "customer value", "supplier value", and "stakeholder value") (Sects. 2 and 3). Second, the chapter analyses the key dimensions of a service system (Sect. 4): (i) customers (Sect. 4.1); (ii) people (Sect. 4.2); (iii) information (Sect. 4.3); and (iv) technology (Sect. 4.4). Later the chapter focuses on the value process as consisting of: (i) value proposition; (ii) value acceptance; and (iii) value fulfilment (Sect. 5). The roles of the identified key dimensions in this value process are then described (Sect. 6). Subsequently, the analysis points out the interactions between the key dimensions shaping two kinds of nets (Sect. 7): (i) a social network (Sect. 7.1); (ii) a technological network (Sect. 7.2); these nets are the basis for a greater value-creating network aimed at increasing stakeholder value (Sect. 7.3). The chapter concludes with a summary of the main findings and implications for managers and researchers (Sect. 8).

## 2 Service Systems and Value Co-creation

The contemporary notion of a "service" implies an activity (or series of activities) in which various resources are utilised by a supplier in interaction with a customer in order to develop a solution to certain needs (Grönroos 2003; Alter 2008). In accordance with this view, Vargo and Lusch (2006, p. 283) define service as:

> . . . the application of specialized competences (operant resources – knowledge and skills) through deeds, processes, and performances for the benefit of another entity or the entity itself.

It is thus apparent that the notion of "service" implies the existence of both a provider and a client who seek to provide value by finding a solution to need (Lusch et al. 2009). The relationship between the provider and the customer can be viewed as a simple *service system* – that is, a systematic interaction of parts that functions to perform a service. The smallest service system is a single person; the largest is the global economy.

Any service system is not simply the sum of its parts; rather, the interactions of the parts form a higher-order construct. As Maglio and Spohrer (2008, p. 18) observe:

> A service system is a dynamic value co-creation configuration of people, technologies, shared information (language, value, measures) and other resources connected via value propositions.

According to this view, the underlying logic of a service system is value creation for itself and value-co-creation for other parties through the proposing, acceptance, and realisation of value propositions. The notion of value co-creation is one of the fundamental ideas of service-dominant (S-D) logic and service science, both of which explicitly recognise the importance of collaboration in sharing and integrating resources. The various actors involved (customers, suppliers, partners, and so on) are seen as "resource integrators" (Vargo and Lusch 2008b) in a network-based stakeholder perspective (Gummesson 2008b). As Cova and Salle (2008, p. 272) point out: "co-creation is carried out in a many-to-many approach between a supplier and [its] network in interaction with a customer and [its] network".

**Service Systems and Value Co-creation**

A tour operator designed and managed its packages by involving its customers in new opportunities for the co-creation of value. It did this by incorporating customers' views as communicated through an e-platform that allowed customers to design their own tourism experiences according to their preferences. The tour operator uses the e-platform to increase contacts with customers and create interactive opportunities which foster value co-creation.

## 3 Concepts and Perspectives of Value

The notion of "value" has been variously applied to such concepts as "customer value", "firm value", "stakeholder value", and "network value" (Mele 2009b).

The first of these, customer value, has at least two meanings – depending on the perspective that is adopted (Woodruff 1997; Anderson and Narus 2004). From the seller's perspective, "customer value" is defined as a specific customer's (or a group of customers) profit contribution; alternatively, from the customer's point of view, "customer value" refers to the perceived value by the consumer defined by Zeithaml (1988, p. 14) as the all-inclusive evaluation of a product's utility, based on the perception of "what is received and what is given" (p. 14). More recently, the understanding of "customer value" has been elaborated to explicitly encompass specific elements of the concept (Anderson and Narus 2004). For example, Ulaga and Eggert (2006) have noted that the notion of "customer value" in business-to-business relationships also includes trade-offs of service, expertise, time, and social benefits as well as the price and process costs related to the supplier–customer relationship.

Firm value is usually based on a resource-based view of the value of the resources that a firm possesses. This form of "value" is thus linked to a firm's potential to continue to exist and evolve (Vicari 1991; Stampacchia 2001). Such potential not only depends on the set of resources that a firm already possesses, but also on its ability to generate new resources from existing resources on an ongoing basis. In particular, firm value depends on the ongoing enrichment of cognitive assets, knowledge, and learning capabilities.

The concept of stakeholder value refers to the satisfaction of the interests of various stakeholders (Christopher et al. 2002; Mele and Colurcio 2006). This notion of "value" draws on Gummesson's (2008a, b) conception of "many-to-many marketing", in which value is not limited to the supplier and the customer, but also involves a network of interested stakeholders. In a similar vein, Mele (2009b) and Mele et al. (2008) have explicitly linked the network perspective to the notion of value in developing the concept of network value in terms of all the benefits that network partners create through their actions and relationships.

It is apparent that the various conceptions of "value" described above are derived from the particular *perspective* on value creation that is adopted. For example, the first conception of "customer value" noted above is based on a *supplier-centric perspective* (whereby "value" is perceived in terms of what the vendor gets from the customer), whereas the second understanding of "customer value" is derived from a *customer-centric perspective* (whereby "value" is perceived in terms of what the customer gets from the purchase). Depending on the perspective that is adopted, different understandings are generated regarding the main actors involved and the content of the value that is created. Table 1 presents an interpretation of value based on the particular perspective that is adopted.

The first perspective shown in Table 1 is the *supplier-centric* perspective. The perspective of supplier centricity is implicitly adopted in most management and marketing studies that assume a goods-dominant logic. According to this perspective, the provider is the value creator who adds value to a product and delivers it to the customer through an exchange transaction. The creative process consists of value-adding activities along the value chain (Porter 1985). The supplier is thus the value builder, whereas the customer is the user who functions outside the value chain. The content of value in this perspective consists of "value-in-exchange", which is basically assessed in terms of the supplier's perspective of value.

The second perspective shown in Table 1 is the *customer-centric perspective* (Prahalad and Ramaswamy 2004). Womack and Jones (2007) propose a customer value chain that ranges from supplier-centric lean production to customer-centric lean consumption. According to this perspective, the customer is conceived as a

**Table 1** Perspectives on value creation

| Perspective | Value content | Creation process and main actor(s) |
|---|---|---|
| Supplier-centric | Value-in-exchange | Supplier as a creator adding value to a product and delivering it to a customer<br>Focus on the Supplier Value Chain |
| Customer-centric | Value-in-exchange<br>Value-in-use | Customer as a prosumer and a value creator<br>Focus on the Customer Value Chain |
| Stakeholder-centric | Value-in-exchange<br>Value-in-use | Interacting contributions from suppliers, customers, and other stakeholders acting as co-producers and co-creators of value (through solutions and experiences) |
| Balanced centricity | Value-in-experience | Focus on stakeholders' interactions and dynamics |

so-called "prosumer" who plays an active part in the value-creation process, rather than being restricted to the consumption process. The content of value in this perspective is understood as "value-in-use", which clearly shifts the emphasis to the customer. The supplier thus makes a "value proposition", which is ultimately realised through the process of value-in-use by the consumer. Interaction between the supplier and the customer thus emerges as a joint process of value creation (Vargo and Lusch 2006).

The third perspective shown in Table 1 is the stakeholder-centric perspective. According to this perspective, the value-creation process is not restricted to a dyad (such as a supplier–customer dyad); rather, value creation occurs within a network of relationships among many actors. Within such a "value network", value is not created in a linear process involving a sequence of actors in a production chain; rather, value is co-created in a constellation of networked co-operant actors (Normann and Ramirez 1994). The final offering that end-consumers receive is a result of the fulfillment of multiple co-productions within a network of actors who interrelate to co-create potential value through their experience and knowledge (Ballantyne and Varey 2006). The content of the value in this perspective is created through value-in-experience as resources (knowledge, products, services) are shared and exchanged by all actors to achieve certain aims. This perspective thus moves from the paradigm of a focal service system managing particular stakeholders to a paradigm of multiple service systems working together as partners to co-create value for all stakeholders through a relationship network (Polese 2009b). According to this view, the customer is one of the beneficiaries, but not the only one. All stakeholders effectively contribute to the co-creation of value while also expecting value in return for themselves. It is therefore more accurate to speak of *stakeholder centricity* in terms of *balanced centricity* (Gummesson 2008a, b), as a host of interests have to be taken into account in the analysis of the value co-creation process. This relational pattern suggests the deepening of network as powerful concept declining service systems behaviour and logics.

**Towards a Value-Creating Network**

A local public transport firm decided to introduce more technology into its interactions with customers, partners, and suppliers. Vehicles and stations were equipped with touch-screen PCs that enabled passengers to verify information about connections, traffic, fares, future bookings, self-ticketing, and so on. The screens also placed maintenance staff in direct contact with suppliers for the ordering of components and spare parts. Similarly, drivers were able to provide real-time information about traffic and weather conditions to a central monitoring unit, which was connected to the national highway patrol system and the national weather bureau.

By providing such a network, all stakeholders (providers, partners, and customers) were able to play a role that contributed towards the shared goal of distinctive value-creating network.

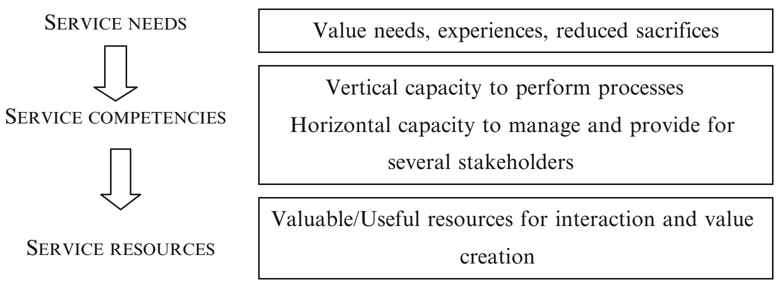
## 4 Key Dimensions of Service Systems

The capacity to create stakeholder value is dependent on the possession and development of well-attuned resources by each stakeholder. According to Barney (1997, p. 143), resources can be defined as:

> . . . all assets, capabilities, competencies, organizational processes, firm attributes, information, knowledge, and so forth that are controlled by a firm and that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness.

In service science, "all nameable things can be classified as one of four types of resources: physical-with-rights (e.g., a person), not-physical-with-rights (e.g., a business), not-physical-with-no-rights (e.g., shareable information or documents, such as a description of a patent), and physical-with-no-rights (e.g., a technology or part of the natural environment)" (Spohrer et al. 2008a, p. 3).

Cai et al. (2008) propose a so-called "service map" for service science, which is arranged in three layers: (i) service needs; (ii) service competencies; and (iii) service resources (see Fig. 1). The first of these, *service needs*, refers to the provision of attractive user experiences and the reduction of user sacrifices by enhancing the availability of service systems and the efficiency of service delivery. The second, *service competencies*, concerns the "capabilities of a service provider to provide high-quality services to its service consumers" (Cai et al. 2008, p. 4); these are divided into vertical competencies (related to the service process) and horizontal competencies (related to various stakeholders). The third, *service resources*, refers to the items or assets required to foster interaction and value creation (information, people, processes, physical assets). They can be internal or external *valuable* resources (Bowman and Ambrosini 2007) in the sense that they contribute to the value creation process; indeed, by leveraging service resources, service systems can strengthen their service competencies in order to respond to service needs, increasing the value created.




Source: Adapted from Cai, Chung and Su (2008)

**Fig. 1** Service map

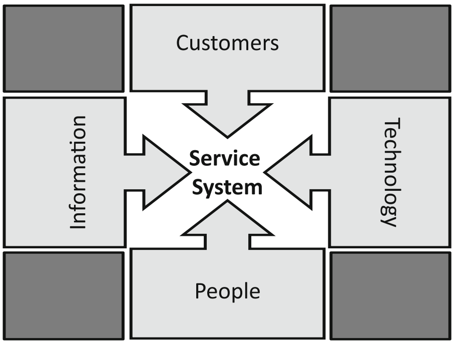



**Fig. 2** Key dimensions of service systems

In services-dominant (S-D) logic, two kinds of resources are distinguished: (i) *operand resources* (which are physical resources upon which an operation or act is performed to produce an effect); and (ii) operant resources (which are the knowledge, skills and core competencies that produce the effect) (Vargo and Lusch 2008a, c). According to Lusch et al. (2008, p. 7), there has been a paradigm shift in services management such that "producing should be transformed into resourcing"; in other words, the emphasis has shifted from goods and services being posited as units of output to their being now perceived as potential input for services and experiences.

In service science, a crucial role is performed by knowledge as a "meta-resource" (Mele 2003) – that is, a primary factor that is capable of activating the development of other resources. From this perspective, the service system is understood as being primarily a cognitive system, which depends for its existence and performance on its own understanding and know-how (Vicari 1991; Rullani 1994). Moreover, as a cognitive system, it creates information and activates knowledge to produce new knowledge through continuous learning processes. As knowledge and competencies become more complex, firms become sets of micro-specialisations that must integrate and transform their resources into a higher order of service potential (Lusch et al. 2007).

Resources and learning processes are thus the foundation for the value-creation processes of service systems. Four key dimensions can be identified in the resources that enable such learning processes: (i) customers; (ii) people; (iii) information; and (iv) technology (see Fig. 2).

## 4.1 Customers

The active role of customers in value creation is well established in the marketing and management literature; indeed, customer knowledge is now recognised as a crucial element in improving the processes, products, and services that are offered in a business context.

According to Karni and Kaner (2006), a service system can be distinguished from other types of systems precisely because the customer's involvement is distinctive. These authors noted that customers can play some or all of the following roles in a service system:

- Initiator and receiver of the service
- Setting the primary objectives for the design and operation of the service
- Input (as a client upon whom the service is to be performed)
- Output (as a client upon whom a service has been performed)
- Participant in the process
- Human resource in the process
- Provider of physical resources to the process
- Provider of knowledge to the process, and
- Setting constraints or standards for acceptable service levels

The central and distinctive role played by customers in service systems means that a "customer orientation" is the reference dimension in the deployment of all other elements in the system. Mele and Colurcio (2006) note that the customer is both the input and the output of any value-creation process.

In summary, as also emphasised by the basic principles of quality management, the customer should be seen as the mainstay of all strategic processes and decision-making for a service system.

## *4.2 People*

Networked service systems involving many-to-many relationships cannot afford to relate positively only with customers. Every interested party – including employees, consumer groups, local associations, pressure groups, and individual citizens – needs to be part of the pursuit of common goals based on cultural interests, common values, and shared rules and constraints. In the development of a value-creation process, various people contribute different skills and knowledge that are vital to service systems. As Maglio et al. (2006, p. 83) observed, "the challenge lies not simply in formally modelling the technology or organizational interactions, but in modelling the people and their roles as knowledge workers in the system".

In this regard, the empowerment of employees with the necessary authority to make decisions and undertake appropriate service actions has the capacity to increase significant value potential to customers. Ensuring the autonomy of co-workers facilitates service innovation through the creative use of the knowledge that they possess (about service, quality, clients, etc.). In particular, front-line employees play an important role in the implementation of innovative service that differentiates a service system from competing services (de Jong and Vermeulen 2003). Specific attention should be focused on talented employees who have the knowledge and competencies to realise superior performance (Hiltrop 1999).

In this context, a crucial role is played by the tools and systems that firms adopt to foster *creativity* (Goldenberg and Mazursky 2002). Creativity can be understood as the ability to leverage, exploit, and re-combine knowledge with the aim of generating new ideas that are original, unexpected, and even astonishing (Colurcio 2009; Mele 2009a). In terms of value creation, such creative imagination can be oriented and managed with a view to shaping new value propositions. To achieve such directed creativity (Colurcio 2009; Mele 2009a), a service system requires the contributions of all organisational members and network partners within a culture that encourages learning processes directed toward fostering creative innovation.

To foster such creativity, a service system needs to become a learning organisation in which new knowledge and new methods are enabled to invigorate its cognitive and methodological practices. In this regard, learning by experience assumes a key role in increasing the capabilities of individuals. Seeing service systems as learning organisations involves the development of shared mental models and the creation of common knowledge throughout the organisation (Senge 1990; Nonaka and Takeuchi 1995).

In summary, service systems' competitiveness has its main source in intellectual capital. People involved with a service system are the most precious resource that the system has at its disposal. By activating learning processes, the service system can stimulate value-generation processes that foster its immediate success and long-term sustainability.

## *4.3 Information*

Information is crucial to the decision-making and performance of the actors involved in any service system. Both customer and provider require basic information about the life cycle of the service, and in the value-creation process there is a process of transfer and sharing of knowledge that influences service processes and ultimately determines service quality.

Spohrer et al. (2007) identify three types of shared information in service systems: (i) language; (ii) laws; and (iii) measures. Shared language is required to begin any dialogue (Ballantyne and Varey 2006) and to coordinate actions. Shared laws are required to create and maintain complex systems because coded routines enable people to interact efficiently, thus reducing risks and unnecessary workload. Finally, four types of shared measures can be identified: quality, productivity, compliance and sustainable innovation. According to Spohrer et al. (2008a, p. 6): "Each of these corresponds to a stakeholder perspective: customers evaluate quality, providers evaluate productivity, authorities evaluate compliance, and competitors evaluate sustainable innovation".

An open organisational culture fosters service innovation because such a culture encourages the exchange of ideas (De Jong and Vermeulen 2003). Sharing information has a positive effect on the workforce's potential to generate ideas and the capacity of the service system to solve problems and prevent mistakes in the development of new services.

In summary, information is the basis for organisational learning and continuous improvement within service systems. The store of knowledge possessed by a service system determines its capability to improve service provision and value processes.

## *4.4 Technology*

The processes within service systems are increasingly becoming more technologically complex as information infrastructures have provided enhanced capacity to strengthen computing productivity (Demirkan and Goul 2006). Information technology (IT) not only facilitates interactions between customers and suppliers, but also between consumers themselves. Customers and/or users can thus effectively provide information that stimulates change and development, and managers can evaluate suggestions for improvement from consumers and implement the best of them. The technology now being routinely used on the world wide web (referred to as "Web 2.0") has enhanced collaboration and interactivity among users by facilitating information-sharing. As a consequence, the popularity of web-based communities has grown quickly, and software developers are increasingly providing social networking sites for users.

Within a service system, technology can support the development of organisational knowledge, in terms of shared mental models or organizational memory, by fostering the transformation of tacit knowledge into explicit knowledge, which represents a vital step in the "knowledge spiral" cycle of Nonaka and Takeuchi (1995). According to Johnson et al. (2005), technology can facilitate this process in three ways. First, technology can be utilised to remove routine activities of low value from employees, thus freeing them to be assigned activities of higher value. Secondly, technology can improve the speed of the decision-making process; moreover, it can improve the quality of its output by providing ready access to sorted and organised information. Thirdly, new and emerging technology will foster tacit interactions and extend their breadth and impact; technology can thus support talented people in their work and personal development (Johnson et al. 2005).

According to Demirkan and Goul (2006, p. 549), service systems can enhance the potential role of technology by adopting a so-called "service-oriented architecture" (SOA), which they described as:

> . . . a paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. It provides a uniform means to offer, discover, interact with, and use capabilities to produce desired effects consistent with measurable preconditions and expectation.

Such an SOA can utilise IT to map business processes and provide measures to support service systems in developing a service-oriented enterprise (Demirkan et al. 2008).

**Key Dimension of Service Systems**

The practical application of the four dimensions of service systems described above can be illustrated in the case of contemporary waste management, which increasingly requires a value-creating network that aims for sound environmental policy and sustainable behaviour.

*Customers*: The primary customers are obviously the citizens, but other customers of the service system include businesses that produce waste, municipalities which are responsible for waste disposal, transport firms, treatment works, and so on.

*People*: All people in the community, including ordinary citizens and those involved in business, have an interest in separating and managing every piece of waste that they produce in order to ensure that the whole chain functions efficiently in a sustainable fashion.

*Information*: Appropriate information on waste management must be communicated effectively in many-to-many interactions within the network. In this regard, information technology of many kinds can be used to ensure that every actor has an opportunity to maximise the benefits of effective waste management.

*Technology*: Technology is required for wise product design and the appropriate choice of materials and components in the service system.

## 5 Value Proposition, Acceptance, and Fulfilment

Service systems take on three key activities in order to develop value creation process (Spohrer et al. 2008b): (1) proposing value, (2) accepting a proposal, and (3) realizing the proposal. A value proposition can be defined as a firm's promise to deliver resources able to spread out a potential value through customer's activities (Ravald 2010). Such value is defined by the beneficiary; that is, the value proposition that a service system develops should be based on the needs of the beneficiary that must be satisfied (Mele 2007). However, because value is a dynamic multidimensional construct that includes functional and emotional benefits (de Chernatony et al. 2000), any value proposition is subject to continuous reformulation and innovation (Parasuraman 1997; Mele 2007).

The value proposition defines the mix of various resources (economic, functional, emotional, social, technical) that is promised to the customer (and/or other stakeholders). The nature of this mix depends on the beneficiary's perceptions of the value inherent in the use of the promised resources.

All service systems aim to develop superior value propositions; however, it is usually necessary for the provider to demonstrate that a particular offering really does offer superior value. To achieve this, the supplier must understand how it can

**Table 2** Building block of a successful value proposition

| | |
|---|---|
| Points of parity | Element with essentially the same performance or functionality of the next best alternative |
| Points of difference | Elements that make the supplier's offering either superior or inferior to the next best alternative |
| Points of contention | Elements about which the supplier and its customers disagree regarding how their performance or functionality compares with those of the next best alternative |

Source: Anderson, Narus, van Rossum (2006)

contribute to the customer's value-creation processes and must be able to show the customer that it has the capability to do so (Möller 2006). The crucial question is how the provider's value elements compare with those of competitors as assessed by the customer. In addressing this question, the basic "building blocks" of a value proposition are described by Anderson et al. (2006) as: (i) points of parity; (ii) points of difference; and (iii) points of contention (see Table 2). A recognition of these "building blocks" enables the supplier to substantiate the value proposition by demonstrating its potential value in terms of the benefits (and reduced sacrifices) that it promises for the beneficiary.

The value proposition enables the co-creation of value because it contains "... the promises and contracts the entities agree to" (Spohrer et al. 2008a, p. 4). Based on these promises, service systems interact and connect themselves to other service systems to enable a reciprocal capacity to co-create value with each contributing its own resources and activities. The *acceptance* of a value proposal can thus require a process of dialogue and negotiation in which entities shape the proposed solution to match their aims, knowledge, and skills. The agreements regarding the value proposition let the relationship proceed, and the experience continues to be lived.

As noted above, it increasingly recognised that value realisation involves customer participation (von Hippel 2005; Mele et al. 2008). Value fulfilment thus requires the involvement of the customer's resources to realise the potential value of an offering through usage (Vargo and Lusch 2008a, b). As Gummesson (2007, p. 137) points out:

> A supplier has a value proposition, but value actualization takes place during the consumer's usage and consumption process. Suppliers and customers are co-creators of value.

## 6 Roles of the Key Dimensions in the Value Process

All of the key dimensions identified above perform crucial roles in every phase of the value process (see Table 3).

As shown in Table 3, the *customer* contributes information, knowledge, skills, and other resources that help to shape the value *proposition*. The client is thus not only the beneficiary of value but also a proposer of value. If the customer decides to

**Table 3** Value processes and key dimensions

| | Value process | | |
|---|---|---|---|
| Dimension | Proposing value | Accepting proposal | Realizing proposal |
| Customer | Can contribute information, knowledge and other resources (labor, property) to the provider<br>Can ask for a proposal | The decision-maker | Can contribute resources (labor, property, knowledge, skills)<br>Uses resources to prepare a context in which to use or experience the proposal (solution) |
| People | Work and interact to develop promises and contracts<br>Define the solution<br>Exchange and integrate resources (internal and external)<br>Build a relationship network | Act to support customer in his/her decision-making | Contribute their resources (knowledge, labor, etc.)<br>Exchange and integrate resources (internal and external) among them<br>Interact with the customer to exchange and integrate resources<br>Let the network's actors perform the solution |
| Information | Basis of the value co-creation processes<br>Main starting input of the service process<br>Enable risk assessment for service provider and other stakeholder<br>Enable the learning process | Element of the decision-making process<br>Factor of the trust-building process<br>Enable risk assessment for beneficiary<br>Enable the learning process | Allow people's interaction in order to achieve the offering<br>Enable risk assessments for the service provider, beneficiary and other stakeholders<br>Enable the learning process and the development of a shared mental model |
| Technology | Support personalization proposal<br>Support entities' (people, customer, other stakeholders) interactions<br>Enable relationships<br>Foster information exchange and conversation with customers and between people<br>Support the sharing of information and knowledge<br>Support the learning process | Foster acceptance, acting on time<br>Support the sharing of information and knowledge | Foster contacts with customer and between service system entities<br>Allow the achievement of personalized solutions<br>Foster information exchange and conversation<br>Enable work flows and interaction<br>Increase efficiency<br>E-relationships<br>Support the sharing of information and knowledge<br>Support the learning process |

*accept* the proposal, he or she then can contribute resources to the *fulfilment* of the value proposition as a co-producer of the solution. The customer can also become a partner in the distribution of the solution; for example, by developing a retail community of like-minded consumers. In most cases, the beneficiary decides when and where to use the offering and live the experience (e.g., where and for what occasion to cook a meal) and also prepares the context (e.g., setting up a room – painting, etc. – before furniture delivery).

Table 3 also shows that (employees and other stakeholders) define and develop the proposed solution by exchanging and integrating resources. Their interaction fosters the building of a relationship network, which becomes the high-order actor in the value process. People thus facilitate the creation of potential value and the realisation of value-in-use by providing resources in a process of resource integration (Vargo and Lusch 2008a, b; Mele 2009b). They can also co-develop experiences with beneficiaries (for example, in sports tourism and cultural events) and/or provide a context that allows customers to live an experience (for example, in entertainment and amusement parks) (Carù and Cova 2007). By interacting and integrating resources in this way, customers and other people co-create experiences and strengthen relationships. Other stakeholders (such as local communities, government, and the wider society) can also affect the value process during each phase. This is especially the case in certain complex service systems – such as health, transportation, and public administration – which have a peculiar logic that requires the specialised input of such actors in their diversified systems.

*Information* is both the major initial input of the service process and the main enabler in the subsequent phases. Information has been described as the foundation of intangible resources (Itami 1987) or operant resources (Vargo and Lusch 2008a, c); for example, relationships are established and developed through continuous interaction and information exchange (Hughes and Chafin 1996). Shared information enables people and customers to become familiar with the service maps of different service system entities and to understand their needs, resources, and competencies. This facilitates the identification of the best pattern for creating value from a network-based stakeholder perspective. Moreover, shared information facilitates risk assessments for service providers, beneficiaries, and other stakeholders. Finally, shared information is the basis of the learning processes that occur during the value-creation process. The development and sharing of shared mental models fosters the creation of a shared vision that provides consistency of purpose to the activities that develop the value aims of the service system (Senge 1990, 1992; Mele 2003).

Finally, Table 3 shows that *technology* facilitates the information-sharing process by enabling people and customers to interact without the constraints of time, place, and space. Technology can also assist the value-creation process by organising data and information, supporting the sense-making process, and creating (and using) knowledge at the individual, team, and organisational levels. It is thus an enabler of explicit knowledge (Nonaka and Takeuchi 1995) and a means of enhancing individual talent. As Johnson et al. (2005, p. 22) observed: “Machines can help managers make more decisions more effectively and quickly”.

It is thus apparent that each of the identified dimensions plays a role in the value-creation process; however, it is also apparent that it is the *interaction* of these dimensions that ultimately enables a service system to develop superior value creation process. *Customers* and other *people* share *information* during their interactions. In addition, they also utilise their tacit knowledge to make "complex decisions based on knowledge, judgment, experience and instinct" (Johnson et al. 2005, p. 21). In these processes, *technology* facilitates information-sharing and interaction in various complex, non-linear ways (such as B2B, B2C, C2B, and C2C) (Gummesson and Polese 2009).

**Service Processes as Value Propositions, Acceptance, and Fulfillment**

Tourism-destination services represent a good example of a value process that incorporates value propositions, acceptance, and fulfillment. The destination acts as an integrator of resources. Its natural and contextual points of attraction, along with the complementary resources of related businesses in non-tourism sectors, are included in the proposition of a distinctive package of services and products. The message to the market must be efficiently communicated as a valuable offer if the destination is to reach its potential by satisfactory levels of acceptance in the market. Finally, the tourists who arrive at the destination must be satisfied by the fulfillment of the value proposition. Without this process of value proposition, acceptance, and fulfillment, any tourist destination will lose its attractiveness over time and be transformed into a failed value proposition.

## 7 Building Value-Creating Networks

Service systems networks are defined as service systems connecting to other service system: "they form network of relationships which may have one or more associated value propositions" (IfM, IBM, 2008, p. 18); a service system network puts certain assets together but it requires the integration of the actors' resources according to their expectations, needs and capabilities. As interestingly proposed by the Viable System Approach (Golinelli et al. 2002; Golinelli 2010; Barile 2008), every complex system need to seek an equilibrated balance among its sub-systems and its supra-systems in order to pursue both an efficient valorisation of internal components and an effective valorisation of external resources. In fact integration is, indeed, the incorporation of an actor's resources into another actor's process (Moeller 2008). By widening the meaning, resource integration implies an entire social and cultural process, thus enabling an actor to become a member of a group (or a network). Service systems therefore act as resources integrators – within the organization and through the network – due to operant and operand resource specialization. In all of these situations, firms strive to reach a better matching of resources, activities, and processes.

The integration of resources is idiosyncratic to the partner. Each service system is born and develops as an original combination of resources and contributes to the network in a unique manner. The matching of service systems' resources is crucial ensuring that the role one entities can play in a network is not the same as that of another. The value creation potential of a service system does not only arise from its core competences and distinctive resources, but also from its capability to match, to insert itself in a network and contribute to its success and evolution.

In order to manage and improve service system performance as resource integration mechanism, two main factors enable value-creating networks: the social relations that affect people and customers, and the ICT patterns and tools fostering their participation in the system. In details, the interactions between the key dimensions shape two kinds of nets: (i) a social network; (ii) a technological network. These nets are the basis for a greater value-creating network aimed at increasing stakeholder value.

## *7.1 The Social Net*

People trigger the value process. For this reason, their social relationships, the dense and articulated set of relations characterizing every individual, are an important factor. It is apparent that organisations are not autonomous entities; rather, they are dependent upon individuals and the networks of relationships that exist among them (Vicari 2007). The research focus regarding social capital has thus shifted from enterprises as a whole to the individuals who manage and operate the businesses – because it is increasingly recognised that the values that these individuals own determine their decisions and behaviour. It is the person, within an organisation, who interprets and realises the mission, strategic action, and management practices through their values and cultural identity (Golinelli et al. 2002; Cross et al. 2002). The social networks embedded in every organization, and in particular in every individual participating in the system, are therefore very important and contribute to system performance.

Social relations are not a clear phenomenon. Indeed they are variously intended. In the perspective here adopted: (a) *Social relations do not deal with social responsibility*; (b) *Social relations differ from ethics*; (c) *Social relations involve all stakeholders*; (d) *Social relations include personal relationships*; (e) *Social relations are many to many relations*. In other words, social relations can be defined as follows: *Social relations may be represented by the relational pattern that characterizes every individual in a business and that involve personal, business and stakeholders relations* (Polese, 2009b).

Managing a social net means fostering the development of social relationships, as they form the social capital of the service systems (Batt 2008); doing so increases the potentiality of service system's value creation potential. Social Network Analysis can help service systems analyze and manage social nets in terms of their structure (the entity's position), processes (the entity's activities and ties), and resources and service level.

Though still emerging from its academic roots, Social Network Analysis (SNA) is entering the mainstream thanks to better analytical tools, visualization, complementary technologies and data availability. In this regard social network analysis (SNA) has recently emerged as an important aspect of knowledge management.

## 7.2 The ICT Net

ICT net can be seen indeed as a "nerve systems central to sensing, responding and learning" in a value-creating network (Lusch et al. 2009, p. 4). It enables external relationships, inter-system interactions and internal knowledge.

When considering a service system to be constituted by service providers and clients (individuals/corporations) that work together with support technologies according to the network paradigm and value co-creation concept, the policy adopted by the service system in order for it to produce the requested information is often referred to as the mechanism for the transfer/exchange of information (Service Level Agreement – SLA). Today it is aims to support the use of Web services (designed according to a model of service-oriented architecture – Service-Oriented Architecture – SOA: Erl, 2005) to ensure interoperability between different systems in which business and technical components provide reusable, dynamically discoverable, and complementary services (Demirkan et al. 2008), allowing the use of individual applications as components of business processes and ministering to the demands of users (agents and non-artificial).

The ICT net is reliant upon service-oriented enterprises that implement business processes through an SOA and that provide frameworks for managing business processes across a SOA landscape and structuring service patterns for the provision of services.

In summary, this net is about the ways people engage with computing to execute processes and refers to the semantics that put people and machines together in new ways (Demirkan and Goul 2006). Thus ICT net can be considered as a sets of multidimensional elements, such as relationships (endemic relationships, timely information), tools (scalable technology solutions, Service Oriented Architecture, Service Level Agreements,) and perspectives (client usage, system thinking) (see Fig. 3).

## 7.3 The Integrated Net

The social net and the ICT net are interlinked nets, as the ICT net supports the development of interconnections of the social net, fostering relationships and the sharing of information and knowledge. A service system's key ability is to

**Fig. 3** ICT characteristics in service networks age


foster the integration of the social and ICT nets through appropriate management of the net's links, within both a single service system entity and within the network of service system entities. Integrating the nets enables three elements of a service system's performance (Spohrer et al. 2007, p. 75):

– Efficiency (plans), things are done in the right way
– Effectiveness (goals), the right things get done
– Sustainability (relationships), the right relationships exist

The actors of a value-creating network are held together by competencies to provide service, relationships and shared information (Lusch et al. 2009), with the ICT as nerve system. The integration among different network players is tied to values, culture, transparency and clear rules. The glue that holds the networks together is based on shared finality and common purpose (win–win logic). This shared and participatory atmosphere is a strong promoter of continuous innovation, which in service systems seems to be crucial for stakeholder value. Managing service systems means creating and reinforcing a common identity (through a spirit of cohesion among the participants, a sense of belonging, information about "service systems' resources", appreciation of common leadership, and so on). As already Polese (2004; 2009a) has stressed, *networks are not based only on formal bounds (contractual and legal bounds are weak in the long run), but on strong sentimental ties and cultural affinities as these features guarantee the cohesion, vivid relations, and vibrant pulses of emotion and energy that build sustainable networks.*

The harmonic systemic interaction and integration of the social and ICT nets necessitate system thinking. Without this, "each component in the service system tends to seek behaviors that satisfy its local interest. This may bring controversy in a service company and degrade its customers' experience" (Spohrer et al. 2008a, p. 5). With systematic thinking, each business unit will know its position on the value co-creation map and learn how to be a vital and supporting part of the value creating network (Lusch et al. 2009) through resource development (knowledge, competencies, relationships) and compelling value proposition (to customers and other stakeholders) in order to evolve and survive.

**Networks for Managing Value-Creating Service Systems**

Research clusters (either formal districts or informal geographically close subjects) are powerful organizational proposals in which distinctive competences are valorised for common success and innovation benefits. This is true when competences are contiguous (vertical and specialized in the same sector for every actor), or if competences are close to the same technology, but denote different specializations and peculiarities. In both cases the mobilization and integration of common resources created common knowledge and ultimately network value; this is indeed based upon technological support and targeted to technological innovation, pursued with the contribute of many actors which are not limited to the participating firms, but may involve individuals as well as public entities, NGOs and other local actors.

# 8 Conclusions and Implications

## *8.1 Main Conclusions*

The aim of this chapter was to identify the key dimensions of service systems and to describe how they interact in the process of value co-creation. The four key dimensions identified in the analysis were: customers; people (including employees and other stakeholders); information; and technology.

The chapter has also characterised the value-creation process in service systems as consisting of three related stages: value proposition; acceptance; and fulfilment.

The main conclusion of the chapter is that the four key dimensions interact at all three stages in a network of relationships that *co-create* value through the utilisation of complementary resources. In details, the interactions between the key dimensions shape two kinds of nets: (i) a social network; (ii) a technological network; these nets are the basis for a greater value-creating network aimed at increasing stakeholder value. These conclusions have practical implications for managers and theoretical implications for researchers.

## *8.2 Managerial Implications*

It is apparent from this study that service systems can create a competitive advantage for themselves by improving their management of value co-creation. The notion of a "competitive advantage" in the context of service science refers to whether a service system can apply its operant resources to meet the needs of another service system better than its competitors can do. In other words, the model of competition in the context of service science refers to efforts by service systems to improve their management of the process of value co-creation.

Managers should therefore seek to establish and maintain service systems that are both competitive and sustainable. This search is challenging because it necessarily goes beyond the explicit resources and benefits of the immediate entities that participate in the system. Contemporary managers are dealing with complex systems involving networks of relationships and systems, and this complexity means that service systems are difficult to plan, manage, and govern. Nonetheless, an attempt must be made to address the complexity of such systems in an attempt to better understand their operations, performance, and effects.

Managers need to identify the factors that enhance the internal cohesion of the network in aligning the behaviour of the entities towards the realisation of the system's explicit goals. In identifying these goals, management should not be motivated only by economic considerations; rather, managers should focus on the regeneration of the system's resources and capabilities. This requires special attention being paid to the so-called "soft' issues of systemic integration, information- and knowledge-sharing, and effective communication among the involved parties. In particular, management must sustain all relationships with stakeholders that are important to the service system in providing the vital resources that the system needs.

Managers should also ensure that ongoing service innovation and system reframing occurs as a means of promoting continuous value generation (Normann 2001). In this process, managers should be encouraged to think about innovation inside a single service-system entity (which should be seen as a micro-network), as well as considering innovation within several related service-system entities (a network) (Lusch et al. 2006).

### *8.3 Implication for Researchers*

This chapter has attempted to identify and systematise the roles of customers, people, information, and technology in the value-creation processes of complex service systems. It is apparent from this exploration that extant theory has not provided adequate models and constructs applicable to these complex issues of technological, social, and experiential interaction. More research effort is required to achieve a better understanding of the processes involved in value co-creation. In particular, researchers should address the need for models of the mechanisms of service systems that go beyond intriguing organisational and conceptual theory to provide direction for effective managerial actions in the complexity of the contemporary service economy.

## References

Alter, S. (2008). Service System fundamentals: Work system, value chain and life cycle. *IBM System Journal*, 47 (1), 71–85.

Anderson, J.C. and Narus, J.A. (2004). *Business Market Management: Understanding, Creating, and Delivering Value*, 2nd Edition. Upper Saddle River, NJ: Pearson Education Inc.

Anderson, J.C., Narus, J.A. and van Rossum, W. (2006). Customer Value propositions in Business Markets. *Harvard Business Review*, March, 90–99.

Ballantyne, D. and Varey, R.J. (2006). Creating value-in-use through marketing interaction: the exchange logic of relating, communicating and knowing. *Marketing Theory*, 6 (3), 335–348.

Barile, S. (eds) (2008), *L'impresa come sistema – Contributo sull'Approccio Sistemico Vitale*, II ed., Torino: Giappichelli.

Barile, S. and Polese, F. (2009). Service Dominant Logic and Service Science: a contribute deriving from network theories. In E. Gummesson, C. Mele, F. Polese (eds), "*The 2009 Naples Forum on Service: Service Science, S-D logic and network theory*", Napoli: Giannini.

Barney, B.J. (1997). *Gaining and Sustaining competitive advantage*. Reading, MA: Addison Wesley.

Batt, P.J. (2008). Building social capital in networks. *Industrial Marketing Management*, 37, 487–491.

Bowman, C. and Ambrosini, V. (2007). Identifying Valuable Resources, *European Management Journal*, 25 (4), 320–329.

Cai, H., Chung, J.Y. and Su, H. (2008). Relooking at services science and services innovation. *Service-Oriented Computing and Applications*, 2 (1), 1–14.

Carù, A. and Cova, B. (2007). *Consuming Experience*. London: Routledge.

Christopher, M., Payne, A. and Ballantyne, D. (2002). *Relationship Marketing. Creating Stakeholder Value,* Oxford: Butterworth Heinemann.

Colurcio, M. (2009). TQM: a Knowledge enabler. *The TQM Journal*, 21 (3), 236–248.

Cova, B. and Salle, R. (2008). Marketing solutions in accordance with the S-D logic: Co-creating value with customer network actors. *Industrial Marketing Management*, 37 (3), 270–277.

Cross, R., Nohria, N. and Parker, A. (2002). Six Myths About Informal Networks and How To Overcome Them. *MIT Sloan Management Review*, 43 (3), 65–75.

De Chernatony, L., Harris, F. and Dall'Olmo Riley, F. (2000). Added value: its nature, roles and sustainability. *European Journal of Marketing,* 34 (1/2), 39–56.

De Jong, J.P.J. and Vermeulen, P.A.M. (2003). Organizing successful new service development: A literature review. *Management Decision,* 41 (9), 844-858.

Demirkan, H. and Goul, M. (2006). Towards the Service Oriented Enterprise Vision: Bridging Industry and Academics. *Communications of the Association for Information Systems*, 18, 546–556.

Demirkan, H., Kauffman, R.J., Vayghan, J.A., Fill, H.G., Karagiannis, D. and Maglio, P.P. (2008). Service-oriented technology and management: Perspectives on research and practice for the coming decade. Perspectives on the Technology of Service Operations. *Electronic Commerce Research and Applications*, 7, 356–376.

Goldenberg, J. and Mazursky, D. (2002). *Creativity in product innovation.* Cambridge: Cambridge University Press.

Golinelli, G.M., Pastore, A., Gatti, M., Massaroni, E. and Vagnani, G. (2002). The firm as a viable system: managing inter-organisational relationships. *Sinergie*, 58, 65–98.

Golinelli, G.M. (2010a). *Business Management. A Viable System Approach*, forthcoming.

Golinelli, G.M. (2010b). *Viable S:ystems Approach (VSA). Governing Business Dynamics*, Padova: Kluwer (Cedam).

Grönroos, C. (2003). Adoptive a Service Logic for Marketing. *Marketing Theory,* 6 (3), 317–333.

Gummesson, E. (2003). All research is interpretive. *Journal of Business & Industrial Marketing*, 18 (6/7), 482–492.

Gummesson, E. (2007). Exit services marketing – enter service marketing. *Journal of Customer Behaviour*, 6 (2) 113–141.

Gummesson, E. (2008a). Customer centricity: reality or a wild goose chase?. *European Business Review*, 20 (4), 315–330.

Gummesson, E. (2008b). Extending the New Dominant Logic: From Customer Centricity to Balanced Centricity. *Commentary for Special Issue of The Journal of the Academy of Marketing Science (JAMS) on the New Dominant Logic*, 36(1), 15–17.

Gummesson, E. and Polese, F. (2009). B2B is not an island. *Journal of Business & Industrial Marketing*, 24 (5), 337–350.

Hiltrop, J.M. (1999). The Quest for the Best: Human Resource Practices to Attract and Retain Talent. *European Management Journal,* 17 (4), 422–430.

Hughes, G. D. and Chafin D.C. (1996), Turning new product development into a continuous learning process, *Journal of Product Innovation and Management*, 13.

If M, IBM (2008). *Succeeding through Service Innovation: A Service Perspective for Education, Research, Business and Government*, Cambridge: University of Cambridge Institute for Manufacturing.

Itami, H. (1987), *Mobilizing Invisible Assets*, Cambridge, Mass., Harvard University Press.

Johnson, B.C., Manyka, J.M. and Yee, L.A. (2005), The next revolution in interactions, *The McKinzey Quarterly*, n.4, pp.21–33.

Karni, R. and Kaner, M. (2006). An engineering tool for the conceptual design of service systems, *Advances in Service Innovations*, Springer, NY.

Lusch, R.F., Vargo, S.L. and Wessels, G. (2008). Toward a conceptual foundation for service science: Contributions from service-dominant Logic. *IBM Systems Journal*, 47 (1), 5–14.

Lusch, R.F. and Vargo, S.L. (2006). The Service Dominant Logic of Marketing: Reactions, Reflections, and Refinements. *Marketing Theory*, 6 (3), 281–288.

Lusch, R.F., Vargo, S.L. and O'Brien, M. (2007). Competing through service: Insights from service-dominant logic. *Journal of Retailing,* 83, 5–18.

Lusch, R.F., Vargo, S.L. and Tanniru, M. (2009). Service, Value Networks and learning. *Journal of the Academy of Marketing Science*, forthcoming.

Lusch, R.F, Vargo, S.L. and Tanniru, M. (2010), Service, Value Networks and Learning, *Journal of the Academy of Marketing Science*, 38 (1), 15–31.

Maglio, P.P., Srinivasan, S., Kreulen, J.T. and Spohrer, J. (2006). Service Systems, Service Scientitists, SSME and innovation. *Coomunication of the ACM,* July, 49 (7), 81–85.

Maglio, P.P. and Spohrer, J. (2008). Fundamentals of service science. *Journal of the Academy of Marketing Science*, 36 (1), 18-20.

Mele, C. (2003). *Marketing e qualità nell'impresa che crea valore*. Padova: Cedam.

Mele, C. (2007). The synergic relationship between TQM and marketing in creating customer value. *Managing Service Quality*, 17 (3), 240–258.

Mele, C. (2009a). Value Innovation in B2B: Learning, Creativity, and the Provision of Solutions within Service-Dominant Logic. *Journal of Customer Behaviour*, 8 (3), 199–220.

Mele, C. (2009b). Value logic in networks: resource integration by stakeholders. *Sinergie,* forthcoming.

Mele, C. and Colurcio, M. (2006). The evolving path of TQM: towards business excellence and stakeholder value. *International Journal of Quality and Reliability Management*, 23 (5), 464–489.

Mele, C., Russo Spena, T. and Colurcio, M. (2008). *Service logic in innovation,* 22nd Service Conference and Workshop, Academy of Marketing and University of Westminster, November.

Möller K., (2006). Role of competences in creating customer value: a value creation logic approach. *Industrial Marketing Management,* 35, 913–924.

Nonaka, I. and Takeuchi, H. (1995). *The Knowledge-Creating Company.*, New York: Oxford University Press.

Normann, R. (2001). *Reframing business: when the map changes the landscape,* Chichester: Wiley.

Normann, R. and Ramirez, R. (1994). *Designing Interactive Strategy: From Value Chain to Value Constellation*, Chinchester: Wiley&Sons.

Parasuraman, A. (1997). Reflections on Gaining Competitive Advantage Through Customer Value. *Journal of the Academy of Marketing Science*, 25 (2), 154–161.

Polese, F. (2004). *L'integrazione sistemica degli aggregati reticolari di impresa*. Padova: Cedam.

Polese, F. (2009a). Local government and networking trends supporting sustainable tourism: some empirical evidences. In L. Fusco Girard, P. Nijkamp (eds), *Cultural Tourism and Sustainable Local Development*, London: Ashgate, pp. 131–148.

Polese, F. (2009b). The Influence of Networking Culture and Social Relationships on Value Creation. *Sinergie*, forthcoming.

Porter, M.E. (1985). *Competitive Advantage*. New York: The Free Press.

Prahalad, C.K. and Ramaswamy, V. (2004). *The future of competition: how to create a unique value with customers,* Boston: Harvard Business School Press.

Ravald, A. (2010). “The Customer’s Process of Value Creation”, *Mercati e Competetitività* Special Issue on The 2009 Naples Forum on Service, No.1. Forthcoming 2010.

Rullani, E. (1994). Il valore della conoscenza. *Economia e Politica Industriale*, 82, 48–73.

Senge, P.M. (1990). *The Fifth Discipline, The Art and Practice of the Learning Organization.* New York: Doubleyday Currency.

Senge, P. M. (1992), Building Learning organization, *Working paper* n.03.015, Cambridge MIT.

Spohrer, J., Anderson, L., Pass, N. and Ager, T. (2008a). Service science and S-D logic. Proceedings of the Otago Forum.

Spohrer, J.S., Vargo, S., Caswell, N. and Maglio, P. (2008b). The service system is the basic abstraction of service science. *41sr Annual HICSS Conference Proceedings.*

Spohrer, J., Maglio, P.P., Bailey, J. and Gruhl, D. (2007). Steps Towards a Science of Service Systems. *Computer*, January, 40 (1), 71–77.

Stampacchia, P. (2001). *L’impresa nel contesto globale. Attività, risorse, configurazione.* Torino: Giappichelli.

Ulaga, W. and Eggert, A. (2006). Relationship value in business market: the construct and the dimensions. *Journal of Business-to-Business Marketing*, 12(1), 73–99.

Vargo, S.L. and Akaka, M.A. (2009). Service-Dominant Logic as a Foundation for Service Science: Clarifications. *Service Science*, 1 (1), 32–41.

Vargo, S.L. and Lusch, R.F. (2006). *The service Dominant Logic. Debate and Directions.* New York: Sharpe.

Vargo, S.L. and Lusch, R.F. (2008a). Service-Dominant Logic: Continuing the Evolution. *Journal of the Academy of Marketing Science,* 36 (1), 1–10.

Vargo, S.L. and Lusch, R.F. (2008b). Why Service. *Journal of the Academy of Marketing Science*, 36 (1), 25–38.

Vargo, S.L. and Lusch, R.F. (2008c). From Products to Service: Divergences and Convergences of Logics. *Industrial Marketing Management*, 37, May, 254–259.

Vicari, S. (1991). *L’impresa vivente*, Milano: Etas.

Vicari, S. (2007). Soggetti o sistema? Osservazioni sulla natura dell’impresa. *Sinergie*, 72, 119–139.

Von Hippel, E. (2005). *Democratizing Innovation*. Cambridge: MIT Press.

Womack, J.P. and Jones, D.T. (2007). *Lean Solutions: How Companies & Customer Can Create Value & Wealth Together*. London: Simon & Schuster.

Woodruff, R.B. (1997). Customer value: the next source for competitive advantage. *Journal of the Academy of Marketing Science,* 25 (2), 139–153.

Zeithaml, V.A, (1988). Consumer perceptions of price, quality and value: a means-end model and synthesis of evidence. *Journal of Marketing*, 52 (3), 2–22.

# Making a Science of Service Systems Practical: Seeking Usefulness and Understandability while Avoiding Unnecessary Assumptions and Restrictions

**Steven Alter**

**Abstract** This book's theme is "The Science of Service Systems," yet there is substantial question about whether the definition and nature of service systems have been articulated adequately. This paper examines definitions of service and service system that could frame or otherwise influence future developments in service science and could have implications for what should and should not be included within service science. It argues that the initial development of service science should use straightforward definitions that are understandable, useful, broadly applicable, and teachable. It proposes a definition of service system that is different from the definition proposed in this book's Call for Chapters and in the 2008 White Paper produced by a service innovation symposium attended by many leaders in the effort to create service science. In comparison with that definition, this paper's alternative definition is more understandable, useful, broadly applicable, and teachable.

**Keywords** Service science · Service systems · Service · Work system · Work system framework

## 1 Desired Characteristics of Basic Concepts

Ideally, the evolution of service science should generate intellectually rigorous concepts that are directly relevant to practice. Practical foundational concepts should have the following characteristics:

S. Alter (✉)
School of Business and Professional Studies, University of San Francisco,
2130 Fulton St, San Francisco, CA 94117, USA
e-mail: alter@usfca.edu

H. Demirkan et al. (eds.), *The Science of Service Systems*,
Service Science: Research and Innovations in the Service Economy,
DOI 10.1007/978-1-4419-8270-4_4, 

- *Understandability*: The foundational concepts at the core of service science should be readily understandable by typical business professionals, not just by Ph.D.'s and technical experts.
- *Usefulness*: The foundational concepts should lead to description, analysis, and design methods that are readily useable by most managers and executives. Support of sophisticated descriptions and analysis by technical experts is an important second order issue.
- *Broad applicability*: Foundational concepts should cover all situations that typical business professionals would normally view as service.
- *Teachability*: Those concepts should be teachable to different audiences at different levels of intellectual sophistication.

This paper focuses on two concepts: service and service system. It argues that early leaders in service science seem to favor definitions that have important shortcomings and that might be replaced by more beneficial definitions. In particular, this paper argues that the currently favored conceptualization of *service system* and related ideas is too sophisticated to be useful to typical MBA students and business professionals. That type of issue would not be a problem in the physical or biological sciences, where the future development of physics and biology does not depend on whether most people understand Maxwell's Equations, quantum mechanics, cosmology, or the mechanics of DNA and RNA. It is a problem, however, if the goal of service science is to influence the practice of business.

This chapter proceeds as follows. First, it looks at alternative definitions of service. It identifies three groups of definitions, proposes that the third group comes closest to satisfying the above criteria, and suggests a particular definition that is simple and general. Next, it compares two definitions of service systems, "service systems as work systems" and "service systems as complementary components of economic exchange." It shows why the above criteria are better satisfied by the first definition than the second.

## 2 What Are Services?

Many discussions of services try to define services without giving many examples, thereby skewing the discussion to the author's preferred or unstated examples and sometimes generalizing from one or several types of services. Instead, we start with a set of representative situations that most business professionals would view as services. (See Table 1)

A good definition of service should fit each of the situations in Table 1. We will look briefly at definitions that fall under three categories:

- Services as value creating activities that have certain characteristics
- Services as value creating activities that involve co-production by providers and consumers
- Services as any organized activities performed for the benefit of others

**Table 1** Common examples of services

| | |
|---|---|
| Providing an Internet search engine responding to search inquiries | Performing back-office accounting work at off-shore location |
| Hiring new employees in a company | Download services for books and films |
| Providing training services | Developing custom software |
| Offering food items for sale in a grocery store | Architectural services |
| | Consulting services |
| Providing cash through ATMs, | Entertainment services |
| Educational services | Answering customer inquiries at an off-shore call center |
| Medical care at a health maintenance organization | Janitorial services in office buildings |
| Network repair services | Legal services |
| Package delivery services | Garbage collection services |
| Emergency services such as fire, police, and ambulance | Telecommunication services |

*Category #1: value creating activities that have certain characteristics.* Examples of definitions in this group include:

1. "Any act or performance that one party can offer to another that is essentially intangible and does not result in the ownership of anything." (Kotler and Keller 2006).
2. "A provider–client interaction that creates and captures value" (IBM Research 2009).
3. "A simultaneous or near-simultaneous exchange of production and consumption, transformation in the experience and value that customers receive from engagement with providers, and intangibility in that goods are not exchanged." (Rai and Sambamurthy 2006).

A typical problem with defining services in terms of specific characteristics is that many services lack those characteristics. For example, the service of custom-designing and programming complex software often involves a project that absorbs months of time (inconsistent with #3), involves substantial efforts unrelated to customer interactions or experiences (inconsistent with #2), produces tangible things, such as printed documentation (inconsistent with #1), and results in the ownership of something (inconsistent with #1). Thus, the service of custom-designing and programming complex software does not fit several typical definitions of service. Other relevant examples in Table 1 include package delivery services that move tangible packages, architectural services that result in the ownership of architectural plans, garbage collection services that involve minimal provider–client interaction, and legal services that produce contracts that are used for many years, and hence are not consumed as produced. Along these lines, Vargo and Lusch (2004b) argue that four prototypical characteristics often believed to distinguish services from goods – intangibility, inseparability, heterogeneity, and perishability – "(a) do not distinguish services from goods, (b) only have meaning from a manufacturing perspective, and (c) imply inappropriate normative strategies."

*Category #2: activities involving co-production of value by providers and consumers*. Examples of definitions in this group include:

- A time-perishable, intangible experience performed for a customer acting in the role of a coproducer (Fitzsimmons and Fitzsimmons 2006).
- A process in which "the customer provides significant inputs into the production process." (Sampson and Froehle 2006).
- "The customer is always a co-producer." This is foundational premise #6 from Vargo and Lusch (2004a). Their definition of service is in the next category (below).

The difficulty with defining service in terms of co-production is that an increment from zero co-production to a little bit of co-production to a slightly larger amount of co-production often does not change the essential nature of the activities or of the value that is being produced. Most of the examples in Table 1 involve at least a bit of co-production, such as making a request that initiates a process, or making one or more choices that influence the production process. Even the output of highly automated production lines often involves at least some input from the customer, thereby blurring the distinction between product and service.

*Category #3: activities performed for the benefit of others*. Examples of definitions in this group include:

- "A change in the condition of a person, or a good belonging to some economic entity, brought about as a result of some other economic entity, with the approval of the first person or economic entity" (Hill 1977).
- "Capabilities or competencies that one person, organization, enterprise, or system provides for another" (Vargo and Lusch 2004a).

Although the assumption about customer approval is contradicted in many service situations (e.g., emergency services where the customer cannot provide approval, teaching of unwilling students, and so on), definitions in this category are less restrictive and less encumbered by occasionally irrelevant characteristics such as intangibility and simultaneity. We adopt an even simpler, dictionary-like definition of service:

> Services are acts performed for someone else, including the provision of resources that someone else will use.
>
> (Alter 2008b)

This definition of service encompasses a wide range of categories such as:

- Services for external customers and for internal customers
- Automated, IT-reliant, and non-automated services
- Customized, semi-customized, and non-customized services
- Personal and impersonal services
- Repetitive and non-repetitive services
- Long-term and short-term services
- Services with varying degrees of self-service responsibilities

The phrase about provision of resources for someone else is included to accommodate the shift toward supporting self-service activities. The definition can be extended into the realm of service computing by substituting "another entity" for "someone else." Services in that realm can be viewed as acts performed by one entity for a different entity, including the provision of resources that a different entity will use.

In effect, this definition assumes that every purposeful action performed for the benefit of someone else is a service, an interpretation consistent with discussions that have continued in marketing for over 40 years. For example, Leavitt (1960) noted, "People don't buy a quarter-inch drill. They buy a quarter-inch hole. You've got to study the hole, not the drill. The drill is just a solution for it." More recently, Vargo and Lusch (2004a) extended that train of thought in proposing that "service-dominant logic" should replace "goods-dominant logic" as the basis of economic thought. They argue that value to the customer is the primary issue, and that delivery through goods versus services is secondary. One of eight foundational premises in their 2004 summary of service-dominant logic is that "goods are distribution mechanisms for service provision." Thus, distinctions between products and services may not be fundamental for understanding how value is delivered. If a service is an act performed for someone else, then the production of physical things can be viewed as services.

With our definition of service, just about any business activity is a service because it involves purposeful action performed for the benefit of someone else. Focus on services is still useful, however, because it encourages the use of service metaphors when thinking about almost any system in a business. Of special value are the numerous service-related design dimensions that are potentially important but often overlooked when trying to design or evaluate systems in organizations. This brings us to the discussion of service systems.

## 3 What Are Service Systems?

The literature contains two basic views of service systems:

- Service systems as work systems that produce services.
- Service systems as complementary components of economic exchange.

The first view focuses on service production processes (which involve varying degrees of co-production by providers and customers) and on whatever those production processes produce for customers. Both the initial description of the situation and the subsequent analysis emphasize how the service is produced, how well it is produced, and how it might be improved. The specifics of the description and analysis are consistent with lean solutions (Womack and Jones 2005), Six Sigma, and other methods used in disciplines such as marketing, operations management, and information systems.

In contrast, the second view of service systems starts with economic exchange. It views providers and customers as service systems that provide services for each other. For example, a grocery store is a provider service system that obtains and displays food for sale; customers are customer service systems that perform the complementary service of paying the retailer; they also provide other forms of cooperation, such as acting appropriately in the store.

We look at each of these approaches in turn, emphasizing topics related to deciding which of these two starting points satisfies previously mentioned criteria such as understandability and usefulness. Note, however, that neither view excludes the other. For example, someone starting with the first approach has total freedom to consider economic exchange. In fact, incentives are an important part of the description and analysis related to work system participants and customers. Similarly, someone starting with the second approach has total freedom to analyze the provider service system and customer service system as work systems on their own right.

The following discussion reflects a clear bias toward the first definition because it more directly satisfies the criteria mentioned at the outset. Specifically, it is more effective for helping business professionals produce practical descriptions, analyses, and recommendations for improvement in service situations such as those listed in Table 1.

*Definition #1: service systems as work systems that produce services.* A service system is a work system that produces services for customers. A work system is a system in which human participants and/or machines perform work using information, technology, and other resources to produce products and/or services for internal or external customers. (Alter 2003, 2006a, 2008a). All of the services in Table 1 can be described as work systems.

The work system framework (Alter 2003, 2006a, 2008a, b) identifies nine elements that are the basis for describing and analyzing any work system in an organization. (See Fig. 1) Even a rudimentary understanding of a work system (or service system) requires awareness of each of the nine elements in the framework. These elements are strikingly similar to the elements listed by Karmi and Kaner (2007) in their "taxonomic definition of a work system." The framework covers situations that might or might not have a tightly defined business process and might or might not be IT-intensive. It can be used to describe work systems in general, information systems, supply chains, and projects.

The location of the customer at the top of the framework's triangular representation is totally consistent with our definition of service (acts performed for someone else). It encourages including a service mindset in both description and analysis by illustrating the incompleteness of focusing totally on the internal operation of the work system. Also, the arrows in the framework show that changes in customer needs lead to desired changes in the form, cost, or quality of products and services, which in turn lead to desired changes in the form or performance of processes and activities. Following arrows from the other direction, changes related to participants, information, and technology can be evaluated based on their impact on both internal efficiency and customer satisfaction.

The bilateral form of the service value chain framework (Alter 2008a) is based on the co-production of value by providers and customers. (The framework is not

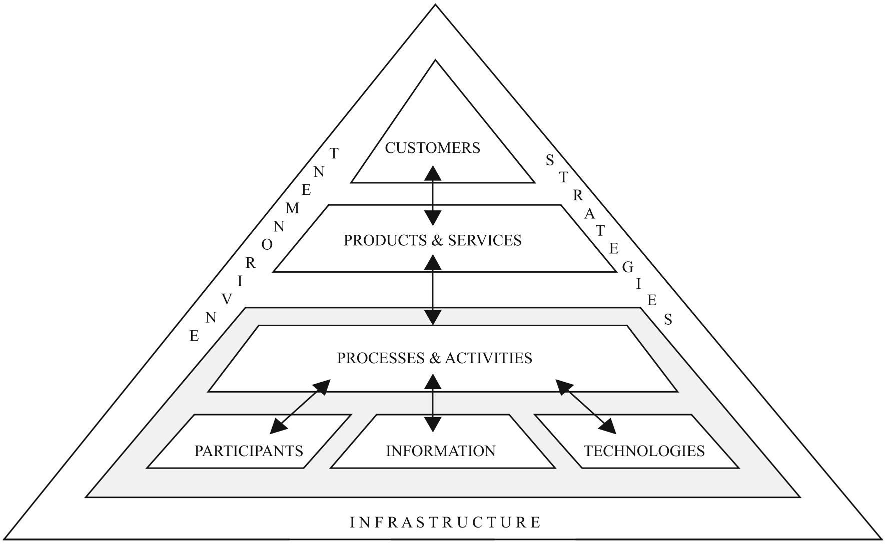



**Fig. 1** The work system framework (Alter 2006a), slightly updated

shown here due to space limitations.) That framework, which can also be applied readily to describe or analyze each of the services in Table 1, augments the work system framework by incorporating typical categories of service activities and responsibilities, such as negotiating commitments, performing set-up, handling service requests, fulfilling service requests, and performing follow-up. Other aspects of the framework represent important service design issues such as the governance of service instances by service level agreements, the form and frequency of service encounters, the distinction between front-stage vs. back-stage activities, and the importance of value capture by both customer and provider.

In addition to providing useful and distinct component views of service systems, both the work system framework and the service value chain framework help in identifying important design dimensions that can be used to describe and compare service systems. For example, Alter (2006a) discusses business process design dimensions such as degree of structure, range of involvement, level of integration, complexity, rhythm (frequency) and degree of automation, among others. Focusing on these dimensions when evaluating, analyzing, or designing a work system helps in addressing big picture issues before plunging into details. Similar design dimensions related to the service value chain framework include the balance between provider and customer responsibilities, the relative amount of effort to be devoted to negotiating commitments, the relative importance of customer encounters, and the relative prominence of front-stage vs. back-stage activities.

*Definition #2: service systems as complementary components of economic exchange*. In contrast to viewing service systems as work systems, the concept of service system in recent publications of leading proponents of service science (e.g., Spohrer et al. 2007, 2008; IfM and IBM 2008; Springer 2008) treats service systems as complementary components of economic exchange. For example, the definition of service system on the first page of this book's Call for Chapters (Springer 2008) says that service "derives from the interactions of entities known as *service systems*. Service systems at multiple scales of organizations, from individual people to businesses and nations, chain together into globally integrated *service networks* of multiple types... [B2B, B2C, etc.]" A footnote at the bottom of the first page says "Service systems are dynamic value co-creation configurations of people, technology, organizations, and shared information (such as language, laws, measures, models, etc.), connected internally and externally by value propositions, with governance mechanisms for dispute resolution." (Spohrer et al. 2007). In other words:

- Service is produced by the interaction of service systems (i.e., an individual service system does not produce services).
- Service systems are dynamic.
- Service systems are shared co-creation configurations of people, technology, organizations, and shared information.
- Service systems range from individual people to businesses and nations.
- Service systems are connected internally and externally by value propositions.
- Service systems have governance mechanisms for dispute resolution.

A subsequent White Paper on service innovation generated by a Cambridge UK symposium of service science leaders (IfM and IBM 2008) is largely consistent with the above view. Its glossary of terms adds the following:

- Service systems ... "can create and deliver service while balancing risk-taking and value-cocreation." (p. 18).
- "Service systems are complex adaptive systems." (p. 18).
- A customer service system is "a service system from the viewpoint of a customer or consumer. A customer service system searches provider value propositions looking for win–win value-cocreation opportunities." (p. 16).
- A provider service system is "a service system from the viewpoint of a provider. A provider service system aims to meet the customer's needs better than competing alternatives consistently and profitably (in business context) or sustainably (in non-business context). Provider service systems seek deep knowledge of customer service systems ... to improve existing, and create new, value propositions." (p. 16).
- A value proposition is "a specific package of benefits and solutions that a service system intends to offer and deliver to others. ... Value proposition emphasizes key points of difference in comparison to competing alternatives." (p. 19).

## 4 Is the Second Definition of Service System Practical?

While recognizing that testing is required to evaluate a definition's practicality, it is nonetheless possible to find relevant hints about practicality in prior uses of related ideas and in direct implications of the definitions.

The practicality of the first definition is supported by extensive experience. Various versions appeared in a series of information system textbooks culminating in Alter (2002) and in term paper assignments requiring the application of related analysis methods. In an attempt to continue developing the work system approach over many years, the author collected and evaluated over 400 term papers representing system analysis efforts by teams of undergraduate, MBA, and Executive MBA students at a typical university, i.e., not at elite universities like MIT or Stanford. Most of the MBA and Executive MBA students were employed and are a reasonable proxy for early career business professionals. A paper on the results through 2005 was published several years ago (Alter 2006b). Elsewhere, Petkov and Petkova (2006) demonstrated the usefulness of the work system framework by comparing grades of students who did and did not learn about the framework before trying to interpret the same ERP case study. More recently, Truex and Alter (2010) describe how 75 advanced MBA students at Georgia State University applied a work system analysis template to produce preliminary analyses of real world systems in their own organizations, and to produce recommendations for improving those work systems, most of which produced services. Results to date indicate that typical employed MBA students can use the work system approach to attain a basic understanding of service systems such as those in Table 1.

The second definition was published several years ago. The author is not aware of any attempts to test whether the second definition can be used effectively by typical students or business professionals. However, even at this stage, it seems likely that typical MBA and EMBA students and typical business professionals would be hard pressed to apply or even understand the relevance of certain aspects of the service system characteristics associated with the second definition. That conclusion is based on examination of the ideas (below) and on experience in teaching related courses and grading hundreds of papers written by employed MBA students. Here are some of the relevant issues:

*Issue #1: Assumption that service is created by the interaction of provider service systems and customer service systems.* Most MBA students would be confused by this assumption. It seems highly doubtful that they would find it natural to think of themselves as customer service systems when they buy something at a store or obtain information from a search engine. They would find it much more natural to think about service systems as single systems that produce (or co-produce) services for customers who may or may not be involved extensively in the service process. It is not apparent why one would have to describe or analyze customers as service systems in order to understand or analyze any of the services listed in Table 1. Seeing services as the interaction of service systems is especially awkward with services such as medical care, in which the direct customer, the recipient of the medical care, may be completely uninvolved with the economic exchange that pays for the medical services. Yes, the customer or someone else needs to pay, but it is not apparent why calling a paying customer a service system is always beneficial when trying to understand how and how well medical services are provided and used.

*Issue #2: Individuals, businesses, and nations all viewed as service systems.* Most MBA students would have difficulty seeing how individuals, businesses, and nations could all be viewed usefully as instances of service systems. Although all three of these can be viewed as legal entities with rights and responsibilities, it is not clear what would be the teachable common denominator for describing or analyzing service systems across that range – from one person to over a billion. Characteristics and activities of individual people usually do not appear on the same scale as characteristics and aggregate activities of businesses and nations.

*Issue #3: Unnecessary restrictions.* A fundamental view of service systems should apply to the complete spectrum of services: services for external customers and for internal customers; automated, IT-reliant, and non-automated services; customized, semi-customized, and non-customized services; personal and impersonal services; repetitive and non-repetitive services; long-term and short-term services; and services with varying degrees of self-service responsibilities. Contrary to the previously mentioned definition of service system in IfM and IBM (2008), many service systems are not dynamic or complex, many do not require consistency or strive for profit, and many serve both internal and external customers. Most business professionals who have had difficulties related to services such as airline travel and health insurance would question whether "a customer service system searches provider value propositions looking for win–win value-cocreation opportunities." (IfM and IBM 2008, p. 16)

*Issue #4: Unnecessary complexity.* Defining service systems as "dynamic value co-creation configurations" that are "connected internally and externally by value propositions" introduces terms that most MBA students and business professionals would find difficult to understand and use. For example, assume that the service is public transportation, package delivery, or reimbursement of travel expenses. What is the meaning of dynamic configuration in those contexts? Are some configurations more dynamic than others? In such contexts typical MBA students and business professionals would have difficulty explaining how the service systems are "connected internally and externally by value propositions." They would have difficulty viewing most of the service systems in Table 1 as complex adaptive systems. (What would that tell them?) Also, most would recognize that services need to be managed but would have difficulty articulating why "governance mechanisms for dispute resolution" are first order elements of most of the services in Table 1. For example, governance mechanisms for dispute resolution would not be first order topics when thinking about how to improve educational services, telecommunications services, janitorial services in office buildings, and many of the other services in Table 1.

*Issue #5: Inherent characteristics vs. design dimensions.* Service science should avoid confusions between inherent characteristics of all services versus service dimensions that call for design decisions. For example, IfM and IBM (2008, p. 16) says that service systems "aim to consistently and profitably meet the customer's needs." It is more accurate to say that consistency is a design dimension.

Consistency is very important for some service systems and unimportant for others. A service system designer should decide the extent to which consistency should be encouraged or enforced. A similar observation about inherent characteristics of service versus dimensions of service applies to other proposed characteristics such as dynamic, complex, adaptive, connected internally and externally, and win–win. Likewise, profitability is important in some service situations but not in many others, such as those provided by government and non-profits.

## 5 Conclusion

An important part of the initial development of service science has involved the search for basic definitions and concepts that bring the potential of organizing and focusing this newly emerging field. Service science needs a foundation of concepts that satisfy criteria such as understandability, usefulness, broad applicability, and teachability.

This paper has argued that a currently favored conceptualization of *service system* is too sophisticated to be useful to typical MBA students and business professionals. That type of issue would not be a problem in the physical or biological sciences, but is a problem for service science since the goal of influencing the practice of business is more important than the goal of allowing Ph.D. researchers to philosophize about abstractions.

*Implications for practice*. The development of service science might have important impacts on practice by providing organized sets of ideas that can be used to describe, analyze, and improve service systems. Those impacts depend on the existence of a conceptual basis that is genuinely usable by typical business and IT professionals. Managers and other decision makers are unlikely to embrace service science fully until its basic ideas are clear, straightforward, and usable by their business peers in practical situations.

*Implications for research*. This paper's discussion of the work system approach to service systems demonstrates that the IfM and IBM (2008) approach is not the only alternative for defining service, service system, and other relevant terms. Ideally, proponents of that approach should test its understandability, usefulness, breadth of applicability, and teachability. This can be done by asking business professionals or MBA students to use that approach to analyze a broad range of service examples. Better yet, research subjects could try to apply that approach to analyzing and making recommendations about real world situations, much as has been done in the development of the work system approach. Ideally, both approaches might be compared to additional alternatives and then evaluated by observing how effectively business professionals, students, and Ph.D. researchers can apply each approach fruitfully to the complete gamut of services.

## References


Alter, S. (2002). *Information Systems: The Foundation of E-Business*, 4th ed., Prentice Hall: Upper Saddle River, NJ.

Alter, S. (2003). 18 Reasons why IT-Reliant Work Systems Should Replace the IT Artifact as the Core Subject Matter of the IS Field. *Communications of the Association for Information Systems*, 12(23), 365–394.

Alter, S. (2006a). *The Work System Method: Connecting People, Processes, and IT for Business Results*. Larkspur, CA: Work System Press.

Alter, S. (2006b). Pitfalls in Analyzing Systems in Organizations. *Journal of Information System Education,* 17(3), 295–302, Fall.

Alter, S. (2008a). Service System Fundamentals: Work System, Value Chain, and Life Cycle. *IBM Systems Journal*, 47(1) 71–85.

Alter, S. (2008b). Service System Innovation. *Proceedings of IFIP Working Group 8.2 Conference on IT and Change in the Service Economy*, Toronto, Canada, August 2008.

Fitzsimmons, J.A. & Fitzsimmons, M.J. (2006). *Service Management*, 5th ed. New York, NY: McGraw-Hill.

Hill, T.P. (1977). On goods and services. *The Review of Income and Wealth*, 23, 315–338.

IBM Research. (2009). Services Science, Management and Engineering. http://researchweb.watson.ibm.com/ssme/services.shtml. Accessed 19 Sept. 2009.

IfM & IBM. (2008). Succeeding through Service Innovation: A Service Perspective for Education, Research, Business and Government. Cambridge, United Kingdom: University of Cambridge Institute for Manufacturing. ISBN: 978-1-902546-65-0. http://www.ifm.eng.cam.ac.uk/ssme/documents/080428ssi_us_letter.pdf. Accessed 19 Sept. 2009.

Karmi, R. & Kaner, M. (2007). Integration of a Service Taxonomy. *The TRIZ Journal*, October, http://www.triz-journal.com/archives/2007/10/04/. Accessed 19 Sept. 2009.

Kotler, P. & Keller, K. (2006). *Marketing Management*, 12th ed., Upper Saddle River, NJ: Prentice Hall.

Leavitt, T. (1960). Marketing Myopia. *Harvard Business Review*, 38(4), 45–56.

Petkov, D. & Petkova, O. (2006). The Work System Model as a Tool for Understanding the Problem in an Introductory IS Project. Paper presented at the 23rd Information Systems Education Conference (ISECON 2006), Dallas, TX.

Rai, A. & Sambamurthy, V. (2006). Editorial Notes – The Growth of Interest in Services Management: Opportunities for Information System Scholars. *Information Systems Research* 17(4), 327–331.

Sampson, S.E. & Froehle, C. M. (2006). Foundations and Implications of a Proposed Unified Services Theory. *Production and Operations Management* 15(2), 329–343.

Spohrer, J., Maglio, P.P., Bailey, J. & Gruhl, D. (2007). Steps Toward a Science of Service Systems. *IEEE Computer* 40, 71–77.

Spohrer, J., Vargo, S.L., Caswell, N. & Maglio, P.P. (2008). The Service System is the Basic Abstraction of Service Science. *Proceedings of HICSS-41, The 41st Hawaii International Conference on System Sciences*, *Waikoloa, HI.*

Springer. (2008). Call for Chapters. http://www.public.asu.edu/~hdemirka/index_files/CFC_SS_Books_Springer.pdf. Accessed 19 Sept. 2009.

Truex, D.P. & Alter, S. (2010). Systems Analysis for Everyone Else: Empowering Business Professionals through a Systems Analysis Method that Fits Their Needs, *Proceedings of ECIS 2010*, the European Conference on Information Systems, Pretoria, South Africa.

Vargo, S.L. & Lusch, R.F. (2004b). The Four Service Marketing Myths. *Journal of Service Research*, 6(4), 324–335.

Vargo, S.L. & Lusch, R.F. (2004a). Evolving to a New Dominant Logic for Marketing. *Journal of Marketing*, 68, 1–17.

Womack, J. P. & Jones, D.T. (2005). *Lean Solutions: How Companies and Customers Can Create Value and Wealth Together*. New York, NY: Free Press.

# Flexible Service Systems

**Artem Polyvyanyy and Mathias Weske**

**Abstract** Service science combines scientific, management, and engineering disciplines to improve the understanding of how service systems cooperate to create business value. Service systems are complex configurations of people, technologies, and resources that coexist in a common environment of service provisioning. While the general concepts of service science are understood and agreed upon, the representation of service systems using models is still in its infancy. In this chapter, we look at business processes and their role in properly representing service systems. We propose flexible process graphs, a high-level process modeling language, and extend it in order to specify service systems and their compositions within shared environments in a flexible way. The discussion in this chapter is the first step towards a formal description of service science environment, including service systems, networks, and whole ecology.

**Keywords** Service science · Service systems · Flexible process graph · Flexible service systems · Modeling

## 1 Introduction

Service computing and service oriented architectures (SOA) have gained increasing attention recently as a new way of designing complex software systems consisting of service components (Burbeck 2000; Gottschalk 2000; Newcomer and Lomow 2004). To provide business agility, one of the main promises of SOA is to bridge the

A. Polyvyanyy (✉)
Business Process Technology Group,
Hasso Plattner Institute at the University of Potsdam,
Prof.-Dr.-Helmert-Str. 2–3, 14482, Potsdam, Germany
e-mail: Artem.Polyvyanyy@hpi.uni-potsdam.de

H. Demirkan et al. (eds.), *The Science of Service Systems*,
Service Science: Research and Innovations in the Service Economy,
DOI 10.1007/978-1-4419-8270-4_5, © Springer Science+Business Media, LLC 2011

gap between business aspects and information technology. Despite considerable efforts by industry and standardization consortia, as of today, this gap remains.

The term service oriented architecture was coined by the computer science community, focusing on how software functionality can be specified, wrapped and discovered to be easily re-usable. It turns out that the technical point of view taken by available approaches is too narrow to provide a solid understanding of service environments. Therefore, service science has been founded, an integrating discipline that investigates not only technical aspects of services, but also their economical and organizational foundation (Spohrer et al. 2008).

While the main concepts and the overall design of service systems are beginning to shape, the representation of service systems is still in its infancy. In computer science, complex systems are represented by models, such as data models in database design (Silberschatz et al. 1997) or process models in the design of process oriented information systems (Weske 2007). Once the modeling technique for capturing service systems and their environments is in place, they can be studied, analyzed, compared, classified, etc.

In this chapter, we introduce an approach to model service systems using flexible process graphs (Polyvyanyy and Weske 2008a, b), which is a method for modeling business processes with a limited degree of structuring. Limited process model structuring leaves an opportunity for flexible behavior within captured process scenarios and supports straight-forward merging of models to reflect partner relations between service systems. The flexibility of the process is essential, since service episodes are in general not following a strict and well-defined business process, but result from a rather loose couplings of independent service systems, particularly if we talk about professional, scientific, and technical service systems.

The rest of the chapter is organized as follows: In the next sections we give preliminaries on service systems and flexible process graphs. Afterwards, in Sect. 4, an approach of employing flexible process graphs to represent service environments is presented. Section 5 illustrates the concepts by an example. Concluding remarks complete this chapter.

## 2 Service Systems

This section introduces the main concepts of service systems, identifies their key properties and motivates the use of modeling techniques to represent service systems.

### *2.1 Foundation*

In the foundation of service science, the transition from a Goods-Dominant to a Service-Dominant (S-D) logic of value creation has played a crucial role (Vargo and Lusch 2004). In particular, S-D logic places the service – a process of doing something for another party – in its own right, without a reference to goods as the primary focus of economic exchange (Vargo and Lusch 2006). The authors introduce fundamental principles of Service-Dominant logic. Ten foundational premises are proposed:

- The service, the application of operant resources (skills and knowledge) for the benefit of another party, is the fundamental basis of exchange
- Indirect exchange masks the fundamental nature of exchange
- Goods are a distribution mechanism for service provision
- Operant resources are the fundamental source of competitive advantage
- All economies are service economies
- The customer is always a co-creator of value
- The enterprise can not deliver value, but only offer value propositions
- A service centered view is inherently customer oriented and relational
- All economic and social actors are resource integrators
- Value is always uniquely and phenomenologically determined by the beneficiary

The declared principles are adopted to become the foundation of the theory of service – the *service science* (Spohrer et al. 2007, 2008; Lusch et al. 2008). In S-D logic, a *service* is the application of competence for the benefit of another party. From this basic definition, it is clear that each service involves at least two roles: at least one role possesses a competence and is able to apply it – the *provider* of a service, and at least one is willing to integrate external competence with available resources – the *customer* of a service.

These concepts are illustrated by some every-day examples. Firstly, regard a visit to a restaurant as a service interaction. A client orders a dish and, in collaboration with a waiter, clarifies how she wants a meal to be prepared. The restaurant applies its competence and the customers are willing to accept it.

Another example is a person getting optical glasses. A patient might use several service providers, e.g., one from a medical authority in order to obtain a medical prescription, another from an optical store to produce the glasses. There are several roles involved, each of which applies its competence for mutual benefit.

Finally, the research work performed during a collaborative project can be regarded as a service. A company has a concrete research problem, and a research group is asked to use its competences to solve the problem. In this case, again, competence is integrated into the resources of the company, solving its problem.

In most real-world scenarios, the competences of the parties participating in the service are far from trivial, assume complex interaction scenarios and, hence, cannot be easily decomposed into precise instructions. Furthermore, services that seem straightforward can be immensely complicated beneath the surface.

The key concepts used in the examples are now described in more detail.

- A *competence* identifies the ability of a service provider to apply knowledge and skills at a level of expertise sufficient for the accomplishment of a requested work specification by a customer in given settings. Customers in need of a competence enter markets to evaluate and pursue competence propositions presented by service providers.

- Upon an agreement between a customer and a provider a *service episode*, i.e., an occurrence of a service, takes place. During a service episode the provider provisions the service, often with the help of the customer and/or with access to the customer's resources.
- As an outcome of a service episode, the involved parties identify *value* resulting from the service. Value in business markets is the monetary worth of the technical, economic, service, and social benefits customers receive in exchange for the price they pay for a market offerings (Anderson et al. 2007). Therefore, a provider receives the value as a price for applying a competence, whereas a customer sees value in the application of an external competence and in results integration. In many cases, the value generated during a service episode can be measured quantitatively.
- In contrast to the physical assets common in goods dominated logic, such as equipment that eventually wears out and materials that are eventually depleted, the intangible assets common in a service provisioning environment may gain value with each additional use (Ricketts 2008). As an outcome of a service episode, the acquired value for a service provider also includes the *experience* gained after a completion of a service.

Service episodes can be subjects of a quantitative performance measurement. In (Spohrer et al. 2008), the authors propose the ISPAR model for the qualification of service episodes. The model proposes the classification of ten possible outcomes for any particular service episode. Although the ISPAR model is a concrete model, it can be adopted to meet additional requirements. Once the ISPAR, or a similar classification of service episode outcomes, is accepted, it can be used to measure service performance over time. For instance, statistical methods can be employed to derive the qualitative signature of a service as a distribution of observed service episode outcomes.

In S-D logic, as well as in service science, goods play an important role. Services are either provided directly, or conveyed through a good. However, competences and skills are still the aspects creating value during service episodes. Goods result from services that are involved in manufacturing procedures and are used to provision services.

## 2.2 *Properties of Service Systems*

Service science initiative refers to participants of service episodes as service system entities. In (Spohrer et al. 2008), the authors give a precise definition: A *service system* is a dynamic value co-creation configuration of resources, including people, organizations, shared information (language, laws, measures, methods), and technology, all connected internally and externally to other service systems by value propositions. A service system, as an open system, is capable of improving the state of another system through sharing or applying its resources. A system sees an interaction with other systems as having value, and is capable of improving its own state by acquiring external resources, i.e., the system itself sees value in its interaction with other systems. The service systems that participate in a service episode willingly engage in cooperation upon mutual agreement. As the result of a service occurrence both systems are improved.

For our purpose and to our understanding, we summarize a *service system*, or a *system*, as a dynamic configuration of competence propositions. A *competence proposition* can either be of a *provider* role or of a *customer* role. A competence proposition of a provider role hints at the temporal ability of a service system to apply the competence, i.e., the service system has knowledge and skills sufficient to fulfill the competence it proposes to a market. A competence proposition of a customer role hints at the temporal desire of a service system to integrate external competence, i.e., the service system is looking for the competence in a market to derive and integrate potential value with its resources. A *service episode* takes place as a result of a match of provider and customer roles for the same competence proposition.

### 2.2.1 Diversity

Service systems are extremely diverse. The diversity partly arises from the fact that service systems are dynamic configurations of competence propositions. One can envision many combinatorial possibilities to compose competence propositions into one whole service system. Alternatively, the diversity is caused by the procedure of boundaries identification in service systems, which are often blurry. Can something be regarded as more or less a whole or as a whole for some purposes but not for others? Can a whole be also part of another whole or even of several other wholes (Vickers 1983)? At what granularity is a whole acceptable for the identification as a service system? All of the proposed questions relate to the identification of an atomic service system.

### 2.2.2 Complexity

*Atomic* service systems can be combined to form *composite* service systems. For instance, one can envision hierarchical composite structuring or market based economic organizations of systems (Williamson 1985). In part, the complexity also arises from the fact that a service system can simultaneously fill multiple roles in many service episodes with other service systems. Multitasking in the multiple roles carried out by service systems adds a further dimension to the combinatorial possibilities in overall service system diversity. Moreover, the mutual penetrations of the systems while engaging in service episodes aggravate the problem of identifying single service systems and results in intersections of service system configurations. Finally, one might address a sub-system by identifying the boundaries within the whole system (containment relation), e.g., a research group within an institute. However, every identified service system can be addressed by its unique identity as an instance of a type, or a family, of similar service systems.

### 2.2.3 Dynamism

Service systems compose or decompose over time with the main building blocks of service system compositions being competence propositions. Service systems, when together, constitute an extremely dynamic environment – a *market* of service systems. In this environment, every service system is struggling to gain value, which is a comparative concept. Customers assess the value proposition of a given market offering relative to what they regard as the next-best alternative to it. Every market proposes alternatives. The alternatives originate from: an offering from a competitor, the decision by a customer to source an item (to apply a competence) from another partner or to produce the item (to conduct a service episode) by themselves (to perform a self-service), the decision of not doing anything, the option of the most recent offering from the same partner (Anderson et al. 2007), etc.

Service systems change over time; they acquire new competences, give up on supporting economically unprofitable competences, enter new markets, leave declining markets, introduce innovations, etc. Service systems experience the need for external competences and propose competences to markets on the temporal basis following market trends. Service systems exist in time and, thus, have a beginning, a history, and an end. The history of a service system is a log of separate service episodes, conducted with sub-systems within its own configuration or with external partners, as well as a log of configuration snapshots of competence propositions over time.

### 2.2.4 Value Creation

The primary goal of each service system is to increase its value. A primary source for value increment are partner relations with market participants. A service system can increase its accumulated value in a given period of time by engaging in interactions with partners. The increase is expected even if the system outperforms every potential partner in every competence required by the system. The rationale behind this paradoxical statement can be explained by Ricardo's law of comparative advantage (Hardwick et al. 1999; O'Sullivan and Sheffrin 2005). The principle behind the law proposes to service systems to concentrate more on their core competences and to outsource the competences that they do least well to partners. For this reason, the need for cooperation with other service systems has a strong motivation: The natural desire of a service system to increase the generated value.

Ricardo's law provides an instinctive reason for behavior of a service system. The law does not necessarily imply that a service system always looks for an external partner to outsource its secondary activities. A system might as well decide to perform a *self-service*. A self-service might occur in cases where a service system possesses both propositions of provider and customer roles for the same competence. Usually, a service system sees a solid economical profit when it decides to perform a self-service.

Service science initiative describes an innovative perspective on the environment of service provisioning. The core observation of service science is that in many cases, services such as professional, scientific, and technological services do not fit into the widely-accepted picture of repetitive and best-practice service specifications. Complex services may also need special tools and materials, but they often require sufficient levels of expertise (Ricketts 2008). A service episode occurs upon mutual agreement between several partners and results in a transfer of a competence from service providers to customers. Finally, all partners that participate in a service episode see cooperation as having value. The additional value gained from the shared environment is the driving force bringing service systems in partner relations.

## 3 Flexible Process Graphs

In this section, we present flexible process graphs (FPG), a technique to represent business processes on a high level of abstraction. The formalism considers business processes as collections of activities with execution order constraints. Rather than detailing the control flow by edges between two activities, execution order constraints are defined in a much more flexible way, using subsets of activities. In particular, an activity can be performed once all its prerequisites are accomplished. This notion provides much more flexibility than existing control flow based approaches.

FPG were first introduced in (Polyvyanyy and Weske 2008a) as a formal way for representing control flow in ad-hoc business processes. In (Polyvyanyy and Weske 2008b), it is explained how FPG process instances can be parallelized for collaborative execution. At the core of FPG lies the generalization of a directed process graph edge which defines the sequential execution of two adjacent activities. The generalization of a graph is a hypergraph, as introduced in (Berge 1985, 1989). Hypergraph edges (or hyperedges) consist of arbitrary sets of nodes. Thus, a hyperedge is an edge that can connect multiple activities. Different than in the graph-based sequence control flow pattern, a process participant is allowed to choose which activity to execute next within a hyperedge. This way a flexible execution of a process is achieved. A process model becomes hypergraph-structured, rather than graphstructured.

**Definition 1**

A *flexible process graph* (FPG) is a triple ($A$,$E$,$T$) where:

- $A$ is a finite set of activity nodes
- $E$ is a finite set of edges $e = \langle I(e), O(e) \rangle \in E, A \cap E = \emptyset$
  - $I : E \rightarrow \mathcal{P}(A)$ is a function defining edge input activities
  - $O : E \rightarrow \mathcal{P}(A) \backslash \emptyset$ is a function defining edge output activities
  - $\forall e \in E : I(e) I \cap O(e) = \emptyset$
- $T$ is an edge type function, $T$:$E \rightarrow \{and, xor, or\}$.

Each edge $e \in E$ is split in two subsets of input $I(e)$ activities and output $O(e)$ activities. Thus, the structure of an FPG is given by a directed hypergraph. Unlike regular graph-structured process models that contain special gateways to define control flow, FPG introduces edge types which implement routing decisions. The behavior of FPG processes is defined by the FPG execution semantics, which specifies state transition principles. At every point in time, an FPG process is in a certain state:

**Definition 2**

A *state* of a flexible process graph ($A$,$E$,$T$) is defined by a state function $S : A \rightarrow \mathbb{N}^0 \times \mathbb{N}^0$ mapping the set of activity nodes onto the pairs of natural numbers including zero.

In a state $S$, each activity node $a \in A$ is assigned a pair of numbers $S(a) = (i,j) \in \mathbb{N}_0 \times \mathbb{N}_0$ . $S_\omega(a) = i$ (*white* tokens) specifies the number of instances of activity $a$ that need to be accomplished from now on in the process instance. Respectively, $S_\beta(a) = j$ (*black* tokens) specifies the number of activity instances accomplished in the process instance.

*Process instantiation.* Process instantiation is performed in two steps: $S(a)$ is set to (0,0) for all $a \in A$. For each activity $a \in A$ the initial enabling is performed. An activity $a$ is enabled at process start if $\varepsilon^*(a)$ holds:

$$\varepsilon^*(a) = \exists e \in E : a \in O(e) \wedge I(e) = \emptyset \wedge cond(e, a).$$

The *cond* predicate implements edge type $T(e)$ routing decision for edge $e$, e.g., $\forall a \in O(e) : cond(e, a) = true$, if $T(e) = and$. If $\varepsilon^*(a)$ holds, the process state $S$ is modified to result in $S'$, such that $S'(a) = S(a) + (1,0)$.

*Activity firing.* An activity $a \in A$ can fire in an FPG process instance if it is enabled ($S_\omega(a) > 0$). Activity firing results in the process state $S$ change to $S'$, such that $S'(a) = S(a) + (-1,1)$, i.e., one white token gets painted black.

Activity firing is instantaneous, consumes no time, and indicates a completion of the corresponding activity. After activity $a$ has fired, the activity enabling has to be performed on a set of activities: $\cup_{\{e \in E | a \in I(e)\}} O(e)$. The enabling is performed for all the activities that are in the output sets of edges that contained the accomplished activity in the input set.

*Activity enabling*. An activity $a \in A$ can be enabled after execution of an activity $a_\beta$ if $\varepsilon(a_\beta,a)$ holds:

$$\varepsilon(a_\beta,a) = \exists e \in E \forall a_i \in I(e) : a_\beta \in I(e) \wedge a \in O(e) \wedge S_\beta(a_i) \geq S_\beta(a_\beta) \wedge cond(e,a).$$

Enabling of activity $a$ depends on execution of the preceding activity, e.g., activity $a_\beta$. An activity $a$ can be enabled if there exists an edge $e \in E$, such that $a$ is the output activity of $e$ and $a_\beta$ is the input activity of $e$. Further, for each input activity $a_i$ of the edge $e$ it holds that the number of accomplished instances of $a_i$ is at least the number of accomplished instances of $a_\beta$. Finally, the edge type $t \in T$ condition for edge $e$ must hold. If $\varepsilon(a_\beta,a)$ holds, the process state $S$ is modified to result in state $S'$, such that $S'(a) = S(a) + (1,0)$. Intuitively, new activities are available for execution in a process once all the prerequisites are accomplished.

*Process termination*. A process instance terminates when there is no activity to execute, i.e., no activity is enabled: $\forall a \in A : S_\omega(a) = 0$.

Process participants execute process activities following the proposed execution semantics to achieve a process goal. In business processes, activities can be fully automated by software systems, partially automated, or carried out by humans. For the sake of simplicity in FPGs we abstract from the diversity of process participant types and address them as *roles*. We identify each role as a sequential system, i.e., a role can only execute a single activity at a time. Therefore, true parallelism can only be achieved when several roles execute different activities at the same time. In order to coordinate efforts, each process participating role is assigned activities for execution.

**Definition 3**

A flexible process graph $FPG = (A,E,T)$ *role assignment* is a pair $(R,W)$ where:

- $R$ is a finite set of roles,
- $W : A \rightarrow \mathcal{P}(R) \setminus \emptyset$ is a roles assignment function.

Every activity in an FPG process has to be associated with at least one role, otherwise there might be no role responsible for accomplishment of an activity. Once enabled, an activity $a \in A$ can only be executed by a role from the assignment $r \in W(a)$. During FPG process instance execution, each participating role observes a subset of activities currently available for execution – the *role task list*. A participating role contributes to the achievement of the process goal by selecting and accomplishing an activity from the proposed list. The list is referred to as a role task list.

**Definition 4**

A *role task list* for the role $r \in R$ from the role assignment $(R,W)$ for the flexible process graph $FPG = (A,E,T)$ is a function $L(r) = \{a \in A \mid r \in W(a)\} \wedge S_\omega(a) > 0\}$, where $r \in R$, defined on a subset of FPG activities $(L : R \rightarrow \mathcal{P}(A))$.

FPG is a simple formalism to specify allowed state transitions which describe process execution principles. A process is a collection of activity execution constraints. Each constraint allows the accomplishment of process activities only after all the designed prerequisites are fulfilled.

## 4 Formalization of Service Science Environments

In this section, we formalize the environment proposed by service science initiative. The structural as well as behavioral aspects of the service science concepts discussed in Sect. 2 are proposed as a mapping onto the FPG formalism from Sect. 3.

Informally, we understand a service science environment as a competitive environment, or a market, of service systems. Market participants engage in service episodes in order to apply their skills and knowledge, or to discover and to integrate the competence they need to fulfill their needs. In both of the cases, a service system expects to generate value. This highly dynamic environment, in which businesses join or leave markets, new markets appear, and strategic plans change, leads to the ad-hoc nature of service episodes. We propose to capture the state space of possible scenarios for occurrences of service episodes in the market as an ad-hoc process.

A service episode involves at least two service systems: one applying and one integrating the competence. Each service system can be seen as a collection of competence propositions. Furthermore, there is a clear distinction between the provider and customer roles of competence propositions. We formalize competence propositions by introducing a dedicated concept and a modeling construct. Figure 1a, b indicate the visual differentiation of service propositions of a provider role and, respectively, of a customer role, for a competence proposition *a*, e.g., a competence of conducting research. Service systems advertise their competence propositions to the market. In our example, a competence proposition *a* of a provider role means that a service system which advertises the competence in the market possesses sufficient skills in order to perform the research, e.g. a research group within an institute.

Conversely, a competence proposition *a* of a customer role signals to the market that a service system is advertising the need for an external competence, e.g., an enterprise that looks for innovations and is willing to finance a research.

A service system co-creates value with other service systems by engaging in service episodes. A service episode can occur as a result of a *competence match*, and is supplied within a *service episode*. There is a possibility for a competence match on the market if the market possesses competence propositions of both roles, provider and customer, for the same competence. Competence propositions might even belong to a single service system, but must be advertised in the same market. Figure 1c exemplifies competence match based on the competence of conducting


**Fig. 1** (**a**) A competence proposition of the provider role, (**b**) a competence proposition of the customer role, (**c**) a competence match, (**d**) a service episode

research. By performing a competence match, a research group and an enterprise willingly engage in service related interactions. Figure 1d proposes a visualization approach for service episodes. The concept of service episodes aggregates information about a competence match and abstracts from the internal logic of the service provision.

Service systems are subject to constraints. If they had no constraints they could grow as large and as fast as they wanted without any restrictions (Ricketts 2008). Constraints in a service system can be deduced from supported service episode scenarios, and therefore can be propagated to the competence propositions. In the following, we give a formal definition of a service system as an FPG composed of competence propositions, which also incorporates the constraints. We introduce an extension to the FPG formalism to allow differentiation between competence proposition roles.

**Definition 5**

A *service system*, or a *system*, is a configuration of competence propositions given by a quadruple $(C,E,T,R_C)$, where:

- $(C,E,T)$ is a configuration of the service system, given as an FPG composed of a finite set of competence propositions $C$
- $R_C : C \rightarrow \{provider, customer\}$ is a competence proposition role function.

Service systems are hardly useful in isolation. While a competence match might occur within a single system, it is far more likely to occur across service systems. Matching across service systems results in the service systems merging. A service science environment is obtained by merging service systems based on their competence propositions. Under a service science environment we understand a temporal co-existence of service systems which are in competitor or partner relations. Once competence propositions are matched, service episodes might happen. A service episode is enabled for execution if it was obtained as a result of a competence match and is enabled in all participating service systems, assuming the underlying FPG enabling semantics (see Sect. 3). An enabled service episode can occur. An occurrence of a service episode results in a competence transfer from providers to customers. A successful service episode completion signals for an environment state change. The corresponding competence propositions fire following the FPG execution semantics in all participating service systems.

In general, the structure of an FPG is fixed. However, in the case of service systems, we foresee the necessity for structural changes during system lifecycles. A service system is expected to change its structure as a response to market trends. In this case, the restriction of the fixed FPG structure must be waived. Service systems might decide to introduce new constraints or to give up on old ones in order to pursue market trends.

Service systems can rely on FPG role assignment capabilities to distribute operand resources (available products that support service episodes) and operant resources (people or machines producing an effect of competence application) among service propositions. Execution of a service episode can be parallelized following FPG principles (Polyvyanyy and Weske 2008b) and monitored with the help of FPG task lists. The history of a service system can be tracked by logging FPG firings (production of black tokens), as well as by monitoring structural changes of the system. In order to allow quantitative service system evaluation, each token can be enhanced to carry service episode outcome information, like the one proposed within the ISPAR classification. The quantitative signature of a service proposition can further be used as a notion of the experience of a service system in delivering or consuming the corresponding competence.

## 5 Example of a Service Science Environment

In this section, we present an example of a service science environment obtained by merging several service systems. The example illustrates concepts and principles of the service science initiative.

The example scenario is a joint research project that involves three institutions. The scenario specifies an episode from a simplified and anonymous version of a real-world research project. The settings assume a transfer of a research competence from a research group to an enterprise through the application of developed mechanisms to the process model repositories of the enterprise.

In this setting, the enterprise is willing to use the competencies of the research group for process analysis and transformation. The enterprise is willing to integrate the research results in the company (by adding the new process models to the process model repository of the company). The research group provides the competence which is necessary to perform the requested analysis and transformations. If both institutions decide to partner for mutual benefit they require external assistance to settle legal issues in a project contract.

Each of the three proposed institutions, the research group, the enterprise, and the legal authority, is an example of a service system type. In order to partner, the instances of the mentioned service system types need to be present at the same market simultaneously.

In the remainder of this section, we formalize one instance of each service system type mentioned. Afterwards, we exemplify the merging procedure of service systems and discuss the behavior of such temporal phenomena. For the sake of simplicity, we specify service systems to a level sufficient for scenario coverage. Throughout the examples we visualize the formalism by following the proposal for graphical representation of flexible process graphs suggested in (Polyvyanyy and Weske 2008a): Edges in flexible process graphs are represented by regions. Input edge nodes are located on the borderline of the corresponding region, whereas output edge nodes are placed inside the edge region. We employ the visual notation from Fig. 1 to differentiate between the roles of competence propositions and to represent service episodes.

Next, we discuss one concrete example of a service system for each of the following types: a research group, an enterprise, and a legal authority.

## 5.1 Research Group

A research group is an institution with expertise in a certain domain of science and which pursues challenges and innovations in order to contribute to the overall body of knowledge. In our simplistic example, we treat a research group as the decomposition of four competence propositions: $c$ – preparation of the project contract, $n_1$ – contract legal issues negotiation with authorities, $m$ – process model repository transfer, and finally $r$ – the research undertaken.

In our example, the research group has expertise in business process management. It is interested in obtaining real-world data – process model repositories. To do that, a project contract which negotiates work packages needs to be developed. To derive a contract, a research group supplies its legal regulations which have to be obeyed.

A service system of a research group is shown in Fig. 2. It can be formalized as a configuration of competence propositions: $(C,E,T,R_C)$. $C = \{c,m,r,n_1\}$, $E = \{e_1,e_2,e_3,e_4\}$, where $e_1 = \langle\emptyset, \{c\}\rangle$, $e_2 = \langle\emptyset, \{m\}\rangle$, $e_3 = \langle\emptyset, \{n_1\}\rangle$, and $e_4 = \langle\{c, m\}, \{r\}\rangle$. All of the edges are of *and* type ($\forall e \in E : T(e) = and$), $R_C(c) = R_C(m) = customer$, $R_C(r) = R_C(n_1) = provider$.

Internal constraints of the research group are enforced by edges which describe the structure of the service system. It requests external competences to engage into service episodes for negotiating the project contract and obtaining process model repositories. These requests are represented by the competence propositions $c$ and $m$, both of the customer role.

The outer line around competence propositions, e.g., $c$ and $m$, stands for an FPG edge which contains only the competence proposition corresponding to the output node – there are no prerequisites for the proposition. If the service system succeeds in obtaining the value from service episodes that involve competence propositions $c$ and $m$, it can proceed with supplying the competence of research ($r$). At any time, the research group can engage into a service episode of legal negotiation for a project contract ($n_1$), as no prerequisites are modeled.

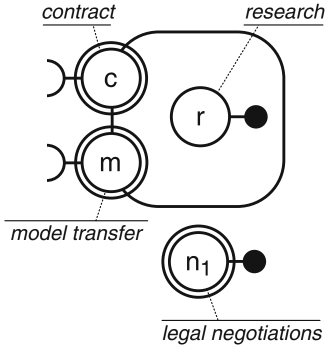



**Fig. 2** A research group system

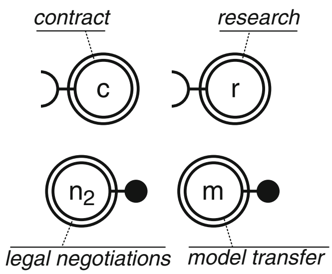



**Fig. 3** An enterprise system

## 5.2 Enterprise

For the purpose of our example, we see an enterprise as a decomposition of four competence propositions: $c$, $m$, and $r$ are similar as in the case with the service system of the research group, and $n_2$ – contract legal issues negotiation with authorities specific to an enterprise. An enterprise is looking to obtain research results. For this purpose, an enterprise is ready to provide its process model repositories. Upon request, an enterprise is ready at any moment to negotiate legal issues and to set up a contract.

A service system of an enterprise is given in Fig. 3 and can be described by a configuration of competence propositions $(C, E, T, R_C)$. $C = \{c, m, r, n_2\}$, $E = \{e_1, e_2, e_3, e_4\}$, where $e_1 \langle \emptyset, \{c\} \rangle, e_2 = \langle \emptyset, \{m\} \rangle, e_3 = \langle \emptyset, \{r\} \rangle, e_4 = \langle \emptyset, \{n_2\} \rangle$. All of the edges are of *and* type $(\forall e \in E : T(e) = and)$, $R_C(c) = R_C(r) = customer, R_C(m) = R_C(n_2) = provider$.

To simplify the example, we abstract from complex internal enterprise logic and assume all the competence propositions to be enabled. Both $n_1$ from Fig. 2 and $n_2$ from Fig. 3 are competence propositions of the same type – legal issues negotiation. Please note that the fact that all competence propositions are enabled does not imply that a service system has no constraints. An enterprise is constrained to be able to only participate in service episodes that involve competence propositions $c$, $r$, $m$, and $n_2$.

## 5.3 Legal Authority

An institute of a legal authority is included in our example to have a system which is capable of delivering a competence of setting up a contract. A legal authority is capable of conducting legal negotiations with each of the contractors and, afterwards, to issue a legal document which regulates partner relations – a contract.

For our purposes, it is sufficient to see a legal authority as a system consisting of three competence propositions: $n_1$ and $n_2$ are both competence propositions of the type legal issues negotiation, and $c$ – similar as proposed above, preparation of a project contract.

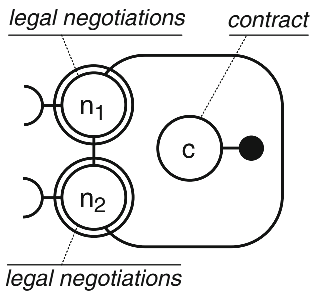



**Fig. 4** A legal authority system

A service system of a legal authority is visualized in Fig. 4 and is a configuration of competence propositions $(C, E, T, R_C)$. $C = \{n_1, n_2, c\}$, $E = \{e_1, e_2, e_3\}$, $e_1 = \langle \emptyset, \{n_1\}\rangle$, $e_2 = \langle \emptyset, \{n_2\}\rangle$, $e_3 = \langle \{n_1, n_2\}, \{c\}\rangle$. All of the edges are of *and* type ($\forall e \in E : T(e) = and$), $R_C(n_1) = R_C(n_2) = customer$, $R_C(c) = provider$.

A service system of legal authority has a constraint which states that it is capable of delivering the competence of setting up a contract ($c$) only after it has finalized service episodes of legal issue negotiations ($n_1$ and $n_2$) with each of the partners.

## 5.4 Shared Environment

Operational principles of service systems are governed by FPG execution semantics. State transitions result from the successful completion of service episodes, implying prior competence match. Service systems from Figs. 2–4 are scarcely useful in isolation. Standalone systems only describe their own constraints, i.e., the way they do their business. The real value comes from service system compositions. In the following, we discuss two examples of service system environments formed by merging service systems.

Figure 5a shows a potential shared environment of a research group and an enterprise. The merging results in two competence matches based on the competences of process model repository transfer ($m$) and research ($r$). The research group imposes the constraint to the overall environment – a contract must be settled ($c$) and models transferred ($m$) before research ($r$) can take place.

In the environment, a service episode $m$ might happen; it is obtained as a result of a competence match and all competence propositions that participate in a match are enabled within the corresponding service systems (see Figs. 2 and 3). A completion of service episode $m$ results in a firing of corresponding competence propositions in the participating service systems. However, a service episode of research (r) cannot occur after this. Although it is enabled within the enterprise, the research group requires a contract ($c$) before it enables $r$. The environment proposed in Fig. 5a does not have a competence match for $c$. Therefore, the partners may start with model transfer, but still require external competence to assist with contract preparation in order to proceed with research.

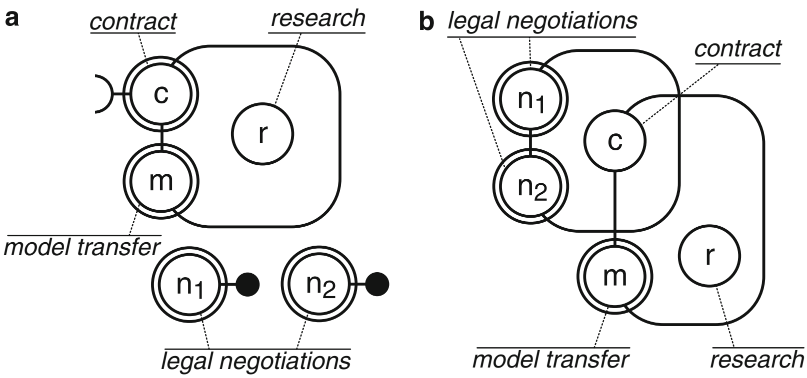



**Fig. 5** (**a**) An environment of a research group and an enterprise, (**b**) An environment of a research group, an enterprise, and a legal authority

Figure 5b completes the composition of the environment by additionally merging the service system of a legal authority. Now, all the competence propositions are matched and can occur. By participating in the service episodes, the participants of the environment start to collectively approach realization of their goals: First, service episodes of legal negotiations ($n_1$, $n_2$) and model transfer ($m$) are enabled. Once negotiations are finalized, the project contract can be settled ($c$). Once the contract is ready and the models are transferred, the partners can proceed with research ($r$).

Each service episode within the project can be addressed as a complex interaction that in the end delivers value to the participants. For example, model transfer ($m$) can involve complex interaction on shaping, correcting, finalizing, or enhancing models. A service episode of research ($r$) is aimed at delivering desired results to the enterprise, but may also result in new findings and methods for the research group. Service episodes $n_1$ and $n_2$ are the examples of knowledge transfer services. The service episode of setting up a contract ($c$) is obtained as a result of merging of all three participants with one provider role and two customer role competence propositions; it can represent a joint meeting.

In our example we have performed all competence proposition matches possible. However, in a general case, a service system should decide on the desired configuration of competence proposition matches once it enters an environment.

## 6 Conclusion

In this chapter, we made the first steps towards formalization of service science environments. Many open questions are still to be answered, and many issues are still to be concretized with our approach, as well as with S-D logic and service science initiative. As for the state of the art, we proposed a modeling technique to capture service systems and their ecology. Service systems are addressed as FPG configurations of service propositions. Models of service systems can then be used for execution, analysis, optimization, or redesign of service systems.

A service science environment is obtained once several service systems decide to merge. The merging is guided by matching competence propositions and results in resource integration. Such behavior of service systems is explained by the desire to achieve a synergy effect, i.e., the key to success is not to destroy but to enhance your partners. After the competence match is reached and is enabled within the environment following FPG execution semantics, the service episode might happen. Service systems split, once there is no need in further partnership.

The future work in service science formalization initiative will have to deal with a better understanding of a service system merging/splitting behavior. In this context, it is a challenging task to understand how competences are defined and brokered. Also, it is interesting to answer how a single service episode can be modeled if it is assumed to be a complex interaction scenario between service partners. All of the above mentioned initiatives can lead to a better understanding of the Moore's law for service system continuous improvement.

## References


Anderson J.C., Kumar N. and Narus J.A. (2007) Value Merchants: Demonstrating and Documenting Superior Value in Business Markets. Harvard Business School, Boston, MA.

Berge C. (1985) Graphs and Hypergraphs. Elsevier, Amsterdam.

Berge C. (1989) Hypergraphs: Combinatorics of Finite Sets. Elsevier, Amsterdam.

Burbeck S. (2000) The Tao of e-business services: The evolution of Web applications into service-oriented components with Web services. http://www.ibm.com/developerworks/library/ws-tao/. Accessed November 2009.

Gottschalk K. (2000) Web services architecture overview: The next stage of evolution for e-business. http://www.ibm.com/developerworks/library/w-ovr/. Accessed November 2009.

Hardwick P., Khan B. and Langmead J. (1999) An Introduction to Modern Economics, 5th edn. Financial Times/Prentice Hall, Harlow, England.

Lusch R.F., Vargo S.L. and Wessels G. (2008) Toward a conceptual foundation for service science: Contributions from service-dominant logic. IBM Systems Journal 47(1), 5–13.

Newcomer E. and Lomow G. (2004) Understanding SOA with Web Services. Addison-Wesley, Maryland.

O'Sullivan A. and Sheffrin S. (2005) Economics: Principles and Tools, 4th edn. Prentice Hall, Upper Saddle River.

Polyvyanyy A. and Weske M. (2008a) Hypergraph-based modeling of ad-hoc business processes. In: Business Process Management Workshops, Springer Verlag, LNBIP, vol. 17, pp. 278–289.

Polyvyanyy A. and Weske M. (2008b) Flexible process graph: A prologue. In: Proceedings of the 16th International Conference on Cooperative Information Systems (CoopIS), Springer Verlag, LNCS, vol. 5331, pp. 427–435.

Ricketts J.A. (2008) Reaching the Goal: How Managers Improve a Services Business Using Goldratt's Theory of Constraints. IBM Press, New York.

Silberschatz A., Korth H.F. and Sudarshan S. (1997) Database System Concepts, 3rd edn. McGraw-Hill, Hightstown.

Spohrer J., Maglio P.P., Bailey J. and Gruhl D. (2007) Steps toward a science of service systems. IEEE Computer 40(1), 71–77.

Spohrer J., Vargo S.L., Caswell N. and Maglio P.P. (2008) The service system is the basic abstraction of service science. In: Proceedings of the 41st Annual Hawaii International Conference on System Sciences (HICSS), IEEE Computer Society.

Vargo S.L. and Lusch R.F. (2004) Evolving to a new dominant logic for marketing. Journal of Marketing 68, 1–17.

Vargo S.L. and Lusch R.F. (2006) The Service-Dominant Logic of Marketing: Dialog, Debate, and Directions, "Service-Dominant Logic: What It Is, What It Is Not, What It Might Be". M.E. Sharpe.

Vickers G. (1983) Human Systems are Different. Harper & Row, London.

Weske M. (2007) Business Process Management Concepts Languages Architectures. Springer, Berlin.

Williamson O.E. (1985) The Economic Institutions of Capitalism. Free Press, New York.

# Semantics for Smart Services

**Charles Petrie, Axel Hochstein, and Michael Genesereth**

**Abstract** In this chapter, the notion of Smart Services is developed based on the concept of semantics and by borrowing ideas from existing planning techniques known from the AI domain. The motivation behind Smart Services is the creation of efficient and effective service systems self-adapting to a constantly changing environment. A major prerequisite for achieving this goal is a semantic description of the considered service system. Different standards and techniques evolved over the past years and can be applied to address this problem. Based on ideas borrowed from situational calculus, different planning techniques can then derive executable plans for achieving certain goals within the service system. Finally, an example from the Web Service domain is used in order to demonstrate the approach. Results show that this approach is promising to increase the level of automation for certain service systems and thereby creates a notion of Smart Services.

**Keywords** Service Science · Service Systems · Semantics · Situation Calculus · AI planning · Smart Services

## 1 Introduction and Motivation

In March 2005, James Womack and Daniel Jones described the following paradox in an article in Harvard Business Review: "Over the past 20 years, the real price of most customer goods has fallen worldwide, even as the variety of goods and the range of sales channels offering them have continued to grow. Meanwhile, product quality – in the sense of durability and number of delivered defects – has steadily improved.

A. Hochstein (✉)
Computer Science Department, Stanford University,
353 Serra Mall, Gates Building, Stanford, CA 94305, USA
e-mail: axel.hochstein@cs.stanford.edu

H. Demirkan et al. (eds.), *The Science of Service Systems*,
Service Science: Research and Innovations in the Service Economy,
DOI 10.1007/978-1-4419-8270-4_6, 

So, if customers have access to an evergrowing range of products at lower prices, with fewer lemons, and from more formats, why is consumption often so frustrating? Why do we routinely encounter the custom-built computer that refuses to work with the printer, the other computers in the house, and the network software? Why does the simple process of getting the car fixed require countless loops of miscommunication, travel, waiting, and defective repairs? Why does the diligent shopper frequently return from a store stocking thousands of items without having found the one item that was wanted? And why is this tiresome process of consumption backed up by help desks and customer support centers that neither help nor support? In short, why does consumption – which should be easy and satisfying – require so much time and hassle?" (Womack and Jones 2005).

This excerpt describes the effect of a different degree of professionalization. More specifically, the above examples reveal the discrepancy between the manufacturing industry, having adapted concepts such as standardization, automation or modularization for many decades, which the service industry has only recently started considering (Levitt 1976).

However, services have been the major growth-driver of entire economies as well as of single businesses in the last decades. In the US, 90% of the population worked on farms in 1800, whereas today less than 3% of the country's workforce is employed in agriculture. The manufacturing of goods or physical products peaked in the US in the mid-1950s, and has been decreasing ever since due to automation and offshoring. About 20% of the US GDP comes from physical products (agriculture, manufacturing, construction) and about 80% stems from the service sector (government, healthcare, education, retail, financial, professional and business, media and communication, entertainment and hospitality, transportation & warehousing, utilities) (Apte and Nath 2007). Within the OECD countries, services accounted for about 72% of value added by 2002 and manufacturing for about 17%. OECD reports show that the gap has widened steadily in recent years as demand for services has risen. This results in economies dominated by the service sector (so-called service economies) as well as businesses converting products into services and combining services with existing products. The so-called Service-Dominant Logic (Lusch and Vargo 2006) presupposes the application of concepts such as standardization, automation, and modularization to the service sector in order to achieve a similar degree of professionalization as in manufacturing. In fact, the Service-Dominant Logic postulates a shift towards a different view of the world – with a less focus on producing and owning physical products but more on the actions that can be performed by using physical products. This view was also promoted earlier by (Kotler 1999): "The importance of physical products lies not so much in owning them as obtaining the services they render."

Within the Service-Dominant Logic, the "service system" is one key concept and the basic abstraction of service science (Spohrer et al. 2008). The best-performing service systems are increasingly IT-enabled, customer-centered, relationship-focused, and knowledge-intensive. Because of this multidisciplinary context, researchers and practitioners in such fields as management, social, and computer sciences are investigating issues related to service systems.

As both the complexity of worldwide service systems as well as the worldwide innovation rate is increasing, the challenge of integrating new service system components into existing service systems is becoming increasingly complex. The main driver that limits growth rates for innovations are missing service systems built around an innovation, that is, services rendering an innovation easily accessible and usable (Spohrer et al. 2007). Therefore, service systems need to be increasingly flexible and easily customizable. In addition, trends such as increasing demand for individualism (Kratochvíl and Carson 2005) require smart service systems that change in real time and adapt more or less automatically to specific situations.

## 2 Goal and Structure of the Chapter

In this chapter a framework for building smart service systems is suggested. It is assumed that smart service systems help to achieve certain results more efficiently and more effectively, thus facilitating more professional service systems that better meet customer expectations. Since businesses are interoperating more and more in order to leverage each other's core competencies and creating more agile supply chains, these considerations apply to both B2C as well as B2B. Most industrial interactions are services as well, and increasingly these are exposed with well-defined interfaces that are accessible over the Internet but which hide the complex back-end processing. What is needed for agile supply chains is similar to what is needed for people to "mashup" services: well-defined service descriptions that can be reasoned about prior to execution and support for changes and contingencies. Examples of the capabilities of future supply chains with advanced support for services may be found at (Petrie 2008). What is key is that various service suppliers and customers are able to parse these descriptions.

The more these descriptions also can be used to analyze and combine the services for new purposes, the more useful they will be. The more that they are declarative and tied to formal constraints, the more useful they will be. The more the descriptions are formally described so that the meaning is tightly constrained among different systems and uses, the more we term them "semantic".

We do not consider here the significant related problem of unifying semantics among the various service descriptions. Some of this is the data integration problem that has been well-treated, particularly by (Duschka et al. 2000) and will be shortly addressed in this chapter. However, it is likely that the problem of sophisticated heterogeneous descriptions will be solved first by the rise of homogenous "industrial service parks" (Petrie and Bussler 2008), which is another reason why industrial services are so relevant.

Behind this background, an approach for implementing smart service systems based on semantics and AI planning is studied in this chapter. The concept of semantics is used in order to describe relevant service system components as well as their relations. Based on the semantic descriptions, planning techniques from the

AI domain are used in order to perform inferences and coordinate communication between the service system agents.

Especially in the web service domain there have been attempts to formalize services and use formal descriptions of service interactions in order to build flexible and self-adapting information systems (Brogi et al. 2004; Decker et al. 2006; Gorrieri et al. 2005; Jones 2005; Sheth et al. 2006). Although we build on corresponding techniques for demonstration purposes, the underlying principles of the approach taken in this chapter are borrowed from situational calculus and thus are quite different in the way the components of service systems are represented.

Based on the formalization of service systems according to situational calculus in combination with AI planning techniques built on top of semantically described service systems allow us to develop a middleware that simulates the behavior of service systems. This can serve as the basis for developing flexible and self-adapting information systems as we demonstrate in this chapter.

It is organized in the following way: After the introduction, in section two necessary term definitions are given. Section three introduces the concept of semantics and shows how service systems can be described semantically. In section four it is then synthesized how semantic descriptions of service systems enable smart behaviors based on AI planning. Insights, generated in a regular challenge for automatically planning semantic web services are presented in section five and show the practicability of above explanations. Finally, section six summarizes and concludes this chapter.

## 3 Towards a Formalization of Services

The first distinction that is useful to make is that of a "server" and a "service". In informal usage, we may conflate the term "bus service" with the company that provides the transportation service. However, in this chapter, we follow the usage of computer science, where we often speak of "servers" that are the agents that provide or perform a "service". When we speak of the "RSS service", we are (or should be) referring to the general characteristics of a service provided, as opposed to the server providing this service.

Common examples are web servers and print servers. We also distinguish between the general provisioning of a service and the performance of it. A server is capable of providing a service (if all goes well). The particular page being served to us at this point is an instance of a general service. The description of the general service would refer to the general properties of the service and the description of the service instance would tell us something about the page now being served. We will in this chapter be referring to general services unless we explicitly refer to the service instance.

The two examples of web and print servers already make an important distinction. The print service is a very simple service in that we need only know the inputs to the service, the postscript file and number of copies, to know precisely what to expect from the service.

The web server output may depend upon the state of the backend of the server as well as that of the client browser. The output of such a server is deterministic from a computer science standpoint in which all information about states is known, but the customer, who wants to treat such a service as a black box, except for its description, does not know precisely the content of the web page requested, even if it was requested previously. That is, from a customer-point of view the web server cannot be described as a mathematical function since it may deliver different outputs at different times, even with the same inputs. Let us call such services to coin a word in order to avoid others in use, as "afunctional".

These two examples do share a nice property that they promise to perform a certain action once when properly called: they get a web page or print a paper page. There is one request and there is one response (modulo popups). A standard email sever is simple because one sends one email and the receiver receives one email. In general, servers may have more complex behavior that is difficult to describe, and which may depend upon circumstance. At a fast food restaurant, the service is also simple. We order our food once and receive it once. The service is over. At such a restaurant, we would not expect a human server to come to our table to refill our glasses, but we do expect this in more expensive restaurants, even without asking for such a service explicitly. A computer science example is RSS, which allows us to subscribe to updates of web pages. We make one request and may receive an unlimited number of responses, without requesting each one.

Let us call those servers, and services, that deliver exactly one response for one input "simple" and ones that may deliver more than one "persistent". Now let us make a more formal definition of "services".

For a formal definition, it is helpful to have a background of the Situational Calculus definition of goals, actions, and situations as stated in (Finzi et al. 2000). Typically, in discussing actions, we say that they change state. The Situational Calculus avoids this by discussing only situations that consist of action sequences.

One nice thing about situations versus states is that we can easily describe constraints over situations if we also refer to the states they create. This is useful for constraining properties of processes, where the individual software programs comprising the process may be considered as actions. But we do need both states and situations. And the goals of the Situation Calculus always implicitly assume some $S_0$ and the goal $G(s)$ described as a formula with one free situation variable $s$. A plan in Situational Calculus is then described as the situation in which $G$ is true. Since we need both states and situations ultimately, we find it more elegant to formalize fluent, states, actions and goals in a similar way.

## 3.1 Fluents, States, and Conditions

We start by defining a set of objects and possible relations between them, at least some of which are fluents, which describe conditions in the world in a given state. For instance, for state $St_0$, "*Rains*" might be a fluent that is true for "*Belmont*": Rains

(Belmont, $St_0$). A state is described by the set of fluents that are true for some set of objects, or alternatively, a triple of a property, object, and value. Thus a fluent may be something "*Is_blue*" which happens to be true of object "*My_house*" in state "*Before_painting*", or we may use such a fluent "*Color*" in triples such as "*Color My_house Blue*" together with a state "*Before_painting*". Let us call such expressions that have a truth value in some states simply fluent expressions. *Conditions* will consist of a *fluent* and a set of properties: $\{(p,o=a)\}$, where $o$ is the object of which $a$ is the value of the property $p$ in state $S$. If we want such a condition to hold in state – we will say $fluent\{(p,o=a),S_i\}$.

## 3.2 Actions

Each instance of the class of "*Action*" is a special relation with two arguments, alternatively properties of the class instances. The argument pair are sets of fluent expressions for some set of objects that are different: these denote partial states. Further, this is an ordered pair: the first partial state precedes the second and the second is the successor of the first. These fluent expressions will be denoted as "*Preconditions*" and "*Effects*".

For example, $A(P,E)$ is the relation "$A$" between these expressions. Alternatively, this denoted instance of class Action has the following properties and values: *Preconditions(A,P)* and *Effects(A,E)*. Any action must have at least one effect, even if it consists only of a single expression using the special fluent "*Know*", which indicates that only the state of things known has changed.

All of these lie in a defined theory $T_0$. All of the fluents and actions and agents and all objects to which they relate are defined here. New instances, including states, may be added to this theory. For instance, we can add $Weather(Belmont, Rains, S_o)$ and then add $Weather(Belmont, Rains, S_1)$. At any one time, the number of instances of all classes and fluent expressions is finite.

Note that the concept of preconditions and effects is quite fundamental for describing service systems. Value propositions as well as the actual value can for example easily expressed with preconditions and effects of actions.

Actions are state transformations. For any $A(P,E)$, for any state $S_i$ in which the set of preconditions $P$ are true, then this action defines a potential set of successor states $(SS)$ in which $E$ holds, i.e. there is a $SS$ for which if $S_j$ is an element of $SS$, then $(S_i<S_j)$ and the set of expressions $E$ holds in $S_j$. Let us denote such a state transformation by $A{:}S_i \rightarrow S_j$.

Further, any fluent expression that was true in $S_i$, that are not changed by the effects $E$ remain true in $S_j$, i.e. for simplicity, assume the persistence of fluent $\rightarrow$ expressions unless they are changed by an action in the sequence. Fluent expression decay is not considered here.

It may be the case, that for some actions, say $A$, and distinguished formula pairs, $P$ and $E$, that there is a (perhaps partial) ordering of actions such that $A(P,E)$ is provable from that ordering. We can express such ordering as a sequence of transformations as in the Situational Calculus.

## 3.3 Services

Based on these definitions, we can now introduce a formal definition of the term "*Service*". A simple service is one subclass of action. The first but not the most important aspect of this class is that it is simply a finite proper subset of action, written to the theory, perhaps arbitrary. Only these designated services can be legally used to prove an arbitrary action.

A service has additional properties in addition to its preconditions and effects, which are "*Provider*", "*Caller*" and "*Input*" and "*Output*" signals. The signals have distinguished relations: "*Sent*" and "*Received*". The values of caller and provider must be of type "Agent". Unique providers are defined for each service. Services that have the same preconditions and effects are identical objects unless they have different providers.

The objects to which signal relations apply are the services themselves with the first and second states that are two states transformed by the services, together with providers and callers.

Outputs also have a fourth argument "*Output*". For example, when service $W(P,E,agent_1,agent_2)\colon S_i \rightarrow S_j$, then it is true that $Sent(W,S_i,agent_1,agent_2)$ and $Received(W,S_j,agent_1,agent_2)$, where it is true that $Provider(S,agent_1)$ and $Caller(S,agent_2)$. Initially, we say that "output" is just a determinate symbol, which may be defined as "*nil*": it is optional.

If some action is not a service, but is provable as a sequence of services, we can denote that sequence as a "*Plan*" that constitutes a virtual service: one not identified in our universe of discourse as a service. There may be many such virtual services that are provable in our theory at any time. These do not have callers or providers but may be converted to services with callers and providers at any time in theory.

## 3.4 Goals

"*Goals*" are a subclass of actions. These are not the same as informal goals that we may have in planning but rather designated objects in our theory with the property "*Owner*" which has the value of type "*Agent*". This property is single-valued and if a plan is constructed that achieves a goal, the caller of the services is the owner of the goal.

In our theory $T_0$ in which we have made a plan $P$, to achieve goal $G$, and $Owner(G,agent_2)$. For each service in our plan $T_i$ we have, $Caller(T_i,agent_2)$. A plan may itself have intermediate goals as part of the planning process but these are distinct from the top-level formal goal that may initiate planning.

# 4 Semantic Service Systems

Based on our understanding of a defined theory $T_0$ for actions, a "*Service System*" is a theory $T_s$ defining all the fluents, goals, services, agents and all objects to which they relate. While value is a key feature of services in service science and would also be part of the service system, we do not focus on that here. A value can certainly be attached to the goals and services we describe, and economics can be part of the analysis based upon the semantic descriptions.

Based on the definitions given above, the descriptions of service systems such as preconditions and effects have to be formalized in a way that we can infer properties of the service system. This is what we mean by semantic annotations. The more complete the model of the service system, the more we can infer about how it works.

With such formal semantic descriptions we can not only infer how systems work, but infer how to build them as we need them: that is the point of planning. We describe more about planning later in this chapter. First we focus on the issue integration of the data used by the services.

Agents typically have access to a certain amount of information about service systems. Some information is implicit and need to be made explicit in order to be accessible for other agents. Some information is explicit but unstructured, in which case it is hard to find for agents. The easiest case is explicit and structured information. In general there is a trend towards increasing amount of available unstructured and structured information due to phenomenons such as increasing usage of the internet by individuals, organizations opening their databases to the public via APIs, or the growing digitalization of the physical world. There are also mechanisms that allow adding structure to unstructured information such as tagging of documents or natural language processing. Thus, we take the assumption that more and more structured information about services becomes available over time, typically in the form of records within relational databases.

However, often available structured information about service systems is not integrated. The main difficulty in data integration is conceptual heterogeneity, i.e. differences in the schemas and vocabularies used by different agents and different data sources. Examples of such differences abound, from simple cases of different words and incompatible units to more complex cases involving different relational attributes and different relational tables.

Techniques able to deal with conceptual heterogeneity have however evolved and matured over the last years, allowing the development of semantic descriptions of service systems. The foundations for semantic services systems are the following:

- Sentential representation of service systems: In order to be able to support resources, classes of resources and inheritances directly in database schemas and in the query language, it is useful to encode each instance of a relation (i.e. each record in a relational database) in the form of a sentence consisting of the relation (i.e. fluent) and the resources (i.e. objects) involved in the instance.

More precisely, given a database containing information about service systems, we define an atomic sentence of a service system to be a structure consisting of an *n*-ary relation from the signature and *n* resources. For example, if *r* is a binary relation and *a* and *b* are resources, then *r(a,b)* is an atomic sentence of the service system. In recent years the RDF (Resource Description Framework) is used more frequently to represent resources . RDF is based on triples, i.e. binary relations subject, predicate, object. It is easy to write any *n*-ary relation as a binary relation by using blank nodes as object and specify this object with further triples. In addition to resources, classes of resources, and sentences also service system rules can be represented: A rule is an expression consisting of a distinguished atomic sentence, called the head, and *k* literals (i.e. resources, classes of resources, or atomic sentences), together called the body. The head of a rule is true if and only if the body is true.

- Ontologies for service systems: The usage of different data schemas necessitates mappings between the different data sources and the schemas used by the agents. There are various approaches to doing this, such as direct mapping of schemas or source-based integration. The dominant approach for a large number of different schemas is the model-centric approach: In this approach a model is created for a certain domain (either the entire service system or parts of the service system), which serves than as the basis for the mappings to all the other schemas. The key to model-centric data integration is the availability of a good master schema. The schema must be rich enough to express the information in the data sources being integrated, but it should not be so elaborate as to make the data integration process needlessly inefficient. There are techniques that allow managing this trade-off and creating rich and efficient master schemas.
- Uniform identifiers for service system resources: There is the problem of irreconcilable naming. Different databases may have different identifiers for the same resources. Sometimes this problem can be dealt with by using other data to relate entries to each other, a process called entity resolution. However, this is not always possible; there simply may not be enough information in the databases to decide which objects in one database correspond to which objects in the other databases. The good news here is that this problem can be mitigated or even eliminated by semantic web technologies of growing popularity, notably the use of uniform resource identifiers (URI) enabling the unique identification of resources over a network. In addition, there are techniques, such as duplicate elimination and statistical methods that enable the identification and resolution of inconsistent naming.
- Mapping with external master schemes: In case of a complete master schema for a service system there is still the challenge to align with master schemes of external service systems in order to be able to represent interrelations between service systems. Although there is no unifying theory, there are a lot of approaches for mapping master schemes (Shvaiko and Euzenat 2005): In general one divides between element-level matching techniques (string-based, language-based, based on linguistic resources, constraint-based, based on alignment reuse and based on upper level formal ontologies) and structure-level

matching techniques (graph-based, taxonomy-based, based on repository of structures and model-based). Many hybrid approaches exist.
- Trust: There is often the problem of inconsistency. It is not uncommon for different databases to have conflicting data. In the absence of a technique for knowing which database to trust, a data broker must be able to manage multiple possible values without inappropriately combining those values to produce silly results. This is often called paraconsistent reasoning. The good news is that there are good techniques of this sort. In addition, there are cases in which the correctness of data can be questioned without having inconsistencies.

Above foundations enable the development of semantic service systems, i.e. descriptions of service systems or at least parts of service systems that are understandable by machines.

# 5 Smart Service Systems

In the following, we describe the techniques used in order to generate a "smart" behavior of service systems. Based on semantic descriptions of service systems it is easy to apply techniques for querying and inferring facts about service systems by using either approaches based on logic or probability based approaches. A more complex task and the focus of this section is the generation and execution of plans for service systems. Planning allows us to construct processes and workflows from services. With sufficient semantic descriptions, as previously discussed and for the formal simple services described, we can do so automatically as needed. This has great potential, for agile supply chains for example.

## 5.1 Planning and Execution of Plans

Suppose we have a plan consisting of a sequence of services $W_1,\ldots,W_n$ that achieves goal $G$ with owner $agent_2$. As the plan is executed service call by service call, we add the input signal to our theory $T_0$: $Sent(W,S_i,agent_1,agent_2)$. However, the output signal is not in the plan.

We now define the conditions for executing service $W_1$ transforming state $S_i \rightarrow S_j$. Such an execution is a meta-action that takes place by writing to our theory at a time corresponding to state $S_i$. The first condition is not only that the preconditions of $W_j$ hold in $S_i$, but also that all of the variables in the fluent expressions that comprise the preconditions are fully instantiated in our theory prior to execution. The effects need not be fully instantiated in this state.

The second condition is that there is an actual actor corresponding to the provider $agent_1$ of the service and this actor writes $Received(W,S_j,agent_1,agent_2,$

*output)* into our theory at the time corresponding to $S_2$. Once this has been done, none of the statements in the theory in previous states can be changed.

The third condition is that the actor corresponding to $agent_1$ will attempt to unify the planned effects of $W_i$ with fully instantiated expressions. If the actor is successful in doing so, these are re-written in our theory, and the next service in the plan is eligible for execution. If not, then the plan has failed. The goal has not been achieved, though after replacing the planned expressions with the ones that the actor provides, a new plan may be developed. This will not occur if our model of the service is complete: then every plan should succeed.

We of course may at anytime add a new service to our designated list, possibly a previously planned goal $G$, but there must be then an associated actor with the capability to write output signals and effects.

### 5.1.1 Indeterminacy

We now introduce an important variation upon this formalization. Our model of services may be incomplete and services may be black boxes. In fact, this may be common condition in the real world.

For each $W{:}S_i{\rightarrow}S_j$, that may be used in the attempted proof, some of the fluent expressions in effects $E$ may not be fully instantiated until state $S_j$. Further, we now say that "output" is also an indeterminate variable. That is, given $Input(W,S_i,agent)$ for $W(S_i,S_j)$, we always know there exists "output" such that $Output(W,S_i,agent, output)$ is true, but we don't necessarily know what it is until $S_j$. Moreover, we now say that there is always a special reserved value "*Failed*" for all services that the provider of the service may write in the theory. When this is done, no effects of the service are written.

In our model of services we may know, for certain services, exactly what the output must be, or we may only know something about the domain of the output variable. It may be a finite discrete variable and we know what the set of possible values is (as in standard CSPs), or we may only know that it is, for instance, a positive integer. Various relations may exist that express the constraints of values for "output" for any given service and owner. Something similar is true for the effects. This is treated in more detail in (Shvaiko and Euzenat 2005) but we go no further here as a full treatment is out-of-scope.

## 5.2 *What Can Be Done with Service Planning?*

Planning as a technology is discussed extensively in (Petrie 2009). The important point is that in a correct plan, the goal state is logically entailed by the initial state and the sequence of actions in the plan. The most sound methods of generating a plan depend upon the use of semantics and computational logic: the plan is generated by proof.

Given a goal state, some information about the constraints governing the process based upon business logic, and the current state of the world, including databases, planning can synthesize a single-use process that achieves the goal if such a process is possible. The result is the same as if the workflow were re-generated each time in response to changed conditions, except that the problem is simpler. The resulting process is guaranteed to be correct because of entailment.

This last means that no verification of the resulting process is necessary: the process is necessarily deadlock free and will terminate. Otherwise, the plan would not be provable.

We expect that development of semantics for such planning will be slow, but inevitable. Current methods of developing workflows and processes by programming will not scale for increasingly complex service systems. Generating provably correct processes automatically is the only possible way to scale development and maintenance of complex and rapidly changing systems.

Technical questions about the scaling of computational logic are also out-of-scope for this chapter, but we can say that anyone that has experience in developing and maintaining a complex supply chain knows that the effort and time required is not supportable with only humans in the future.

## 6 Lessons from the Web Service Domain

For 3 years the Stanford Logic Group is performing a challenge, called Semantic Web Service Challenge, with the goal to develop a common understanding of various technologies intended to facilitate the automation of web service planning using semantic annotations. For more information about this challenge see also (Petrie et al. 2008). We understand Web Services as a subclass of services. As we are not interested in specific technologies here, we go no further in defining the specifics of web services except to note that many different so-called "non-functional" properties may be added to the definitions above. However, similar techniques as used in the Semantic Web Service Challenge should be applicable for services in general.

The Semantic Web Service Challenge defines problem scenarios that serve as the basis for the certification and comparison of approaches participating in the challenge. Figure 1 depicts an example scenario for the challenge.

The challenge focuses on the use of semantic annotations: Participants are provided with semantics in the form of natural language text that they can formalize and use in their technologies. One example for a semantic annotation of the order management services is shown in Fig. 2.

Different technologies are used for these annotations. Having semantic annotations, goals can be achieved automatically using a similar planning algorithm as depicted in Chap. 4.

In the challenge, we started with three Web Services simulating a client trying to purchase goods using the RosettaNet protocol and its counterpart, the Moon

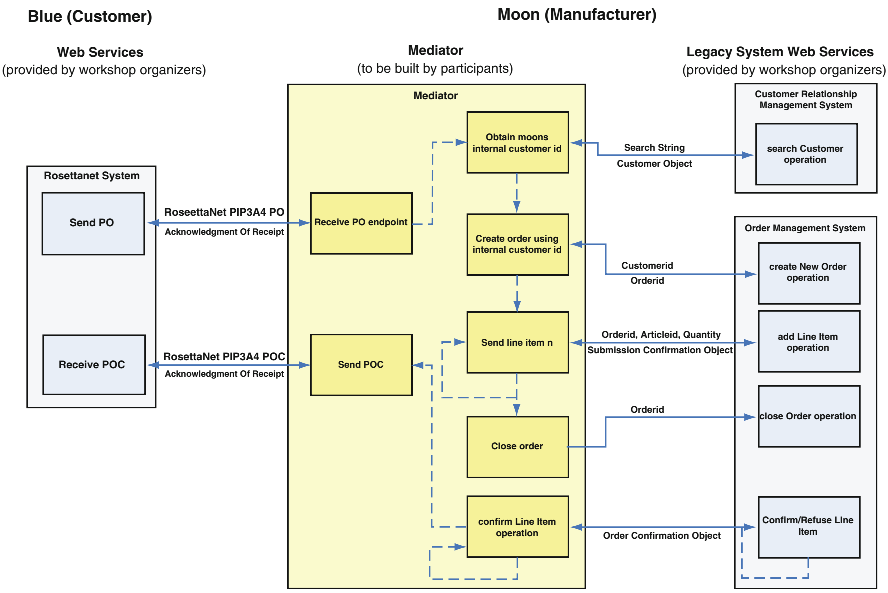



**Fig. 1** Purchase order scenario for semantic web service challenge

| *sop* | $sop_1$ | $sop_2$ | $sop_3$ |
|---|---|---|---|
| *op* | CreateNewOrder | AddLineItem | CloseOrder |
| *in* | CustomerID | LineItemEntry,Order | OrderID |
| *out* | OrderID | AddItemResult | ConfirmedOrder |
| *pre* | | orderComplete $\wedge$ orderClosed | orderComplete $\wedge$ orderClosed |
| *eff* | negative:{orderComplete, orderClosed} | positive:{orderComplete} | positive: { orderClosed } |
| *fault* | $sop_1$fault | $sop_2$fault | $sop_3$fault |

**Fig. 2** Semantic Annotation of the order management services

legacy system. Taking into account different versions of services and the mediation systems that have been implemented to test the system we are operating at present around 20 different Web Services. Over time, five different developers have been involved for different aspects of the execution platform. All services have now been migrated to the axis2 engine for Web Services.

The complexity of the messages used has revealed several bugs in the implementation of the axis2 engine, which caused major resource expense just on the underlying technologies and not purely on "business" problem. However, we consider it a benefit of the challenge that we are able to expose the deficiencies of the current state-of-the-art middleware tools, and work with the developers to fix them.

In fact it turns out that a variety of skills is required to master such a testbed. First, in-depth knowledge of WSDL and XML schemas is required to design proper service description utilizing the maximum of the descriptive power of the standards. Most obviously some knowledge on a web service engine (such as axis2) and the underlying application server (such as tomcat) is required as well as a fair amount of database design and web application programming skills. It also turned out to be necessary to understand a good deal about the Internet Protocol and firewalls in order to help participants to manage their invocations. And, last but not least, such an infrastructure requires some monitoring facilities that guarantee a 24/7 live system, which is not the usual approach in a university research environment, such as the one that supports the testbed now. All this is necessary in an industrial setting.

Effectively it demonstrated that in spite of the fact that Web Services are an established technology, current tools are only able to hide a small degree of the underlying complexity. As soon as we reached some case on the boundary conditions, understanding of underlying protocols and standards was essential and many problems occurred, especially with propagation of errors through layers of middleware.

None of this lessens the potential of semantic services, but it does say that the current specifications for web services are perhaps overly complex, the tools not quite mature, and that the issue of adding semantic annotations to this industrial standard is overwhelmed, right now, by the usual programming effort. This may, in fact, be a good insight into why SOA has not become more popular.

Of course in these challenges only simple scenarios are studied. However, in future research the focus lies on more complex scenarios and also the involvement of non web services.

## 7 Conclusion

In this chapter a formal definition of the term service is given and it is shown how semantic annotations enable the automation of planning for service systems. There are first examples that demonstrate the application of suggested techniques within the web service domain. This domain is characterized by the existence of formal definitions for atomic services. However, even these definitions are mostly not semantic and usually preconditions and effects of web services are not considered. The main challenge will be the installation of incentive systems in order to generate semantic annotations for services and service systems.

The approach suggested in this chapter can serve as a guideline for developing smart service systems based on the notion of semantic descriptions as well as planning techniques for automatically executing services. Still many open research issues need to be addressed. The prototype presented in this chapter focuses on a small, well defined challenge and covers only a fraction of the complexity that exists in real environments. Mechanisms for scaling the suggested approach need to be further explored, for example.

However, it is shown how theories from situational calculus can be applied to the field of service science and service scientists as well as practitioners can use the suggested framework in order to describe and incrementally improve existing service systems. In addition, the suggested approach can be extended with more detailed representation of either generic or specific service system concepts.

## References

Apte, U., and Nath, H. (2007). Size, Structure and Growth of the U.S. Information Economy. *Managing in the Information Economy*, 1–28.

Brogi, A., Canal, C., Pimentel, E., and Vallecillo, A. (2004). Formalizing Web Service Choreographies. *Electronic Notes in Theoretical Computer Science*, 105, 73–94.

Decker, G., Puhlmann, F., and Weske, M. (2006). Formalizing Service Interactions. *Proceedings of Business Process Management*, 4102, 414–419.

Duschka, O., Genesereth, M., and Levy, A. (2000). Recursive Query Plans for Data Integration. *Journal of Logic Programming*, 43(1), 49–73.

Finzi, A., Pirri, F., and Reiter, R. (2000). Open World Planning in the Situation Calculus. *Proceedings of the Seventeenth National Conference on Artificial Intelligence and Twelfth Conference on Innovative Applications of Artificial Intelligence*, 754–760.

Gorrieri, R., Guidi, C., and Lucchi, R. (2005). Reasoning About Interaction Patterns in Choreography. *Formal Techniques for Computer Systems and Business Processes*, 3670, 333–348.

Jones, S. (2005). Toward an Acceptable Definition of Service. *IEEE Software*, 22(3), 87–93.

Kotler, P. (1999). *Marketing Management: Analysis, Planning, Implementation, and Control*. Australia: Prentice Hall College Div.

Kratochvíl, M., and Carson, C. (2005). *Growing Modular: Mass Customization of Complex Products, Services and Software*. Berlin: Springer.

Levitt, T. (1976). Industrialization of Service. *Harvard Business Review*, 5, 1976.

Lusch, R., and Vargo, S. (2006). *The Service-Dominant Logic of Marketing*. Armonk, NY: M.E. Sharpe.

Petrie, C. (2008). Collective Work. *IEEE Internet Computing*, 12(2), 94–96.

Petrie, C. (2009). Planning Process Instances with Web Services. *Proceedings of the 11th International Conference on Enterprise Information Systems*.

Petrie, C., and Bussler, C. (2008). The Myth of Open Web Services: The Rise of the Service Parks. *IEEE Internet Computing,* 12(3), 95–96.

Petrie, C., Margaria, T., Lausen, H., and Zaremba, M. (2008). *Semantic Web Services Challenge: Results from the First Year*. Berlin: Springer.

Sheth, A., Verma, K., and Gomadam, K. (2006). Semantics to Energize the Full Services Spectrum. *Communications of the A*CM, 49(7), 55–61.

Shvaiko, P., and Euzenat, J. (2005). A Survey of Schema-Based Matching Approaches. *Journal on Data Semantics*, 4, 146–171.

Spohrer, J., Maglio, P., Bailey, J., and Gruhl, D. (2007). Steps Toward a Science of Service Systems. *Computer*, 40(1), 71–77.

Spohrer, J., Vargo, S, Caswell, N., and Maglio, P. (2008). The Service System Is the Basic Abstraction of Service Science. *Proceedings of the 41st Annual Hawaii International Conference on System Sciences*, 104.

Womack, J., and Jones, D. (2005). Lean Consumption. *Harvard Business Review*, 3, 58–68.

# Designing Auctions for Coordination in Service Networks

**Clemens van Dinther, Benjamin Blau, Tobias Conte, and Christof Weinhardt**

**Abstract** The evolving service ecologies show new ways of value co-creation through combinations of multiple service components which are described in service offerings. An open issue in such a large service ecology is how to efficiently coordinate and price service offerings. Service offerings provide different functionality and quality. Customers need to distinguish their preferences on different combinations of service attributes. In this chapter we address this issue of service offerings allocation and introduce a structure design approach, Market Engineering, as an appropriate method to design such mechanism. In order to apply this approach to service systems we introduce a formal model and a definition of service value networks. Examples exemplify our approach and we show one possible step towards implementing such a mechanism.

**Keywords** Market engineering · Path auction · Web service coordination · Service value networks · Mechanism design

## 1 Introduction

The way how the electronic service industry contributes to value generation has changed in recent years. Flexible service components are developed instead of large monolithic software applications on a licensed-based business model. Service components are described in service offerings and provide certain functionality, e.g. a specific part of a service process. Such service components enable business on a pay-per-use basis. Additionally, they can be easily adapted and extended

C. van Dinther (✉)
Institute of Information Management and Systems, Karlsruhe Institute of Technology, Karlsruhe, Germany
and
FZI Forschungszentrum Informatik, Karlsruhe, Germany
e-mail: Clemens.vanDinther@kit.edu

H. Demirkan et al. (eds.), *The Science of Service Systems*,
Service Science: Research and Innovations in the Service Economy,
DOI 10.1007/978-1-4419-8270-4_7, 

by additional services or a combination of service components can build up *complex* services.

This conceptual and technical change offers customers the opportunity to purchase service offerings on-demand. Thereby, they are not limited to purchase offerings from a single provider. A complex service can rather be composed from the offerings of different providers tightly focused on required features. Such modularity is one of the most promising answers to the question of how to face rising demands for sophisticated, customized products (Baldwin and Clark 2000). Once serving the whole value chain by what has become famous as vertical integration, service providers now tend to engage in networked value creation in ecology-like environments which Blau et al. (2009) call service value networks (SVNs). This development enforces the economic trend to a horizontal specialization in service offerings which in turn calls for new cooperation forms in loosely-coupled configurations of legally independent firms. Thus, horizontal specialization can lower their risk of operating in a changing and uncertain environment.

This is why companies tend to engage in networked value creation which allows participants to focus on their strengths. Partners in such ecologies can leverage the know-how and capital assets of partners, at the same time spreading risk, sharing investment cost, and retain flexibility. In that way, the network has the ability to "rapidly pick, plug, and play" business processes (van Heck and Vervest 2007). By re-aggregating with partners, a company can broaden its range of customer attractions. Especially in complex and highly dynamic industries, forming agile SVNs, is more than an attractive strategic alternative.

From a customer's point of view it is a challenge to find the best combination of service components in such a SVN and to determine prices for it. If it is clear which offerings technically can be combined in order to form a complex service, the following questions remain: Which providers should I choose? What price should be paid for the complex service in total? Which price are the providers of the single components paid? Thereby, heterogeneity of service offerings and service requests is one problem in price determination. Another problem is preference elicitation which is crucial in the service sector where valuations for different kinds of service offerings are hardly determinable directly. Thus, we are interested in building mechanism for this pricing and allocation task.

Auction theory[1] has shown good results in eliciting preferences and efficiently allocating goods. But, auction design is a challenging task. The outcome of an auction does not only depend on the institutional rules of an auction but also on the specific characteristics of the resource to allocate, and on the behavior of the participants. Thus, auction theory which is an applied branch of game theory studies auctions from a theoretical perspective regarding the efficiency of resource allocation, the bidding strategies, and the revenues. Economists often assume bidders to be fully rational. This is a rather strong assumption which does not hold in reality.

[1] Further literature on auction theory, see for example Klemperer (2004), Krishna (2002), Milgrom and Weber (1982), Wolfstetter (1999)

Thus, auctions can show outcomes which were not expected theoretically since human decision making is influenced by various factors. Participants might have incomplete information, different risk attitude or a different reaction to uncertainty. Additionally, psychological or emotional effects can play an important role.

Therefore, it is not sufficient to design new auction mechanisms (for the allocation of offerings) and study them only from a theoretical perspective. It is also necessary to incorporate behavioral aspects. Laboratory or field experiments as well as simulations are possible approaches. Thus, we suggest a structured approach to the design of coordination mechanisms which can be used in designing service value networks. Such an approach was introduced by Weinhardt et al. (2003) and called *Market Engineering*.

The evolving service ecology with a business service choreography (Demirkan et al. 2008) calls for appropriate mechanism which allocate service offerings. This chapter provides both, an introduction to auction theory and mechanism design as well an application to the field of service systems.

Thus, the contribution of the chapter is twofold. First we introduce Market Engineering (ME) as a design approach for mechanism. Second, we apply Market Engineering exemplarily on SVNs. Therefore, we introduce our understanding of SVNs by conducting an environmental analysis in Sect. 3. We develop a path-based auction mechanism and show a possible implementation in a web-service coordination. The chapter closes with a conclusion.

## 2 Market Engineering

Searching an appropriate structure for an economic system is not a new question for economists. But the optimal design of such a system is often unknown. Hurwicz (1973) argues on the question in what respect the structure of an economic system is unknown:

> "Typically that of finding a system that would be, in a sense to be specified, superior to the existing one. The idea of searching for a better system is at least as ancient as Plato's Republic, but it is only recently that tools have become available for a systematic, analytical approach to such search procedures."

The interest in studying electronic markets has increased in the last few years. It can be observed that the market outcome not only depends on the market participants and their valuations, but also on the market structure which stimulates strategic behavior of the participants.

It has been more and more called for scientific support in designing and developing (electronic) markets (Roth 2002; Varian 2002). One approach for the design of markets has been introduced by (Weinhardt et al. 2003) as *Market Engineering* (ME). (Holtmann 2004) remarks that it were McCabe et al. (1993) who used the term Market Engineering for the first time, but since then the term was only used a few times. Therefore, Weinhardt (2003) picked up this term and provided a comprehensive definition of ME as a service oriented design approach to the development of electronic markets. An electronic market can be perceived as a service which enables electronic trading and which is provided by either a non-profit organization or profit oriented company. Holtmann (2004) and Neumann (2004) describe the idea of ME comprehensively.

## *2.1 Markets and Auctions*

There are many views on the term *market* in economic literature. It can be generally stated that a market coordinates exchange, interactions that are mutually beneficial and hence, co-create value for the entities involved. For example, markets can be used to coordinate the exchange of service for service, or the exchange of resources, such as goods, information, (property) rights and/or money. It provides a mechanism to match demand and supply (resource allocation) and determines a market (or clearing) price. This mechanism can be either defined explicitly as e.g. in an English auction, or it can evolve during a negotiation process. Markets are understood as one form of coordination in economic interaction. In contrast to coordination by markets, Coase (1937) discusses hierarchical coordination as it is known from the organization of firms where the coordination of tasks and resources takes place through delegation and control. In their purest form, neither hierarchies, nor markets involve cooperation throughout the coordination process, although in reality mixed forms occur.[2] These two main forms of economic coordination span a continuum where many mixed forms for cooperation lay in between.

From an economic perspective, the study of markets is coined by the question, to which extent markets contribute (and can be optimized) to economic coordination. Smith (1982) developed the *Microeconomic System Framework* that clearly defines the core concepts of a market system. Foregoing work on that issue was accomplished by Hurwicz (1960, 1969, 1973) and Reiter (1977). Smith understands markets as economic systems that, basically spoken, consist of three main components, (i) *economic agents* acting in the market, (ii) *commodities* being exchanged (at least one), and (iii) a *set of rules* defining the *market institution*.

An *auction* is a specific type of market. Auctions are known as one of the oldest forms of trading used already at 500 B.C. in Babylon (c.p. Cassady 1967). Nowadays, auctions are mainly used for three reasons: (i) speed of sale, (ii) information revelation of buyers' valuation, and (iii) prevention of dishonest dealing between the sellers and buyers (Wolfstetter 1999). In auctions economic agents compete against

[2] Strategic alliances are a well established cooperation in e.g. the airlines industry. Airlines cooperate on selected routes but remain competitors on the other flight routes. The need for cooperation increases also in the service sector since companies offer more and more specialized services.

each other on settling a trade by submitting bids representing their willingness to pay. Bertsekas (2001) states that auctions are an "intuitive method for solving the classical assignment problem." The auction rules determine the way of bidding (e.g. amount of bids, increments, start, end), the winner (and thus, the allocation of the good), and the price to pay. McAfee and McMillan (1987) define auctions as follows:

> "An auction is a market institution with an explicit set of rules determining resource allocation and prices on the basis of bids from the market participants."

Bids can be specified in several ways, e.g. by raising the hand when an auctioneer calls a certain price, or explicitly in written form. Wolfstetter (1999) points to the information problem in economic trade, where an individual has incomplete information about the competitors' valuations. This is one of the main issues in auction theory and leads to the question of how to design auctions in order to reveal this information. There is no general answer to this question, since it depends on several factors. Therefore, auction need to be analyzed in the given context.

There are various auction formats depending e.g. on whether one single unit or multiple units are to be traded and whether there are single or multiple sellers or buyers. Auctions with just one seller and multiple buyers (or vice versa) are called single sided auctions. Double sided auctions have multiple buyers and sellers. Klemperer (2004) names four standard single sided auction types: (i) ascending (e.g. English auction), (ii) descending (e.g. Dutch auction), (iii) first price sealed-bid, and (iv) second price sealed-bid (e.g. Vickrey auction). Wurman et al. (2001) propose a classification of five classic auctions by differentiating the attributes (i) single vs. double sided, (ii) open (cry) vs. sealed, and (iii) ascending vs. descending. This classification is also depicted in Fig. 1.

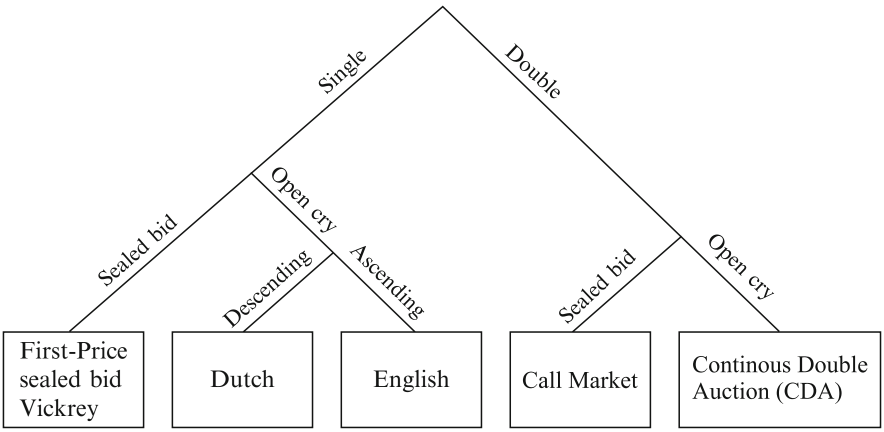



**Fig. 1** A classification of classic auction types (Source: Wurman 2000)

## 2.2 Structured Design Approach

The terms *market design* and *mechanism design* are often used in economic literature to describe the conceptual development of market rules as defined by Smith (1982) comprising the information exchange rules (the language), adjustment process rules, allocation rules, and cost imputation rules. For electronic markets such mechanisms have to be implemented and operated on an Information Technology (IT) infrastructure. The operator of an electronic market can be understood as a service provider for economic trades. This service concept includes also some kind of fee in order to cover at least the costs for service providing. These additional requirements for designing electronic markets are picked up by the ME methodology and lead to the following definition, which summarizes the work of Neumann (2004).

> Market Engineering subsumes the systematic approach to development, analysis and design of electronic market service integrating theory from the scientific areas of economics, business administration, computer science and law. ME focuses on the three core activities (1) design, (2) operation, and (3) research of electronic markets.

In order to appropriately design electronic markets, it is essential to base the design on research results of electronic markets and to study new mechanisms comprehensively. There is also a need for successful business models and powerful technologies. The ME process includes these different aspects according to the service engineering process and engineering design approaches and is described in the following. Figure 2 depicts this approach.

The ME process consists of the four stages (1) Task Clarification, (2) Design and Implementation, (3) Testing, and (4) Introduction. These stages are subdivided into several phases.

1. *Task Clarification*
   At the very beginning of the ME process, it is important to conduct an environmental analysis and to elaborate the market service requirements.

   - Environmental analysis
     The environmental analysis starts with (i) the market definition, including the determination of the trading objects, potential customers and their endowment, preferences of customers and other constraints. Once the market is defined (ii) a market segmentation (regarding e.g. customer or product groups) is examined. Finally, (iii) a market target is determined, meaning that it has to be decided which of the market segments to focus on for trading.

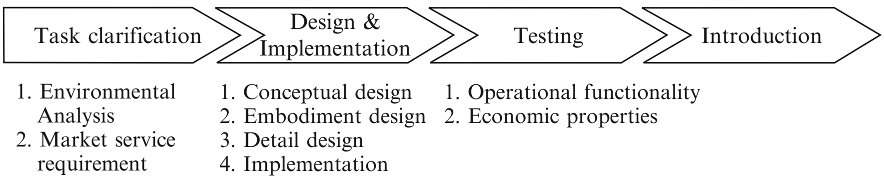



**Fig. 2** The market engineering process

- Market service requirements
  The environmental analysis serves as starting point to identify basic requirements of the electronic market. It comprises the socio-economic environmental aspects such as the (potential) number of agents, their preferences (private or common values), and resources. Additional service offerings to meet customers' expectations are elaborated and also legal aspects are analyzed. Important requirements regarding the business process (e.g. cost coverage), incentives for participation, or computational requirements are defined.

2. *Design and Implementation*
   The second stage is structured into four phases:

   - Conceptual design
     At the beginning the market system is defined with abstract descriptions regarding the market rules, the infrastructural requirements and the business rules as identified in Stage 1.
   - Embodiment design
     The abstract descriptions of the conceptual design phase are redefined into semi-formal description of the institutions such as trading protocols. Often there are diverse trading protocols (or descriptions) for one and the same trading mechanism. The descriptions of the embodiment design phase abstract from implementation details.
   - Detail design
     Detail design starts with building the layout of the system, which is subsequently refined and which finally results in a complete and detailed system model, e.g. based on UML. This model also considers implementation details.
   - Implementation
     The predefined and developed software model is implemented using a standard software development process.

3. *Testing*
   The developed system is tested regarding its operational functionality and its economic properties.

   - Operational functionality
     It is important to assure that the implemented system works correct. Therefore, it has to be checked if the code maps to the specified requirements (verification). Common techniques such as unit testing can be applied. Additionally, it is necessary to verify if the requirements themselves are correct or if additional requirements exist (validation).
   - Economic Properties
     Electronic markets can be analyzed with respect to their economic performance either on an analytical basis, using experimental techniques or based on simulation. Theoretic analysis is not suitable for all markets and market environments. Especially the behaviour of human economic agents is not always obvious and hard to model. Therefore, game theoretic experiments

can help to gain new insights. It is also possible to apply simulations for testing and evaluating electronic markets.

4. *Introduction*
   After comprehensive tests, the developed market service can be launched and operated. Market Engineering recommends permanently observing and reassessing the market. The gathered feedback helps to improve market service and facilitates the redesign of markets.

As pointed out auctions are one way of selecting and allocating goods or service. In order to find a good combination of service offerings it is necessary to design an auction mechanism with specific properties. Krishna (2002) is a very good reference for introduction to auction theory. He outlines different properties of mechanisms and describes efficient mechanisms. In the next section we construct an efficient mechanism for find efficient combinations of service offerings in service value network.

Having learned about auction design we now apply the concept of Market Engineering to service value networks in the next two chapters.

## 3 Environmental Analysis: Service Value Networks

Ever since the seminal work of Williamson (1985) at least three types of business governance structures have been identified: market, hierarchy, and hybrid forms. In pure markets all information is publicly and instantaneously observable via the price mechanism, which in turn provides a perfect incentive mechanism to align individual profit with economic efficiency. However, by this it is assumed that an effective price mechanism exists in the first place. This is a presumption which is generally not warranted for non-standard goods and service that involve a high factor of specificity (sunk costs), customization, low frequency of trade, or high uncertainty in demand or supply.

In a purely hierarchical organization, on the contrary, value is created strictly within the boundaries of the integrated firm. Here, by definition, opportunistic behavior of business partners is not feasible, and thus neither the revelation of knowledge nor the incompleteness of contracts poses impossibility constraints. However, such formal control usually comes at the price of inefficiency and inflexibility, which are both crucial in an increasingly competitive economy. Hybrid governance forms such as networks combine the advantages of market governance, in particular adaptability and incentive compatibility with those of hierarchies, foremost control.

Consequently, *business networks* have been proposed as the superior governance form for today's highly dynamic and complex business world (Miles and Snow 1986). Business networks evolve from a pool of potential horizontal as well as vertical business partnerships. In this respect they differ both from strategic alliances, comprising only horizontal business partners, and supply chains, denoting purely vertical relationships.

Likewise *service value networks* constitute a special type of business network, which, although frequently used, lack a generally accepted definition.

## *3.1 Definition and Characteristics*

**Definition 3.1: Service Value Networks**

Service value networks are business networks, which provide business value through the agile and market-based composition of complex service offerings from a steady, but open pool of complementary as well as substitutive standardized service modules by the use of ubiquitously accessible information technology.

In the following, we will discuss each part of the definition in detail and thereby highlight the boundaries of service value networks.

*Complex service*. By a *complex service* we understand the composition of services components. In more detail, complex or composite service offerings typically involve the assembly and invocation of several service components offered by diverse enterprises in order to complete a multi-step business functionality (Papazoglou 2008) In turn, service *component* are either other complex service offerings or functionality that is provided via a Web service. The term *utility service* originates from the energy domain, denoting core service offerings such as the provisioning of gas or electricity. Adapted to the area of e-service, the term denotes infrastructure service offerings that provide enabling technologies for ecologies such as storage capabilities and the provisioning of computing power (cp. Sect. 3.3).

*Standardized service modules.* In order to be plug-and-playable, the utility service must provide standardized interfaces for interchanging machine-readable parameter values.

*Steady but open pool of complementary and substitutive service offerings.* Service offerings must register (or be registered) with the service value network in order to be eligible for composition. This set of registered service offerings forms the steady pool from which a complex service is composed. However, the registration is open for any service which meets certain minimum requirements, such as modularity provided through a detailed interface specification. Moreover, it is also feasible that the service value network itself will actively browse the service landscape for eligible service offerings and register them automatically. In particular, in this context *steady* means that the SVN maintains a list of service offerings (including their interface descriptions) also if there is no current service composition request in the network. *Open* however, refers to the fact that no service can be excluded from the network, as long as it meets the publicly known minimum requirements.

*Automatically on-demand service composition. Agile* service composition refers to the network's ability to orchestrate a complex service ad-hoc and demand driven. On the time of the request, the SVN will search automatically for an optimal path through its network of registered service offerings. Hereby, optimality is evaluated e.g. in terms of efficiency, i.e. the allocated complex service should maximize the sum of costumer and provider welfare. This can only be achieved through an appropriate mechanism, e.g. by means of a reverse auction.

*Universally accessible information technology.* Finally, the SVN must be run on and by universally accessible information technology, such as the Internet. This requirement comes as a direct consequence from the openness of the service pool and the call for efficiency. If any service meeting the requirements of the SVN shall be allowed and encouraged to register with the SVN, the SVN itself cannot rely on proprietary and protected information technology.

## 3.2 Formal Network Model

A service value network is described by means of a simplified state chart model (Harel and Naamad 1996) and is aligned with the representation provided by Zeng et al. (2003). State charts have proven to be the preferred choice for specifying process models as they expose well-defined semantics and they provide flow constructs offered by prominent process modeling languages (e.g. WS-BPEL) and therefore allow for simple serialization in standardized formalisms.

Hence, a service value network is represented by a $k$-partite, directed and acyclic graph$G = (V, E)$. Each partition $y_1, \ldots, y_K$ of the graph represents a *candidate pool* that entails service offers that provide the same (business) functionality. The set of $N$nodes $V = \{v_1, \ldots, v_N\}$ represents the set of service offers[3] with $v_i$,$v_j$ being arbitrary service offers. Service offerings are provided by a set of *Qservice providers* $S = \{s_1, \ldots, s_Q\}$ with $s$ is an arbitrary service provider. The *ownership information* $\sigma : S \rightarrow \mathcal{P}(V)$that reveals which service provider owns which offering within the network is public knowledge.[4] There are two designated nodes $v_s$ and $v_f$ that stand for source and sink in the network. The set of edges $E = \{e_{ij} | i, j \in V\}$ denotes technically feasible service composition such that $e_{ij}$ represents an interoperable connection of service $i \in V$ with service $j \in V$.[5] If two offerings are not interoperable at all, they are not connected within the network.

A *service configuration* $A_j$ of service $j \in V$ is fully characterized by a vector of attributes $A_j = (a_j^1, \ldots, a_j^L)$ where $a_j^l$ is an attribute value of attribute type $l \in \mathcal{L}$

[3] The terms *service offer*, *servic*e and *node* are used interchangeably

[4] The reverse ownership information $\sigma^{-1} : V \rightarrow S$ maps service offers to single service providers that own that particular service

[5] For the reader's convenience the notion $e_{ij}$ is equivalent to $e_{v_i v_j}$ representing an interoperable connection of service $i \in V$ with service $j \in V$.

of service $j$'s configuration. Attribute types can be either functional attribute types or non-functional attribute types (e.g. availability or privacy). A service's configuration represents the quality level provided and differentiates its offering from others. According to Lamparter (2007), a service configuration can be defined as follows:

**Definition 3.2: Service Value Networks**

A service configuration $A_j$ of a service $j \in V$ selects a value $a_j^l$ for each attribute type $l \in \mathcal{L}$ of a service and thereby unambiguously defines all relevant service characteristics. The choice of configuration might affect the functional and non-functional aspects of a service and is a major determinant of the price.

Furthermore let $c_{ij}$ denote *internal variable costs* that the service provider that owns service $j$ has to bear for that service being interoperable with service $i$ and for the execution of service $j$ as a successor of service $i$. The representation of a detailed cost structure of service providers is intentionally omitted which serves a better understanding and does not restrict the generalization of the model. It is assumed that the representation of internal variable costs reflects the service providers' valuations for their service offers being executed in different composition-related contexts.

The instantiation of a complex service is represented by a path from source to sink within the service value network. Let $F$ denote the set of all feasible paths from source to sink. Every $f \in F$ with $f \subset E$ represents a possible instantiation of the complex service. Focusing on the presence or absence of a particular service $i \in V$, $F_{-i}$ represents the set of all feasible paths from source to sink in the reduced graph $G_{-i}$ without node $i$ and without all its incoming and outgoing edges. In contrary, let $F_i$ be the subset of all feasible paths from source to sink that explicitly entail node $i$.

**Definition 3.3: Service Value Network Model**

A service value network model is an acyclic, $k$-partite and directed graph such that

$$G = (V, E)$$

with the set of nodes $V$ representing service offers and the set of edges $E$ that denotes technically feasible service compositions. $G$ contains two designated nodes $v_s$ and $v_f$ representing source and sink such that every feasible path $f \in F$ connecting both nodes is a possible instantiation of the complex service.

For illustration purpose, Fig. 3 shows the model of a service value network with service offers $V = \{v_1, \ldots, v_4\}$ and service provider $S = \{s_1, \ldots, s_3\}$. Every feasible path $f \in F$ connecting source node $v_s$ and sink node $v_f$ represents a possible realization of the overall complex service.

## *3.3 Examples*

Based on the characteristics presented in Sect. 3.1, we provide two extended examples how service value networks can be arranged and organized in real-world applications.

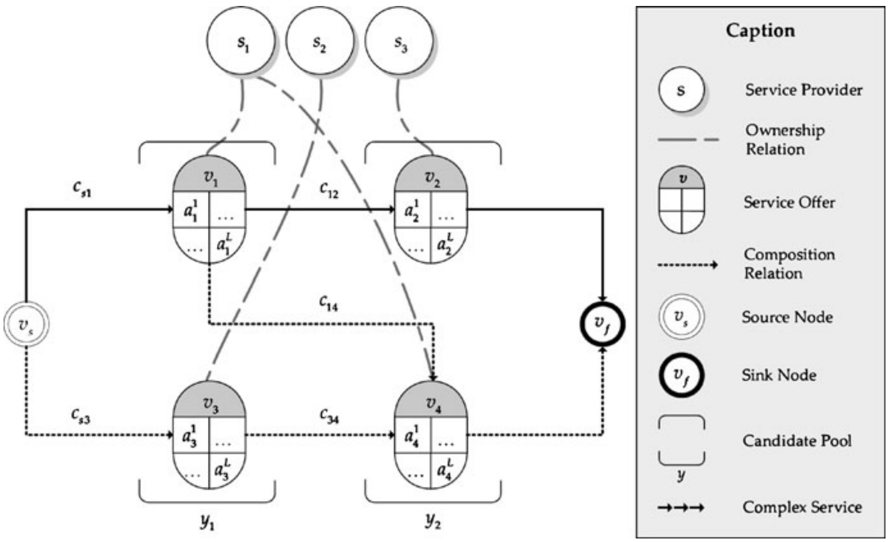



**Fig. 3** Service value network Model

***Example 3.1: Payment Processing*** Consider a manager of a mid-size company that distributes flowers over the Internet. As payment processing is not a core competency of the company, the board decides on the integration of third-party service providers into existing business processes in order to decrease costs of operation and maintenance. The diagram in Fig. 4 sketches an excerpt of the service components of an exemplary complex service that provides payment processing functionality.

The PaymentProcessingService facilitates service components from StrikeIron,[6] Duo Share[7] and CDYNE[8] to verify the customer's address and credit card information. Customer data is stored and managed using a StorageService and a DataBaseService from third-parties. Exemplary service offerings from decentralized storage providers are Amazon S3,[9] Digital Bucket[10] and Box.net.[11] Service offerings for organizing and managing customer data are Amazon Simple DB[12] and Long Jump DaaS.[13] The actual execution of the financial transaction through the

[6] http://strikeiron.com/
[7] http://duoshare.com/
[8] http://cdyne.com/
[9] http://aws.amazon.com/s3/
[10] http://digitalbucket.net/
[11] http://box.net/
[12] http://aws.amazon.com/simpledb/
[13] http://longjump.com/daas/

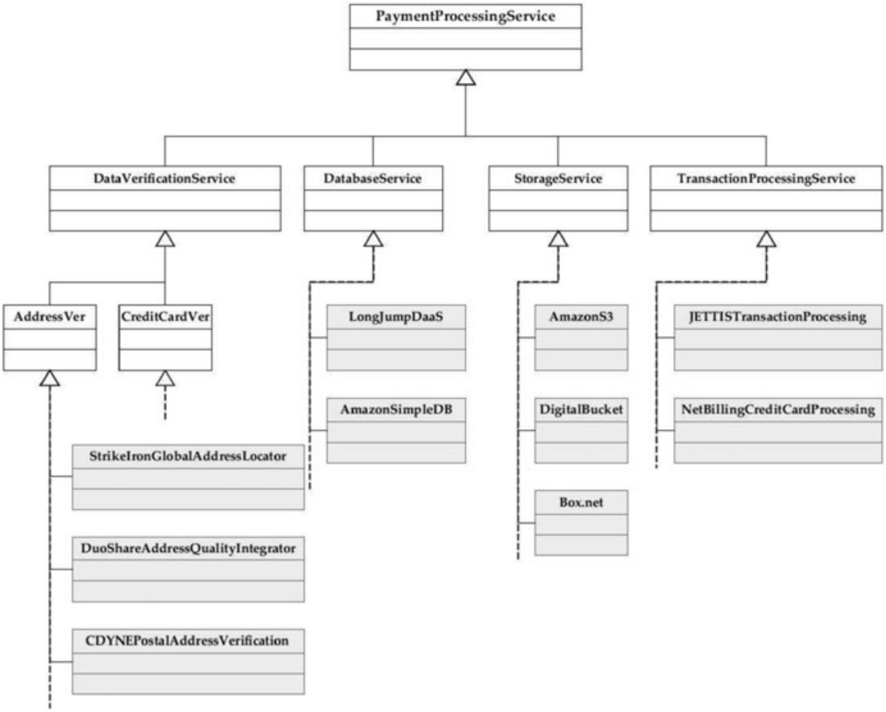



**Fig. 4** Payment processing service (static view)

TransactionProcessingService is provided by JETTIS Transaction Processing[14] and Net Billing Credit Card Processing.[15]

The process behavior of the payment processing complex service is depicted in Fig. 5. Customer data is validated in the first step. After validation the actual transaction takes place and the customer's credit card account is charged by a transaction processing service. The change in state must be updated consequently in the internal database of the company. A database service updates corresponding customer data that is stored using a decentralized storage service. For each step of the complex service there is a potential pool of suitable candidates to fulfill required business transaction. The result of each transaction is passed sequentially to the successor service. In order to successfully instantiate the complex service the overall transaction requires a service candidate from each pool.

***Example 3.2: Realizing a Complex Service: Customer Relationship Management (CRM)*** This example shows the formation of a service value network that is ready to instantiate a complex service based on the requirements imposed by service

[14] http://www.jettis.com/

[15] http://www.netbilling.com/

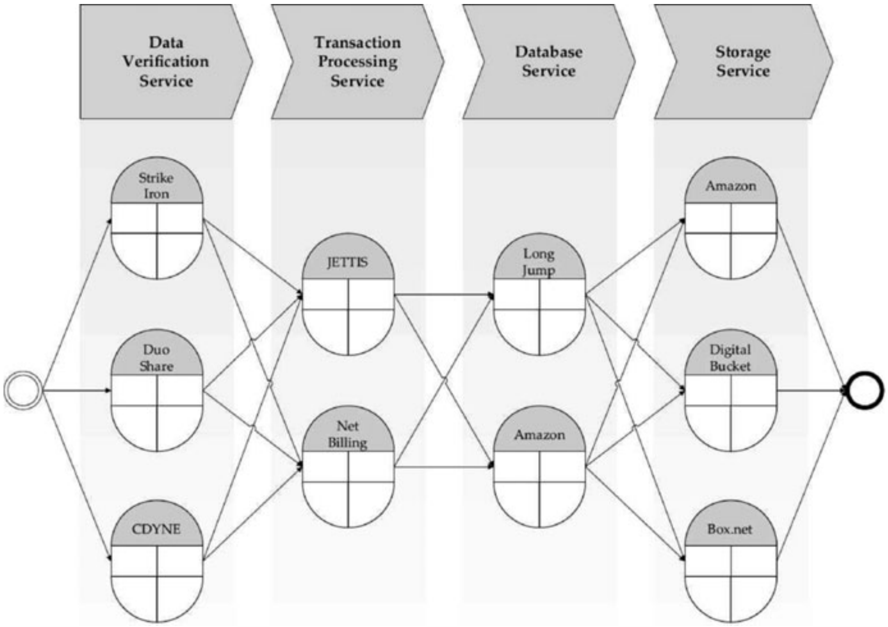



**Fig. 5** Payment processing service (dynamic view)

request. A service requester requires a complex service that scans calendar entries within the upcoming week with regard to future meetings within a company. Based on the meetings' description, the complex service queries soft skills of all meeting participants by browsing their profiles in social communities. Gathered information is then updated in a CRM data base that is stored by on-demand storage infrastructure (Fig. 6).

A set of service providers participates in the SVN by providing service offering grouped in candidate pools. Google offers its Google Calendar service[16] and Google App Engine[17] which provides a scalable infrastructure for service development and storage. The social community platforms Facebook and LinkedIn[18] provide service to browser profiles of registered customers. Amazon offers flexible storage capabilities through its Simple Storage Service (S3). As depicted in Fig. 6 the requested complex service can be realized in four different versions by selecting feasible service combinations (e.g. Google Calendar, LinkedIn Browser and Amazon S3).

[16] http://google.com/calendar/

[17] http://code.google.com/appengine/

[18] http://linkedin.com/

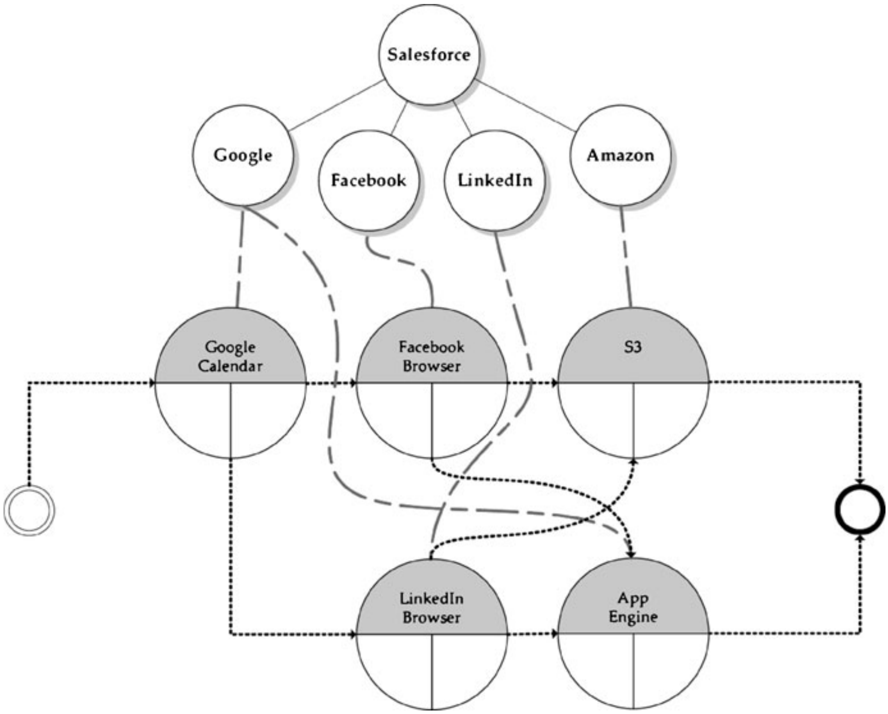



**Fig. 6** Example of a service value network realizing a complex CRM service

As described earlier the challenge in SVN is to determine the best combination of service offers regarding a customer's preferences and the price of this combination. Auctions are one concept for solving the allocation problem. The subsequent step in Market Engineering is to develop an appropriate auction design for the described allocation problem. We introduce such a mechanism in the next section.

## 4 Design and implementation: Coordination Through Auctions in Service Value Networks

As introduced in Sect. 3, service value networks are ad-hoc formations of distributed service providers that offer modularized service components with the intention to realize a complex service to customers. Distributed scenarios with self-interested participants require a form of coordination in order to govern value creation. This section at hand discusses the need for auctions as a special form of coordination to manage the dependencies of distributed activities in service value networks.

## 4.1 Why Auctioning a Complex Service?

An adequate approach for allocation and pricing of complex service offerings has to account for special service characteristics in contrary to goods and products. In general, a service is not storable, production and consumption coincide in time and customers co-produce the final outcome which is fuzzy and hard to measure in terms of value for the customer. As stated by (Smith 1989) "*auctions flourish in situations in which the convential ways of establishing price and ownership are inadequate*". Smith concretizes the argumentation by briefly pointing out the main characteristics of such situations which are predestinated for the application of auctions by focusing on the roles and items involved: "*costs cannot be established*, [...], there is something *special* or *unusual* about the item, *ownership is in question*, *different persons assert special claims*, [...]."

Although this statement is rather fuzzy, the characterization of the type of "item" which price is best established by the application of an auction mechanism opens up an analogy to the service concept. Recall, a service is characterized by the coincidence of production and consumption (uno-actu), it cannot be inventoried, value creation is dominated by intangible elements, customer co-production and fuzzy inputs and outputs.

Smith points out that auctions are preferable in situation where costs cannot be established. From a microeconomic perspective such costs refer to internal costs that are *private information* to the one producing the item, i.e. the producer's individual valuation for the item. In the context of service, this argument also holds for the customer side. Based on the argumentation that value creation through service is mainly dominated by intangible elements, the value of the final outcome for the customer is hard to determine. An objective measurement of quality which might be an indicator for the customer's valuation is also hardly applicable due to a service's fuzzy inputs and outputs. The *complexity of value elicitation* and the problem of establishing adequate prices even increases in scenarios with joint value creation through service compositions (e.g. in service value networks where a complex service is produced). Analogue to Smith's argumentation, such problems can be addressed by the design of a suitable auction mechanism that induces incentives for service providers to report their private valuations truthfully. Auctions haven proven to be the ideal instrument to *aggregate information* from distributed parties which results in an aggregated valuation (Jackson 2003; Pesendorfer and Swinkels 2000). Without prior knowledge about the valuations of each participant, auctions can provide suitable incentives to make truth revelation an equilibrium strategy and therefore automatically *aggregate necessary information* from self-interested participants to determine adequate prices for a complex service.

Another criterion that is crucial to establishing a suitable approach for allocation and pricing according to (Smith 1989) is if the item subject to trade exposes special or unusual characteristics. The uno-actu implies that in the context of service value creation there cannot be a provider without a customer as *production and consumption coincides in time*. This service characteristic has fundamental implications on coordination aspects as service cannot be inventoried in order to balance demand and supply. Following the same direction, Lucking-Reiley (2000) enriches this argumentation by adding an economic perspective which explicitly focuses on the trade of service offerings by stating that "[...] in the future we may see much more auctioning of services [...]. Services are particularly attractive for auctions because they are in *relatively fixed supply* – unlike durable goods, *one cannot store surpluses or draw down inventory* in order to meet fluctuating demand." (Lucking-Reiley 2000, pp 233). Market mechanisms such as auctions are preferable in situations with a *fast changing demand and supply ratio* as dynamic pricing smoothes high amplitudes. This property is crucial to success of *efficient allocation* and pricing especially when perishable service offerings are traded (Eso 2001).

The rapid growth of ICT has tremendously decreased transaction costs for service provision and consumption. Computing power and storage raises exponentially while prices drop anti-proportionally for hardware as illustrated by Moore's Law. This development directly leads to a tough *price competition* for service providers. In order to stay competitive, service providers have to *differentiate their service offers with respect to quality* and not to price (Berry and Parasuraman 1991; Dan et al. 2003; Devlin 1998; Liu et al. 2001; Matthyssens and Vandenbempt 1998). *Quality is the main value-determining factor* in the context of service offerings as service customers experience a service activity mainly based on the quality provided. Quality is idiosyncratic to the individual and often determined by various factors and the interplay of multiple service components that are part of a service composition. Hence, it is unbearable for service customers to reason about all feasible combinations of single service offerings and the resulting quality provided by the service composition in order to meet their requirements. Therefore an auction mechanism is needed which accounts for *different preferences of service requesters* defined for a *variety of quality characteristics* that are determined by each component that is part of feasible complex service instances. Especially in the context of a situational complex service provided by distributed parties in service value networks, a QoS-sensitive auction mechanism allows for the provision and pricing of highly customized short-term solutions to various types of customers leveraging the nature and benefits of situational applications and service mashups. As a consequence, service providers in service value networks are able to *address the long tail of business* by satisfying a great amount of individual service requests (Anderson 2006). In these environments, it is assumed that service offers are under the control of distributed self-interested owners. In the absence of central control, non-performance or complete drop-outs of service components are inevitable. Auction mechanisms that are *computational feasible* allow for reallocation and price adaption during run-time enabling *dynamic failovers* in unreliable environments (Foster et al. 2002).

## 4.2 Mechanism Design Desiderata

When we get to mechanism design within the market engineering process we have to design the components it consists of: a set of possible messages to be exchanged, the allocation rule, and the payment rule. Additionally, we need to consider the desired properties of the social choice function. Typical properties are e.g. allocation efficiency, revenue maximization, incentive compatibility, individual rationality, fairness or budget balance. Note that some of the mentioned properties exclude each other. For further discussions and background on mechanism design we refer to Arrow (1951), Hurwicz (1973), Klemperer (2004), Krishna (2002), or Myerson (1981).

In the context of SVNs, allocation efficiency can be one desired property in order to find an optimal match between service requester's preferences and service offers. Auctions can be a good solution to that problem. On the other hand, a SVN platform provider might want to limit opportunistic and strategic behavior or to increase the variety of service offerings provided. Therefore, the platform provider could search for ways to also reward parties that are willing to contribute in niches. An adequate mechanism should be tailored to deal with coordination aspects in service ecologies in which participants are both, self-interested but also fully bound to the success of the whole system. In that case concepts from cooperative game theory like the Shapley-value might be appropriate mechanisms.

Another challenge that results from the characteristics of SVNs which should be addressed in the design stage is the stability of the network. An adequate mechanism implementation should provide incentives to on the one hand sustain participating service providers and requesters and on the other hand attract further candidates.

These consideration shows that it is essential to first define the objectives the mechanism should fulfill. The objectives might change during time, e.g. it the initial stage while the network is forming, the variety of service offers is more important which calls for a different mechanism compared to a later phase when the network is more stable in its service offer variety. The next section gives an example for service network implementation and a possible coordination mechanism.

## 4.3 Web Service Coordination

Environments in which distributed units provide functionality in a loosely-coupled manner (according to the SOA paradigm) require some sort of process or set of rules to align activities in order to generate a desired outcome, i.e. they require *coordination*. The objective of coordination is to make a set of entities – either by providing incentives or establishing constraints upon them – pursue a common goal, e.g. producing a defined outcome.

In the context of Web services two specifications provide frameworks to implement coordination scenarios, WS-Coordination (Newcomer et al. 2007a) and WS-CF (Chapter et al. 2005). This section focuses on WS-Coordination as it is a finalized standard in contrary to WS-CF, which is still a public review draft. A detailed comparison of WS-Coordination and WS-CF can be found in (Little and Webber 2003) and (Kratz 2005). WS-Coordination is based on concepts and roles that are represented by Web services. *Initiator*, *coordinator* and *participants* communicate using a common *context* that glues their interaction to the coordinated activity. The framework allows for different coordination protocols to be plugged in, in order to coordinate domain-specific work between clients, services and participants. Work is defined as activities performed by one or more distributed parties. Examples for specific transaction protocols are WS-AtomicTransaction (Newcomer et al. 2008) and WS-BusinessActivity (Newcomer et al. 2007b). WS-AtomicTransaction specifies a rudimentary ACID[19] transaction protocol focusing on ad-hoc short-term transactions in a general manner. In contrast WS-BusinessActivity defines transactions with relaxed ACID properties with the purpose to coordinate long-term business transactions.

***Example 4.1 WS-Coordination Compliant Reverse Auction.*** To illustrate the specification of a coordination model according to the WS-Coordination framework, an auction mechanism is introduced as a special type of coordination, i.e. a single item sealed bid reverse auction. There is one *buyer* who intends to procure a single good or service from multiple *sellers*. The auction conduction including the type of messages to be exchanged between the participants is specified by *auction rules* which are controlled and enforced by an *auctioneer*. The mapping between roles and entities in a reverse auction and a coordination model is depicted in Fig. 7.

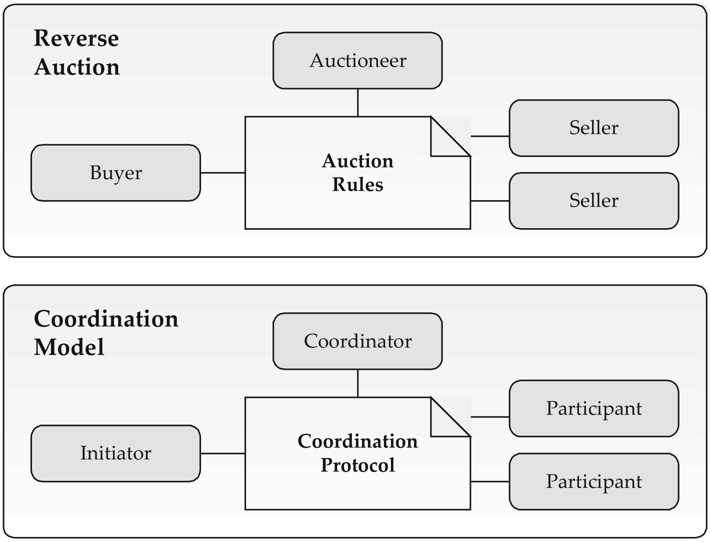



**Fig. 7** Mapping of a reverse auction to a coordination model

[19] ACID stands for *atomicity*, *consistency*, *isolation* and *durability*, which are properties that guarantee a reliable transaction.

The buyer starts the auction by announcing a *request* for the desired good or service. The auctioneer receives sealed *offer* bids from the sellers by a public deadline. After the deadline the winner determination is performed by the auctioneer, the good or service is transferred and the winning seller receives its payment. Based on the WS-Coordination framework, the buyer is represented by the initiator and the sellers are instances of the participant role. The auctioneer as the coordinator is responsible for the coordination protocol, that is, the set of auction rules. The initiator starts the activation phase and receives a coordination context from the coordinator. The invitation phase is generally done by the initiator according to (Newcomer et al. 2007a). Nevertheless, this might not be practicable for the reverse auction scenario as the buyer is not necessarily responsible for the discovery and selection of potential sellers. As the WS-Coordination framework provides a generic coordination model independent of domain-specific application logic, a tailored invitation process can be implemented on-top in order to shift responsibilities.

## 5 Conclusion

In this chapter we have introduced service value networks resulting from the possibility of combining single service offerings to a complex service. In order to find good combinations of offerings and to answer the question of determining prices we introduce an auction mechanism. Such auction mechanisms need to be carefully design – especially in the context of service systems which rapidly become complex systems consisting of a large variety of service providers which offers an even larger number of service components. Consequently, Market Engineering proposes four steps starting with the environmental analysis which studies the environment of the service offerings traded and the agents which interact. This stage is followed by the design phase in which objectives of the mechanisms that is to be developed are determined and the mechanism itself is designed. Before the mechanism is implemented its properties need to be studied. Besides the theoretical analysis it might be useful to apply techniques such as experimental economics or computational approaches.

Since auctions are well known to allocate goods and service described by multiple attributes we discuss Market Engineering in the context of service value networks. Therefore, we study the environment for which the auction mechanism is to be developed and introduce our understanding of service value networks. Service providers offer their service within these networks. A service offering comprises all attributes which unambiguously define all relevant service characteristics. Service customers demand specific service offerings and might also combine offerings to a complex service. The choice of configuration might affect both, functional and non-functional aspects of a service.

We introduce a formal modal to cope with service offerings and possible combinations of them in a SVN. The practical use of this formal modal is exemplified in characteristic examples. The first example describes an online payment process which can be split in sub-processes. These sub-processes can be provided by different service providers. The second example realizes a customer relationship management task as a complex service.

In Sect. 4 we bring together the two presented fields of research, Market Engineering and Service Value Networks. The main questions a designer of systems for service networks has to answer is how a coordination mechanism can be defined. There might be different objectives for the social choice rule. One central question in service value networks is how to efficiently match service offerings in order to satisfy customers' complex service requests and dynamically determine prices. Thereby, one can search for incentive compatible mechanisms that fulfill the efficiency criterion. On the other hand it might be valuable in networks not only to reward those service providers that deliver the service but also those providers that increase the value of the whole network. A starting point for such considerations might be the Shapley value (Shapley 1953).

Besides the technical challenges, one key challenge of the still young field of service value networks is the creation of mechanisms that match supply and demand in appropriate manner. There is also need for creating formalisms which are understood by many disciplines. We have provided an attempt to a formal model, but still there is a need for further approaches and a common vocabulary. Much research needs to be done in that respect. Market Engineering is one approach to structure the design approaches and which we feel is a valuable contribution to the research in Service Systems.

## References


Anderson, C. (2006). *The Long Tail*: *How Endless Choice is Creating Unlimited Demand*. London: RandomHouse.

Arrow, K. (1951). *Social Choice and Individual Values*. New York: Wiley.

Baldwin, C. Y., and Clark, K. B. (2000). *Design rules: The Power of Modularity*. Cambridge: MIT Press.

Berry, L. L., and Parasuraman, A. (1991). *Marketing Services: Competing Through Quality*. New York: Free Press.

Bertsekas, D. P. (2001). *Auction algorithms*. In Encyclopedia of Optimization. London: Kluwer.

Blau, B., Krämer, J., Conte, T., and van Dinther, C. (2009). *Service Value Networks*. Proceedings of the 11th IEEE Conference on Commerce and Enterprise Computing. (Vienna, Austria). 194–201.

Cassady, R. J. (1967). *Auctions and Auctioneering*. Berkeley: University of California Press.

Chapter, M., Newcomer, E., Little, M., and Pavlik, G. (2005). *Web Services Coordination Framework (WS-CF)*, OASIS, Public Review Draft.

Coase, R. H. (1937). *The nature of the firm*. Economica 4(16):386–405, November.

Dan, A., Ludwig, H., and Pacifici, G. (2003). *Web Service Differentiation with Service Level Agreements*, White Paper, IBM Corporation), 3.

Demirkan,H., Kauffman, R. J., Vayghan, J. A., Fill, H.-G., Karagiannis, D., and Maglio, P. P. (2008). *Service-oriented technology and management: Perspectives on research and practice for the coming decade*. Electronic Commerce Research and Applications 7:356–376.

Devlin, J. F. (1998). *Adding value to service offerings: The case of UK retail financial services*. European Journal of Marketing 32(11):1091–1109.
Eso, M. (2001). *An iterative online auction for airline seats*. IMA Volumes In Mathematics And Its Applications 127:45–58.
Foster, I., Kesselman, C., Nick, J. M., and Tuecke, S. (2002). *Grid services for distributed system integration*. Computer 2002:37–46.
Jackson, M. O. (2003). *Efficiency and information aggregation in auctions with costly information*. Review of Economic Design 8(2):121.
Harel, D., and Naamad, A. (1996). *The STATEMATE semantics of statecharts*. ACM Transactions on Software Engineering and Methodology 5(4):293–333.
Van Heck, E., and Vervest, P. (2007). *Smart business networks: How the network wins*. Communications of the ACM 50(6):29–37.
Holtmann, C. (2004). *Organisation von Märkten - Market Engineering für den elektronischen Wertpapierhandel*. PhD thesis, Universität Karlsruhe (TH), Karlsruhe, Germany.
Hurwicz, L. (1960). *Optimality and informational efficiency in resource allocation processes*. In K. J. Arrow, S. Karlin, and P. Suppes, editors, Mathematical Methods in the Social Sciences, Stanford University Press, California, pp. 27–46.
Hurwicz, L. (1969). *On the concept and possibility of informational decentralization*. The American Economic Review 59(2):513–524, May.
Hurwicz, L. (1973). *The design of mechanisms for resource allocation*. The American Economic Review 63(2):1–30, May.
Klemperer, P. (2004). *Auctions: Theory and Practice*. Toulouse Lectures in Economics, 1st edition. Princeton and Oxford: Princeton University Press.
Kratz, B. (2005). *Protocols For Long Running Business Transactions*, Infolab Technical Report Series.
Krishna, V. (2002). *Auction Theory*. San Diego: Academic Press.
Lamparter, S. (2007). *Policy-Based Contracting in Semantic Web Service Markets*. Ph.D. dissertation, Universität Karlsruhe (TH).
Little, M., and Webber, J. (2003). *Introducing WS-CAF – More than just transactions*. Web Services Journal 3(12):52–55.
Liu, Z., Squillante, M. S., and Wolf, J. L. (2001). *On Maximizing Service-Level-Agreement Profits*, Proceedings of the 3rd ACM conference on Electronic Commerce 2001, pp 213–223.
Lucking-Reiley, D. (2000). *Auctions on the internet: What's being auctioned, and how?* Journal of Industrial Economics 48(3):227–252.
Matthyssens, P., and Vandenbempt, K. (1998). *Creating competitive advantage in industrial services*. Journal of Business and Industrial Marketing 13:339–355.
McAfee, P., and McMillan, J. (1987). *Auctions and bidding*. Journal of Economic Literature 1(2):699–738, June.
McCabe, K. A., Rassenti, S., and Smith, V. (1993). *Designing a uniform-price double auction: An experimental evaluation*. In D. Friedman and J. Rust, editors, The Double Auction Market: Institutions, Theory, and Evidence, pages 307–322, Cambridge, MA, 1993. Perseus Publishing.
Miles, R. E., and Snow, C. C. (1986). *Organizations: New concepts for new forms*. California Management Review 28(3):62–73.
Milgrom, P. R., and Weber, R. J. (1982). *A theory of auctions and competitive bidding*. Econometrica 50(5):1089–1122, September.
Myerson, R. (1981). *Optimal auction design*. Mathematics of Operations Research 6:58–73.
Neumann, D. (2004). *Market Engineering - A Structured Design Process for Electronic Markets*. PhD thesis, Universität Karlsruhe (TH), Karlsruhe, Germany.
Newcomer, E., Robinson, I., Feingold, M., and Jeyaraman, R. (2007a). *Web Services Coordination (WS-Coordination)*, OASIS.
Newcomer, E., Robinson, I., Freund, T., and Little, M. (2007b). *Web Services Business Activity (WS-BusinessActivity),* OASIS.

Newcomer, E., Robinson, I., Little, M., and Wilkinson, A. (2008). *Web Services Atomic Transaction (WS-AtomicTransaction)*, OASIS.

Papazoglou, M. (2008) *Web Services: Principles and Technology*. Harlow: Addison-Wesley.

Pesendorfer, W., and Swinkels, J. M. (2000). *Efficiency and information aggregation in auctions*. American Economic Review 90(3):499–525.

Reiter, S. (1977). *Information and performance in the (new) welfare economics*. The American Economic Review 67(1):226–234, February.

Roth, A. E. (2002). *The economist as engineer: Game theory, experimentation, and computation as tools of design economics*. Econometrica 70:1241–1378, July.

Shapley, L. S. (1953). *A Value for n-person Games.* In: H.W. Kuhn and A.W. Tucker (Eds.): *Contributions to the Theory of Games, volume II.* (Annals of Mathematics Studies v. 28), Princeton University Press, Princeton 1953. pp. 307–317

Smith, V. L. (1982). *Microeconomic systems as an experimental science*. American Economic Review 72(5):923–955.

Smith, C. W. (1989). *Auctions: The Social Construction of Value.* Berkely, CA: University of California Press.

Varian, H. R. (2002). *When economics shifts from science to engineering*. The New York Times 29:29, August.

Weinhardt, C., Holtmann, C., and Neumann, D. (2003). *Market engineering*. Wirtschaftsinformatik 45(6):635–640.

Williamson, O. (1985). *The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting*. New York: Free Press.

Wolfstetter, E. G. (1999). *Topics in Microeconomics – Industrial Organizations, Auctions and Incentives*. Cambridge University Press, 2002 2nd edition.

Wurman, P. R., Wellman, M. P., and Walsh, W. E. (2001). A parametrization of the auction design space. *Games and Economic Behavior* 35(1–2):304–338, April.

Zeng, L. Benatallah, B., Dumas, M, Kalagnanam, J., and Sheng, Q. Z. (2003). *Quality Driven Web Services Composition*, in WWW '03: Proceedings of the 12th international conference on World Wide Web ACM, 411–421.

# Service Systems Modeling: Concepts, Formalized Meta-Model and Technical Concretion

**Martin Böttcher and Klaus-Peter Fähnrich**

**Abstract** Over the past years service science has changed. Nowadays the object of research is highly professionalized complex service systems. For this area of research, service systems modeling provides concepts and formalized meta-models for describing service systems in a precise way. In this paper different aspects of service systems modeling are presented: (a) the specification of singular service components (component model), (b) the specification of the component's resources (resource model), (c) the definition of interdependencies of service components relevant for configuration (product model) and (d) the temporal dependencies between service components necessary for defining process instances (process model). This paper offers a modeling-relevant definition of service systems, the theoretical foundation of the meta-model (based on a wide literature research) as well as the concepts and terms, necessary for modeling service systems. Finally, the advantages and limitations of service system modeling are discussed.

**Keywords** Service components · Service modeling · Service science · Service systems

## 1 Potentials of Service Systems Modeling

As business and societal services are increasingly important for growing economies, new academic discipline areas emerged during the past years, e.g. service management, service operations, service marketing and service engineering.

---

M. Böttcher (✉)
Faculty for Mathematics and Computer Science, Department of Computer Science,
Business Information Systems, University of Leipzig,
Johannisgasse 26, 04103 Leipzig, Germany
e-mail: boettcher@informatik.uni-leipzig.de

H. Demirkan et al. (eds.), *The Science of Service Systems*,
Service Science: Research and Innovations in the Service Economy,
DOI 10.1007/978-1-4419-8270-4_8, 

Service engineering provides methods and tools for a systematic and structured development of new information-intensive service offerings and service systems.

The modeling and therefore formalized description of service systems form a part of service engineering and increasingly attract interest. But contrary to other disciplines (e.g. product engineering and software engineering), service engineering still lacks an adequate modeling approach that helps to design, develop and provide services (Alonso-Rasgado et al. 2004; Maglio et al. 2006), even though a formalized description of service systems would facilitate the following benefits:

- *Standardized vocabulary*: Descriptions given in natural language (e.g. English) lead to an ambiguity and space of interpretation (Linckels and Meinel 2006). By defining a meta-model for service systems modeling, a domain-specific language (van Deursen et al. 2000) is given. Such a language presents a vocabulary (syntax and semantics) that allows an unambiguous description of service systems.
- *Subsequent usage by information technology*: Since information represented by natural language (text) is not structured, a further processing by information technology is quite difficult. However, a representation of structured information (e.g. based on a given meta-model) firstly enables support during service systems design and secondly allows a subsequent processing by information technology (e.g. simulation, optimization, scheduling).

Akin to the pros of modeling in product- and software engineering (Bézivin 2005), several advantages could be expected for the field of service engineering. They could result in different enhancements within the key performance dimensions of offered services:

- *Service quality*: Even though the quality of services often depends on human beings, it can be maintained that the quality also depends on both the expectation of the customer and the execution by the provider. Both represent certain gaps of the gap-model (Parasuraman et al. 1985) and both can be solved by a formalized service systems description. Firstly, it would lead to a precise description for the customer (contrary to a brochure written in natural language) and, therefore, narrow the gap of expected and perceived service. Secondly, a formalized service systems description could provide a clear directive for the staff. A formalized described service system with little space of individual adaption would lead to a persistent level of quality. Furthermore, service systems could be enhanced before service provision by optimizing it through the use of information technology that bases its processing on the formalized model.
- *Service productivity*: Service productivity comprises the productivity of the development of service systems and the productivity of service provision. The productivity of the development depends on the procedure model and the applied method of description (Meyer et al. 2008). A formalized description of service systems would support the development process because all artifacts (e.g. first idea of a service, requirements, conception) are specified with a unique representation technique and a unique vocabulary. All developers could, therefore,

use the results of other development steps more efficiently. Furthermore, the productivity of reengineering service systems is improved because reengineering demands a clear understanding of a current service system, which is enabled by a formalized description. Finally, searching for a sufficient service by a customer can be supported by an IT-based research that relies on a formalized service systems model.

- *Service innovation*: One critical aspect of service innovation is the modularization of services and service systems. Modularized components can be transformed or reconfigured into new service bundles, leading to a short-term innovation cycle (Miles 2006). A service systems modeling approach that considers the modularization and provides adequate support for defining service components eventually enhances service innovation.

Due to the advantages outlined above, service systems modeling seems to be quite promising for service science. Nevertheless, it must be stated that it might not be sufficient for every kind of service system. Based on the classification scheme of Schmenner (Schmenner 1986) and Fähnrich et al. (Fähnrich et al. 1999), a formalized modeling of service systems seems to fit best for so-called Service Factory and Mass Service. These services are characterized by a low degree of Interaction and Customization. Furthermore, service modeling fits when services are of high complexity. That is, services like "hairdresser" do not gain as much benefit as goods-related services like "remote maintenance" do. This effect is due to the tradeoff between the modeling effort and the advantages of service systems modeling.

While Sect. 2 discusses the adaption of a system approach for service modeling, Sect. 3 displays the theoretical foundations of the service systems modeling. Subsequently, Sect. 4 specifies the service systems meta-model. Section 5 draws a conclusion and discusses the results of this paper.

## 2 Adaption of a System Approach for Service Modeling

Closely related to a formalized description of services systems is the question of what a service system is. For the term "service", this more theoretical question has been discussed for decades and different definitions have been suggested (Fitzsimmons and Fitzsimmons 2005). This pluralism has had different implications for service modeling. Especially aspects of intangibility and so-called soft factors made a clear description of services quite difficult. Hence, the approach of looking at service systems supports a service modeling approach, for it allows the specification of concrete facts instead of focusing on soft factors. Service systems are discussed widely in the literature (Chesbrough and Spohrer 2006; Brax 2007; Spohrer et al. 2007). Based on explanations given by various authors (Gadrey 2002; Araujo and Spring 2006; Spohrer et al. 2007; Vargo 2009), service systems can be defined in the local context of service modeling as follows:

A *service system* is a set of interacting resources provided by the customer and the provider. *Services* are an offered functionality performed by the interaction of these resources. The functionality leads to a change of state of at least one resource of the service system. At least one of the changed resources belongs to the customer to whom the change is of any value.

Basically, a service system can, therefore, be defined as

$$(R, S, I, F) \tag{1}$$

$R$ is a set of resources that are relevant for offering a service (e.g. “desk”, “staff”, “machine”). $R$ consists of two subsets: resources owned by the customer $R_C$ (e.g. “customers’ car”) and resources owned by the provider $R_P$ (e.g. “auto lift”): $R_C \cap R_P = R$. $S = \{s_1, \ldots s_o\}$ is a set of states that a resource can enter (e.g. it can be “clean” or “dirty”). $I$ is a function that describes the initial state of the service system ($\wp$ is the power set (math.)):

$$I : R \rightarrow \wp(S) \tag{2}$$

$F$ is a function that describes the final state of the service system and, therefore, implies the functionality and the service of a service system:

$$F : R \rightarrow \wp(S) \tag{3}$$

As the offered functionality of a service system has to change the state of at least one resource owned by the customer, the following condition has to be fulfilled consequently:

$$\exists r \in R_C : I(r) \neq F(r) \tag{4}$$

Based on the given definition, modeling service systems will be described in the subsequent sections.

## 3 Towards a Service System Meta-Model

By now different approaches exist in the domain of service modeling. While most of them represent important aspects, almost none of them is based on a certain modeling understanding. This lack leads to a mixture of terms like “model”, “meta-model” and “reference model” and also hinders a comparison, a further development or a combination of the existing modeling approaches (Böttcher 2008). Therefore, service systems modeling has to be based on an adequate modeling theory.

## *3.1 Modeling Theory*

A modeling theory with a precise specification of the modeling-relevant terms is given by Favre (Favre 2005). This theory can be adapted for service systems modeling as depicted in Fig. 1. The real world service system (e.g. remote maintenance) is located on level M0 and is named “system under study”. For representing the whole service system or aspects of it (e.g. all resources of a remote maintenance service), a so-called “service systems model” can be specified (located on level M1). This model conforms to a “service system meta-model” that represents a “service systems modeling language”. Such a meta-model would specify the concepts that are necessary for modeling service systems (e.g. “resources”, “availability”, “location”). The meta-model and the service systems modeling language are located on level M2. According to Favre (Favre 2005), a meta-model itself needs to conform to a certain model – the so called “meta-meta-model” which represents a “meta-modeling language”. A meta-meta-model contains concepts that allow the specification of a meta-model (e.g. “classes”, “connectors”, etc.). The meta-meta-model and the meta-modeling language are located on level M3. The technical realization (the implementation by using information technology) of these three levels can be called “technical space” (Kern et al. 2008). When defining concepts for modeling service systems, it is most suitable to focus on level M2 because this level specifies the “service system meta-model” and its corresponding “modeling language”.

The main parts of a service system meta-model are domain-specific concepts (e.g. “resource”, “provider”) and their relations (e.g. “resource belongs to”). Different approaches can be used for retrieving these concepts. A mixture of qualitative and quantitative research methods has been applied for the meta-model underlying this paper. The concepts were derived from a) literature analysis, b) existing modeling approaches (in the domain of service modeling) and c) case studies.

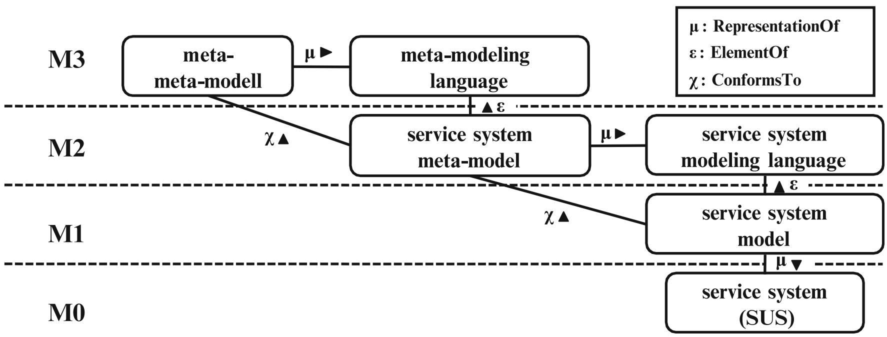



**Fig. 1** Meta-model levels for service systems

### 3.2 Analysis and Concept Extraction

The literature analysis was based on different works of the service domain. (20 German and international scientific papers and books, e.g. (Corsten 2001; Meffert and Bruhn 2006; Johne and Storey 1998; Vargo and Lusch 2004; Fitzsimmons and Fitzsimmons 2005)). All of the literature sources were either recommended by chairs of service science or were repeatedly cited in service-relevant articles. The literature analysis allowed a first insight into the state of the art of service science and provided a huge amount of domain relevant concepts. Further literature analysis, especially done automatically (e.g. using text-mining techniques), could improve and augment the identified concepts.

In addition to the general literature of service science, existing modeling approaches were analyzed. Twelve modeling approaches which explicitly cope with the domain of service science were identified, such as (Shostack 1982; Congram and Epelman 1995; Kaner and Karni 2006; Baida et al. 2003; O'Sullivan 2006). Modeling approaches in the field of computer services (e.g. web services or service-oriented architecture) were not analyzed for concept extraction, but utilized for developing the meta-model.

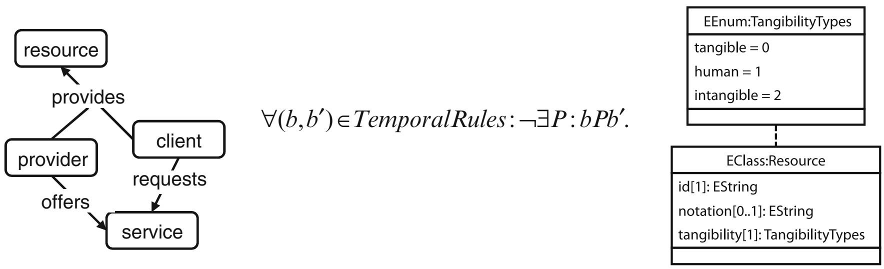
Finally, two use cases were taken into account for enhancing the literature-based concepts. The use cases were conducted with global players which developed complex services for enriching their product portfolio.

After the text analysis, domain-relevant concepts were extracted (e.g. Fig. 2). These concepts were, then, aggregated due to the existence of synonyms or they were rejected because they were not primarily necessary for service systems modeling (e.g. "uno-actu-principle"). The remaining concepts were augmented, if necessary (e.g. very abstract concepts were detailed by the specification of further concepts, e.g. the concept "hierarchy" was augmented by specifying the concept of a "graph" for representing such hierarchies). Finally, the remaining and newly specified concepts were used to define a domain-specific language (meta-model).

### 3.3 Concept Representation

In a first step identified concepts and their relations were represented in so-called concept maps (Novak and Cañas 2008). They provide an overview of the extracted and specified concepts (Fig. 3). Even though concept maps can be used for achieving a good visualization of the domain-specific concepts, their formalization is quite limited and makes a further processing (e.g. by information technology)


**Fig. 2** Process of concept extraction




*1. concept maps* *2. formalized description* *3. technical concretion*

**Fig. 3** Examples of concept maps, formalized description and technical concretion

quite difficult. Therefore, the concepts were described in a formal way. This formalized description of the concepts was realized by mathematical and propositional logical expressions (Fig. 3).

The implementation of a meta-model and an editor demands a technical concretion. This requirement implies that the description of the concepts and their relations have to conform to a specific meta-meta-model. For the model underlying this work, the Eclipse Modeling Framework (EMF) (Budinsky et al. 2004) was applied. In EMF the meta-meta-model (level M3) is called "ecore" and the developed meta-model (level M4) is called "EMF-meta-model". The formalized description was transformed into the technical space EMF, which allows a further processing by implementing a concrete syntax and an editor (e.g. Fig. 3). EMF was chosen because it offers an undisclosed meta-meta-model and because it is explicitly meant for modeling.

## 4 Service Systems Meta-Model

The specified meta-model will be described in this section. As the meta-model is quite complex, it has been divided into four sub-meta-models. Such a division has already been proposed in the literature (Bullinger et al. 2003). Each of these models represents specific aspects of service systems. Even though each of these sub-meta-models can be used separately, they are, nevertheless, highly interrelated. To outline what can be described by applying the meta-model, a simplified example is depicted in Fig. 4.

A service system (e.g. "remote maintenance") can be divided into three subsystems (e.g. "problem analysis", "solution finding" and "treatment"). Every service system as well as every component of it can be described by its functional (e.g. "increase in availability") and non-functional properties (e.g. "time", "location"). Furthermore, the resources of every service system (e.g. "analysis tool", "device", "staff") are described by the so-called resource model. Hierarchical dependencies which outline the composition of service systems are specified by the use of the

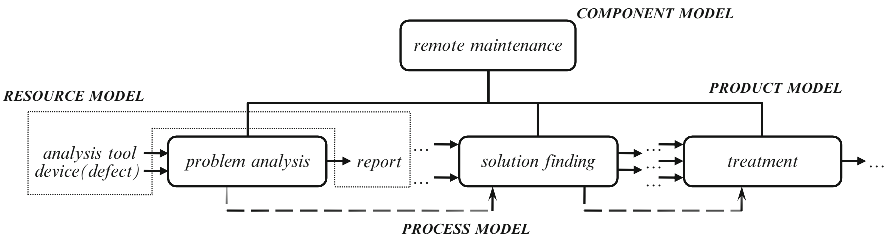



**Fig. 4** Simplified example of the four sub-meta-models

product model (e.g. "remote maintenance" consists of "problem analysis" etc.). Finally, the temporal sequences are modeled by using the process model (e.g. "problem analysis" has to be processed before "solution finding").[1]

## 4.1 Component Model

When coping with comprehensive service systems, modularization reduces the complexity and meets the demands for standardization and individualization (Da Silveira et al. 2001). Therefore, the idea of modularization has been adopted for service systems modeling and the concept of service components (*ServiceComponents*) was consequently specified. Each component defines a self-contained functionality (e.g. finding a solution for a given problem) that can be combined with other components (e.g. "solution finding" can be combined with "treatment"). Furthermore, components can be described by their functional and non-functional properties and they can correlate to each other in hierarchical (product model) and temporal issues (process model).

The functional properties of a component comprise all properties that define the functionality of a given (sub-) service system (e.g. "reduces the percentage of failure"). The implicit functionality is represented by the alteration of resources and will be described in a subsequent section (e.g. see Sect. 4.2). Furthermore, the functionality can be explicitly described by the definition of functional property types (*FunctionalPropertyTypes*) (e.g. "increase in turnover") and corresponding values (*FunctionalPropertyValues*) (e.g. "30 percent"). Both of them have to be specified by the modeler:

$$\begin{aligned} &FunctionalPropertyAllocation : ServiceComponents \rightarrow \\ &\wp(FunctionalPropertyTypes \times FunctionalPropertyValues). \end{aligned} \tag{5}$$

[1] As the precise description of the four sub-meta-models focuses on the aspects of service *systems*, the following description does not comprise the full meta-model. The complete meta-model can be found at http://bis.informatik.uni-leipzig.de/.

Non-functional properties describe restrictions on the functionality (e.g. “only available on Monday” or “available in Europe”). Even though such non-functional properties have been described (e.g. O’Sullivan 2006), they have always been specified for a service itself (e.g. a service is available at five o’clock). Applying the idea of service systems and, therefore, focusing on the resources makes it necessary to specify non-functional properties for resources (*Resources*) that are used in the service system (e.g. a certain resource has to be added to a service at five o’clock) instead of defining it for the service as a whole. The following expression specifies temporal and locative properties by defining an availability allocation (*AvailabilityAllocation*). These expressions allow specifying locative availabilities (e.g. “Cambridgeshire”) as well as locative exceptions (e.g. “Cambridge” as an exception for “Cambridgeshire”). Furthermore, temporal availabilities (e.g. “every Friday”) and temporal exceptions (e.g. “Friday 15th”as an exception for “every Friday”) can be specified. Finally, it is defined for which service component this non-functional property is valid and whether it is defined for a resource that is used as input or that is obtained as an output.

$$\begin{aligned}
&AvailabilityAllocation : Resources \rightarrow \\
&\quad \wp(\wp(LocationPoints) \times \wp(LocationPoints) \times \\
&\qquad \wp(TemporalPeriods) \times \wp(TemporalPeriods) \times \\
&\qquad\quad \wp(ServiceComponents) \times ResourcePositions). \\
&AvailabilityAllocation(resource) = \{(LocativeAvailabilities, \\
&\quad LocativeExceptions, TemporalAvailabilities, TemporalExceptions, \\
&\qquad ServiceComponents', resourcePosition)\}.
\end{aligned} \tag{6}$$

Furthermore, the specified meta-model enables the definition of additional non-functional properties such as “provider”, “duration”, “price”, “payment”, “consequences”, “reputation“ and “restrictions”.[2]

## 4.2 Resource Model

The modeling of service systems necessarily demands a modeling of the resources which are part of the service system. The interaction of the resources results in the functionality offered by a service system.

As resources are modified leading to a customer value, it is necessary to specify what resources have to be added by the customer and what type of modification derives from a given service system. Additionally, resources used by the provider to offer a service have to be specified. The given definition of a service system

[2] The complete meta-model can be found at http://bis.informatik.uni-leipzig.de/.

(e.g. see Sect. 2) specifies initial states and final states. These states can be represented by defining whether a resource is described and used as an input (initial state) or whether it results as an output (final state):

$$ResourcePositions = \{\text{“}input\text{”}, \text{“}output\text{”}\}. \tag{7}$$

Properties such as “identifier”, “capacity”, “flexibility” and “quantity” are definable by using the meta-model. Furthermore it is necessary to classify resources. This classification allows a semantic specification of sets of resources; thus enabling a clustering of service systems (e.g. services for human beings) due to the kind of resources that are used. Three attributes are defined for the classification of resources:

- *Source*: This property specifies whether a resource is added to a service system by the customer (*customer*), the provider (*internal*) or a third party (*external*):

$$\begin{aligned} &ResourceSourceTypeAllocation: Resources \rightarrow \\ &\quad \wp(ResourceSourceTypes \times \wp(ServiceComponents) \times ResourcePositions), \\ &ResourceSourceTypes = \{\text{“}customer\text{”}, \text{“}internal\text{”}, \text{“}external\text{”}\}. \end{aligned} \tag{8}$$

- *Tangibility*: Different approaches exist for defining the tangibility of resources (e.g. Baida et al. 2003). For modeling service systems it is sufficient to specify three different types of resources: *tangible* (e.g. machine), *intangible* (e.g. rights, information, patents) and *human* (e.g. patient). The latter one is specified, although it is a kind of tangible resource because services that alter human beings are of special interest to the customer since it affects the customer itself.

$$\begin{aligned} &ResourceTangibilityTypeAllocation: Resources \rightarrow ResourceTangibilityTypes, \\ &ResourceTangibilityTypes = \{\text{“}tangible\text{”}, \text{“}human\text{”}, \text{“}intangible\text{”}\}. \end{aligned} \tag{9}$$

- *Mobility*: The term “mobility” defines the technical ability and the individual willingness of a resource to change its local position. An immobile resource (e.g. a power plant) defines the location of a service provision, whereas a mobile resource (e.g. a car) can be moved. The mobility of a resource is specified as follows:

$$\begin{aligned} &ResourceMobilityTypeAllocation: Resources \rightarrow \\ &\quad \wp(ResourceMobilityTypes \times \wp(ServiceComponents) \times ResourcePo\text{sition}), \\ &ResourceMobiltyTypes = \{\text{“}mobile\text{”}, \text{“}immobile\text{”}\}. \end{aligned} \tag{10}$$

Furthermore, properties can be specified so as to allow an implicit conclusion of the functionality of a service system because they specify the alteration of resources.

- *Attributes*: The given definition of the service system specifies a modification of the states of resources. These states can be represented by attributes (ResourceAttributes) (e.g. "color") and their values (ResourceAttributeValues) (e.g. "green", "blue", "red"):

$$ResourceAttributes \times ResourceValues \in S. \tag{11}$$

The allocation of the attributes is done as follows:

$$\begin{aligned} &ResourceAttributeAllocation: Resources \rightarrow \\ &\quad \wp(ResourceAttributes \times \wp(ResourceAttributeValues) \times \\ &\quad\quad \wp(ServiceComponents) \times ResourcePositions). \end{aligned} \tag{12}$$

- *Activity*: A resource can either be used to modify a resource (operator) (e.g. wrench) or it can be modified by a resource (operand) (e.g. repaired car). An operator resource that can be used again after applying a service is specified as *usageOperator* (e.g. hammer), while a resource that cannot be used afterwards is named *consumptionOperator* (e.g. dishwater):

$$\begin{aligned} &ResourceActivityTypeAllocation: Resources \rightarrow \\ &\quad ResourceActivityTypes \times \wp(Resources) \times \wp(ImpactTypes) \times \\ &\quad\quad \wp(ServiceComponents). \\ &ResourceActivityTypes = \{\text{``}usageOperator\text{''}, \text{``}consumptionOperator\text{''}\}. \end{aligned} \tag{13}$$

- *Relation*: Resources can have relations with each other. These relations can change due to an offered service (e.g. from "loose" to "glued"). Every resource can have a relation to other resources specified by a type (*ResourceRelationTypes*) (e.g. "glued", "married"). In terms of the service system definition (Sect. 2), these relations are part of the state a resource can have: $ResourceRelationTypes \in S$. The relation is specified for a certain set of service components and a resource position (input or output):

$$\begin{aligned} &ResourceRelationAllocation: Resources \rightarrow \\ &\quad \wp(ResourceRelationTypes \times \wp(Resources) \times \\ &\quad\quad \wp(ServiceComponents) \times ResourcePositions). \\ &\forall (resourceRelationType, Resources', ServiceComponents', resourcePosition) \\ &\quad \in ResourceRelationAllocation(resource) : resource \notin Resources' \}. \end{aligned} \tag{14}$$

The functionality of a service system can implicitly be described by the modification of resources. This change depends on the alteration of attributes (e.g. Fig. 5), the alteration of resource relations (e.g. Fig. 6) or the alteration of a special kind of

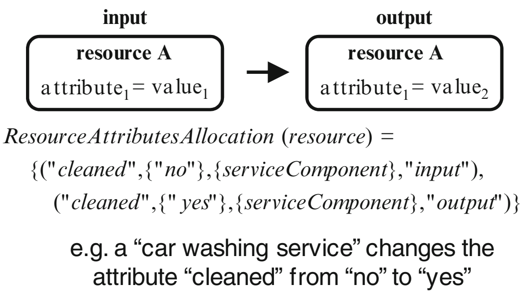



**Fig. 5** Changes of resource attributes

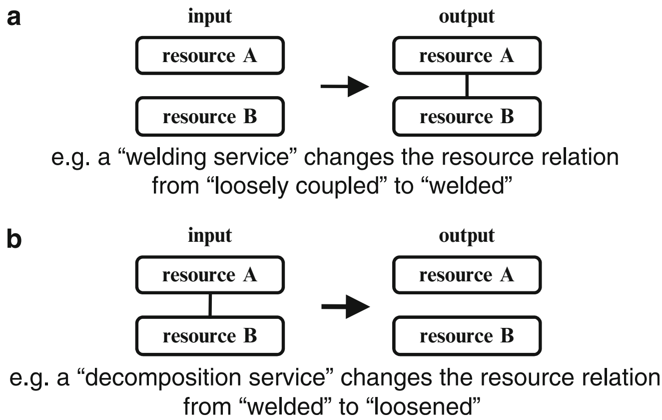



**Fig. 6** Change of resource relations

resource relations – sub-system relations (e.g. Fig. 7). Only Fig. 5 represents the formal specification exemplary.

The resource model presented above enables a comprehensive description of the resources necessary for offering a defined functionality of a service system.

### *4.3 Product Model*

To tap the full potentials of the modularized service components, it is necessary to offer concepts for correlating singular service components by the so-called product model. This correlation enables the choice between different sub-services during configuration processes. Comparable approaches can be found in software engineering (e.g. feature modeling (Czarnecki and Eisenecker 2000)). Basically, the product model allows the specification of hierarchical (e.g. "sweeping service" and "wiping service" are part of "cleaning service") and non-hierarchical relations

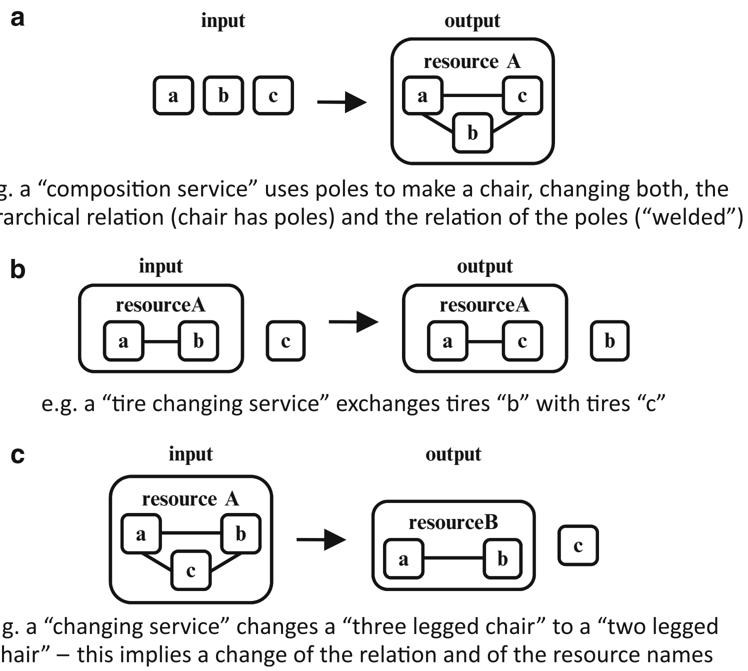



**Fig. 7** Changes of resource sub-systems

(e.g. "wiping service" can only be processed when "sweeping service" is processed as well) between service components. For these relations, three different modeling levels are defined: graphs, cardinalities and non-hierarchical dependencies.

### 4.3.1 Graphs

To specify that a service component is a combination of a set of other components, a graph consisting of vertices and directed edges can be used:

$$Edges \subseteq Vertices \times Vertices,\ Edges \cap Vertices = \emptyset,\ \forall (v, v') \in Edges : v \neq v'. \tag{15}$$

In this graph a component consists of other components that are connected to it by a directed edge. To enable the choice between different components during configuration (e.g. whether a "cleaning service" consists only of a "sweeping service" or also of a "wiping service"), it is necessary to extend the graph by defining "connecting vertices" and "service component vertices":

$$\begin{aligned} Vertices &= ServiceComponents \cup Connectors, \\ ServiceComponents &\cap Connectors = \emptyset. \end{aligned} \tag{16}$$

While "service component vertices" represent different service components, "connecting vertices" represent five different types of nodes necessary for enabling configuration. These nodes allow expressions such as: "component A consists of at least one of the subsequent components". Every type of connecting vertices has an individual syntax and semantics: (1) "conjunctive nodes": all of the subsequent components have to be chosen during configuration; (2) "exclusive-or nodes": exactly one of the subsequent components has to be chosen; (3) "optional-exclusive-or nodes": one or none of the subsequent components has to be chosen; (4) "disjunctive-obligatory nodes": at least one of the subsequent components has to be chosen; (5) "disjunctive nodes": no restrictions for the configuration.

$$C_{all\_node} \cup C_{one\_node} \cup C_{at\_most\_one\_node} \cup \\ C_{at\_least\_one\_node} \cup C_{free\_choice\_node} = Connectors. \tag{17}$$

Figure 8 exemplifies the different node types.

### 4.3.2 Cardinalities

The "connecting vertices" presented above allow a certain level of configuration. But expressions such as "*service component A consists of two or three service components of the set {B, C, D, E, F}*" cannot be modeled by these vertices.

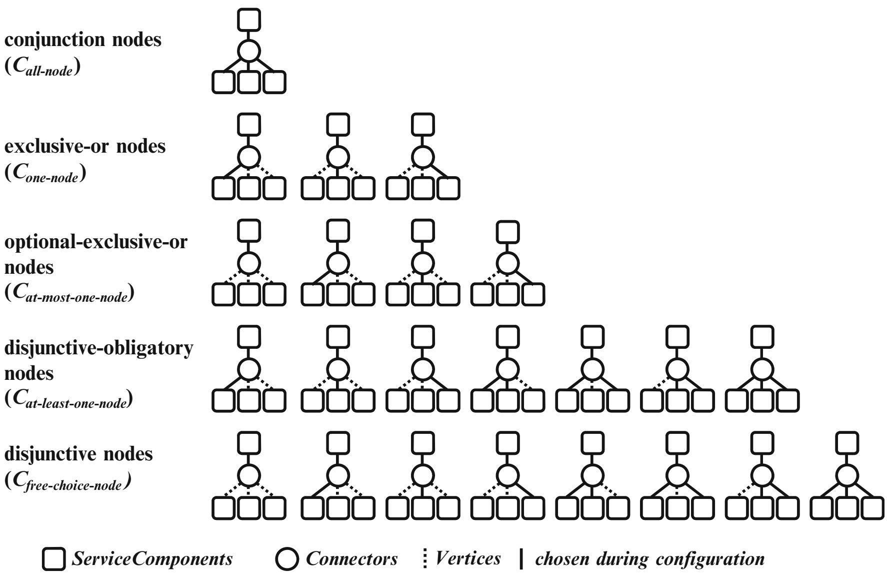



**Fig. 8** Examples of connecting nodes

Cardinalities are defined to enable such expressions. Although cardinalities are more expressive than the *Connectors*, they are at the same time more difficult to handle. Therefore, it depends on the structure of a service system and the intention of modeling whether the graph should only be used or also the cardinalities. Cardinalities (*NodeOccurence*) consist of a minimum and maximum value and are specified as follows:

$$
\begin{aligned}
NodeOccurrence : Connectors \rightarrow \wp(\mathrm{N} \times \mathrm{N}), \\
\forall(min, max) \in NodeOccurrence(c) : (min \leqslant max), \\
\forall(min, max) \in NodeOccurrence(c) : \neg(\exists(min', max') \in NodeOccurrence(c) : \\
min \leqslant min' \leqslant max \vee min \leqslant max' \leqslant max).
\end{aligned}
\tag{18}
$$

### 4.3.3 Non-hierarchical Dependencies

The graph and the cardinalities allow the specification of interdependencies between components as long as they can be displayed in the structure of the specified graph. In addition, dependencies exist that cannot be displayed in this graph (e.g. statements such as "*service component F cannot be chosen during configuration, if service component R has been chosen in advance*". Such interdependencies demand so-called "non-hierarchical dependencies". These dependencies facilitate the specification of dependencies on service components and of dependencies on cardinalities. Expressive rules can be specified by using logical expressions. As these logical expressions are quite complex, four specific rules were defined, covering most of the cases of non-hierarchical dependencies and supporting modeling by non-experts (e.g. Table 1). These rules can as well be mapped on the linear temporal logic (LTL) for further processing (e.g. automatic model checking), as proposed in the literature (Aalst and Pesic 2006). This approach allows the specification of additional rules as long as they conform to the ones presented.

**Table 1** Rules for non-hierarchical dependencies

| rule | LTL notation | Example |
|---|---|---|
| b_implies_b´ | $\Diamond b \Rightarrow \Diamond b'$ | If component b is chosen, component b´ must be chosen as well. |
| not_b_implies_b´ | $\Box\neg b \Rightarrow \Diamond b'$ | If component b is not chosen, component b´ has to be chosen. |
| b_excludes_b´ | $(\Diamond b \Rightarrow \Box\neg b') \wedge (\Diamond b' \Rightarrow \Box\neg b)$ | If component b is chosen, component b´ must not be chosen (vice versa). |
| not_b_implies_not_b´ | $\Box\neg b \Rightarrow \Box\neg b'$ | If component b is not chosen, component b´ must not be chosen. |

**Table 2** Rules for a declarative process description

| Rule | LTL notation | explanation |
|---|---|---|
| *b_needs_succeeding_b'* | $\Box(b \Rightarrow \Diamond(b'))$ | If component b is processed, component b´ has to be processed at any time afterwards. |
| *b'_needs_preceding_b* | $\neg(\neg b \; U \; b')$ | Component b´ can only be processed, if component b was processed at any time before. |
| b_needs_imediate_succeeding_b' | $\Box(b \Rightarrow (\bigcirc(b')) \vee (\bigcirc(b)))$ | If component b is processed, component b´ has to be processed immediately afterwards. |
| b'_needs_imediate_preceding_b | $\neg\Diamond(\neg b \wedge \bigcirc b')$ | Component b´ can only be processed, if component b has been processed immediately before. |
| b_never_before_b' | $\neg\Diamond(b \wedge \Diamond b')$ | If component b is processed, component b´ must not be processed at any time afterwards. |
| b_never_imediately_before_b' | $\neg\Diamond(b \wedge \bigcirc b')$ | Component b´ must not be processed immediately after the processing of component b. |

### *4.4 Process Model*

Due to the character of service systems, components are time-dependent (e.g. before wiping a floor, it needs to be swept). It is, therefore, necessary to specify when a component has to be processed. Statements like "*component A has to be processed immediately before component B*" or "*component C must not be processed after component D*" have to be made. Instead of describing precisely the process as a whole in advance, Aalst and Pesic (Aalst and Pesic 2006) propose a declarative approach that specifies necessary temporal interdependencies. This approach allows a more flexible change of the product model without having to alter complete process descriptions.

The process model provides concepts (rules) for a declarative description of temporal interdependencies between service components. These rules can be mapped on LTL comparable to non-hierarchical dependencies. The rules provided can be divided into two sets: "necessity rules" (defining that a component needs another component to be processed in advance or afterwards) and "exclusivity rules" (defining that a component excludes the execution of another component) (e.g. Table 2).

## 5 Final Discussion and Implications

The proposed meta-model can be used to describe service systems in a formalized, precise and detailed way; thus aiming at a better understanding, less friction and better processing by information technology. As it is based on a broad literature analysis and on an analysis of existing modeling approaches, it covers a fairly wide range of the current state of the art in service systems modeling. The development approach of the meta-model (extracting concepts, a formalized meta-model and technical concretion) allows a continuous enhancement because further concepts can be added or changes of the actual meta-model can be made.

The evaluation of the meta-model (in different use cases) has shown that the concepts provided are sufficient, yet the meta-model might be too expressive and therefore too difficult sometimes to understand. Hence, a revision of the current meta-model might decrease the complexity and simultaneously increase usability. This revision can be achieved by further use cases or by a theoretical analysis of the given meta-model.

Even though the given meta-model can generally be used for modeling all kind of service systems, it is obvious that there are some weaknesses in modeling soft factors of the service domain (e.g. customer satisfaction or "moment of truth") as they cannot be expressed by determinate values.

For a further improvement of the service modeling effort several steps are necessary. Firstly, an automatic analysis of comprehensive text resources would allow an additional extraction of specific concepts in the domain of service science. These concepts could contribute to the meta-model. Furthermore, the meta-model lives up to its promises only when modelers agree on used vocabularies. Therefore, specific vocabularies need to be defined for certain sub-domains of the service domain (e.g. "remote services") and the meta-model has to be adapted to these vocabularies.

While other disciplines have standards (e.g. "UML" in Software Engineering) that can be developed further, no consistent standard exists for modeling service systems so far. Therefore, it is worth thinking about developing a standard for modeling services or investigating standards from other disciplines (e.g. Web Service description standards like WSDL, UDDI, etc.) and analyzing to what extent they can be used or adopted. This standard would lead to a faster and continuous enhancement of existing modeling approaches.

As the modeling approach has the aim to provide a better understanding of service systems and allow a better processing by information technology, it is necessary to build different tools that can facilitate this meta-model. In addition to a graphical editor, tools for simulation, optimization and planning as well as for operational management are necessary.

By the given meta-model a first step has been taken towards a formalized description of services with regard to the idea of service systems.

## References

Aalst, M.W.P. v. d., and Pesic, M. (2006). *Specifying, Discovering, and Monitoring Service Flows: Making Web Services Process-Aware*. BPM Center: BPM Center Report.

Alonso-Rasgado, M.T., Thompson, G. et al. (2004). *State of the art in service design and modelling*. UK: University of Manchester and Volvo Aero.

Araujo, L, and Spring, M (2006). Services, products, and the institutional structure of production. *Industrial marketing Management* 35, 797–805.

Baida, Z., Gordijn, J., et al. (2003). *Service Ontology*, Amsterdam: Vrije Universität.

Bézivin, J. (2005). On the Unification Power of Models. *Software and Systems Modeling* 4(2), 171–188.

Böttcher, M. (2008). *Architecture for Integrated Service Systems*. ASME Engineering Systems Design and Analysis Conference (ESDA 2008), Haifa (Israel).

Brax, S.A. (2007). Service Engineering and Management: Towards a Framework. Research Perspectives. In: S. A. Brax (ed.) *Service Engineering and Management*. (pp. 14–29). Helsinki: IMI Publications.

Budinsky, F., Steinberg, D. et al. (2004). *Eclipse Modeling Framework*. Boston: Addison-Wesley.

Bullinger, H.-J., Fähnrich, K.-P. et al. (2003). Service engineering – methodical development of new service products. *International Journal of Production Economics* 85, 275–287.

Chesbrough, H., and Spohrer, J. (2006). *A Research Manifesto for Service Science*. Communications of the ACM 49(7): 35–40.

Congram, C., and Epelman, M. (1995). How to describe your service – An invitation to the structured analysis and design technique. *International Journal of Service Industry Management* 6(2), 6–23.

Corsten, H. (2001). *Dienstleistungsmanagement*. München, Wien: Oldenbourg.

Czarnecki, K., and Eisenecker, U. (2000). *Generative Programming: Methods, Tools and Application*, Amsterdam: Addison-Wesley Professional.

Da Silveira, G., Borenstein, D. et al. (2001). Mass customization: Literature review and research directions. *International Journal of Production Economics* 72, 1–13.

Fähnrich, K.-P., Meiren, T. et al. (1999). *Service Engineering – Ergebnisse einer empirischen Studie zum Stand der Dienstleistungsgesellschaft in Deutschland*. Stuttgart: Fraunhofer IRB Verlag.

Favre, J.-M. (2005). Foundations of Meta-Pyramids: Languages vs. Metamodels – Episode II: Story of Thotus the Baboon1. In: J. Bezivin and R. Heckel (Ed.). *Language Engineering for Model-Driven Software Development*. Dragstuhl: Internationales Bildungs-und Forschungszentrum für Informatik IBFI.

Fitzsimmons, J.A., and Fitzsimmons, M.J. (2005). *Service Management*. Boston: Irwin Mc-Graw-Hill.

Gadrey, J. (2002). The misuse of productivity concepts in services: Lessons from a comparison between France and the United States. In: J. Gadrey and F. Gallouj (Ed.) *Productivity, innovation and knowledge in services: New economic and socio economic approaches*. (pp. 26–54). Cheltenham: Edwar Elgar.

Johne, A., and Storey, C. (1998). New service development: a review of the literature and annotated bibliography. *European Journal of Marketing* 32(3/4), 184-251.

Kaner, M., and Karni, R. (2006). *A Knowledge Framework for a Service Concept*. 6th International Conference on Knowledge Management, Journal of Universal Computer Science, Graz (Austria).

Kern, H., Böttcher, M. et al. (2008). *Ansatz zur ganzheitlichen Erstellung und Verarbeitung von Dienstleistungsmodellen*. Dienstleistungsmodellierung 2008 – Workshop im Rahmen der Modellierung 2008, LNI, Berlin (Germany).

Linckels, S., Meinel, C. (2006). Resolving Ambiguities in the Semantic Interpretation of Natural Language Questions. In: E. Corchado, et al. (Ed.) IDEAL 2006, LNCS 4224 (pp. 612–619). Berlin, Heidelberg: Springer.

Maglio, P.P., Srinivasan, S. et al. (2006). Service Systems, Service Scientists, SSME, and Innovation. *Communications of the ACM* 49(7), 81–85.

Meffert, H., and Bruhn, M. (2006). *Dienstleistungsmarketing – Grundlagen, Konzepte, Methoden*. Wiesbaden: Gabler Verlag.

Meyer, K., Müller, R. et al. (2008). *Requirements in the Development of Hybrid Industrial Service Systems – an Exploration in the Field of Remote Services*. Stuttgart: RESER 2008.

Miles, I. (2006). Innovation in Services. In J. Fagerberg, D. C. Mowery and R. R. Nelson, *The Oxford Handbook of Innovation.*(pp. 433–458). Oxford: Oxford University Press.

Novak, J.D., and Cañas, A.J. (2008). *The Theory Underlying Concept Maps and How to Construct and Use Them*. Technical Report IHMC Cmap Tools, Florida: Institute for Human and Machine Cognition.

O'Sullivan, J. (2006). *Towards a Precise Understanding of Service Properties*. Queensland: University of Technology.

Parasuraman, A., Zeithaml, V.A. et al. (1985). A Conceptual Model of Service Quality and Its Implications for Future Research. *Journal of Marketing* 49(4), 41–50.

Schmenner, R.W. (1986). How can service business survive and prosper? *Sloan Management Review* 28 (3), 21–32.

Shostack, G.L. (1982). How to Design a Service. *European Journal of Marketing* 16(1), 49–63.

Spohrer, J., Maglio, P.P. et al. (2007). Steps Toward a Science of Service Systems. *IEEE Computer* 40(1), 71–77.

van Deursen, A., Klint, P. et al. (2000). Domain-specific languages: an annotated bibliography. *ACM SIGPLAN Notice* 35(6), 26–36.

Vargo, S.L. (2009). *Alternative Logics for Service Science*. ISSS2009 – International Symposium on Service Science, Keynote speech, Leipzig (Germany).

Vargo, S.L., Lusch R.F. (2004). Evolving to a New Dominant Logic for Marketing. *Journal of Marketing* 68(January 2004) 1–17.

# Onto-ServSys: A Service System Ontology

**Manuel Mora, Mahesh Raisinghani, Ovsei Gelman, and Miguel Angel Sicilia**

**Abstract** In this chapter, we report the design of an ontology (called onto-ServSys) for the relevant service system construct used in the Service Science, Management and Engineering (SSME) arena. These conceptual artifacts have been used to establish a non-ambiguous and common set of basic constructs for supporting automated reasoning on a domain of interest in intelligent systems. While this reported ontology is initial, and still conceptual, we claim it is useful to advance on an integrated view of service systems, which at present, given the multiple and disparate literatures, is fragmented and disperse. Such integration is realized through a Systems Approach, and its design is guided by a conceptual design research method.

**Keywords** Service system · Ontology · Systems approach · Onto-ServSys · i-KMS · Service science · SSME

## 1 Introduction

Service Science, Management and Engineering (SSME), is a holistic academic, business, and governmental endeavor, which has emerged as a plausible interdisciplinary academic response to cope with the knowledge demanded for designing and delivering modern and complex business and governmental services, as well as for designing and managing their co-generative service systems (Chesbrough and Spohrer 2006). Such a service-oriented worldview and knowledge demand can be justified given the shift from a product-based manufacturing economy to a

M. Mora (✉)
Department of Information Systems, Autonomous University of Aguascalientes,
Ave. Universidad 940, Aguascalientes, Ags. México 20131
e-mail: mmora@correo.uaa.mx

H. Demirkan et al. (eds.), *The Science of Service Systems*,
Service Science: Research and Innovations in the Service Economy,
DOI 10.1007/978-1-4419-8270-4_9, 

service-based one (Quinn 1992). Consequently, a vast and rich literature (Spohrer and Kwan 2009) has been generated in the last four decades. However, this avalanche of service frameworks, schemes, models, and constructs has generated also fragmented, disperse and even conflictive knowledge (IfM and IBM 2008). Under this complex situation, a myriad of concepts with a variety of definitions, attributes, and interrelationships, we pose that conceptual artifacts and methods to organize and provide an initial but integrative view are required.

In this chapter, we consider the utilization of ontology – as the conceptual artifact- and the Systems Approach, as the conceptual method for such an aim. An ontology is a formal and computerized specification of constructs for a domain of interest, which have been used for supporting automated reasoning in intelligent knowledge management systems (i-KMS) (O'Leary 1998). The Systems Approach (Ackoff 1971; Checkland 1983; Gelman and Garcia 1989) has showed its usefulness to organize complex conceptual domains (Mora et al. 2008a), and thus, can provide adequate theoretical capabilities to organize conceptually such a complex content. Accordingly, in this chapter, we report the design and conceptual validation of a service system ontology (called Onto-ServSys). This design is guided through a formulative-evaluative conceptual design research method (March and Smith 1995; Glass et al. 2004; Hevner et al. 2004; Mora et al. 2008b). This formulation of formal definitions for such constructs is essential for achieving a theoretically robust foundation and a better understanding of this interdisciplinary field. Consequently, we consider that Onto-ServSys ontology contributes to the literature by adding: (i) an initial ontology which provides integrated conceptualizations and interrelationships on the domain of service systems built on three core analyzed literatures; (ii) harmonization with the core concepts from the Systems Approach; and (iii) an initial knowledge model for deploying i-KMS related to service systems (for instance for describing and comparison of service-oriented process standards and models such as ISO/IEC 20000, ITIL v2/v3 , CMMI-SVC and eSCM-SP v2).

The structure and organization for the chapter is as follows: in Sect. 2 we describe the research method. In Sect. 3, we review the related work on service systems from marketing/managerial, operations research/systems engineering, and IT domains. In Sect. 4 we report the conceptual design and validation of Onto-ServSys. We end this chapter, in Sect. 5 with contributions, limitations and conclusions.

## 2 Research Approach

A formulative-evaluative conceptual design research method can be used for designing a conceptual artifact through a systematic process (Glass et al. 2004). March and Smith (1995) indicate that a design research approach can be used to build and evaluate non-trivial, non-naturally created and non-existent artifacts needed for human-being purposes. In design research, a build activity responds to the inquiry: is it feasible to build an artifact X by using a method, materials, and tools Y?, and an evaluate activity to: does the artifact X fulfill the design range of a set of M expected metrics? While March and Smith (1995) do not report guidelines for the build activity, they suggest two critical metrics for the evaluation activity: utility and value, in contrast to truthfulness of natural and behavioral sciences. Design research method has been also enhanced by Glass et al. (2004) and Hevner et al. (2004). Glass and colleagues propose a formulative-evaluative generic research goal, which can be supported in one specific method from 19 items reported. In Hevner et al.'s framework (2004), seven design research guidelines (reported in Appendix) and four types of products (design artifacts: constructs, models, methods, or instantiations) are reported.

In this chapter, we use a formulative-evaluative conceptual research method (extended by Mora et al. 2008b) with five activities are: CD.1 Knowledge Gap Identification, CD.2 Methodological Knowledge Selection, CD.3 Conceptual Design, CD.4 Design Data Collecting, and CD.5 Analysis and Synthesis. Activities CD.1 and CD.2 corresponds to Sects. 1–3 and 2 of this paper. Activities CD.3, CD.4 and CD.5 are reported in Sect. 4. In CD.2, the selection of the methodological knowledge selection is based on two criteria: (i) adequacy to treat conceptual complex pieces to be analyzed and synthesized, and (ii) specific methodological familiarity by researchers. Given these two criteria, a Systems Approach (Ackoff 1971; Checkland 1983; Gelman and Garcia 1989) and Ontology Engineering (O'Leary 1998) are selected as methodological knowledge tools. Both have proved their effectiveness to organize complex conceptual domains (Mora et al. 2008a). The Systems Approach permits modeling a real or conceptual situation as a system comprised of interacting subsystems, and into a wider system, and an environment, which affects it. All of the systems share a set of essential attributes as: purpose, function, input–output items-flows, and outcomes. Thus, the Systems Approach can provide parsimonious but powerful concepts to organize disparate and complex elements as a hierarchical organization under a common purpose (Mora et al. 2007).

Ontology Engineering approach, in Artificial Intelligence (AI) area, aims to avoid ambiguities in used concepts, promote their re-utilization and standardization, and that they serve as building blocks for more complex automated-reasoning systems (Gruber 1991; Chandrasekaran et al. 1998). An ontology, in the AI domain, is a set of essential agreed definitions on the things to be represented in an intelligent system, and can be defined as: "an intentional specification of the things, their properties, interrelationships, and their basic instances, assumed to exist into a world of interest, expressed explicitly in a formal computerized notation" (extended from Gruber 1993). An ontology differs from a database model in the following issues: (i) ontologies (database models) have a few (a high) number of concepts and a high (a few) number of interrelationships between them; (ii) ontologies (database models) are populated usually with a few (a high) number of instances; (iii) ontologies (database models) permit (does not permit directly) automated inference mechanisms to reason on the concepts per se rather the instances; (iv) ontologies (database models) usually are useful to respond how and why ( what, where, how much, how many) alike queries; and (v) ontologies can be considered meta-models for database models.

Ontologies can be implemented in diverse types of knowledge representations (KR) mechanisms: (i) frames/OKBC based mechanisms (Chaurdhi et al. 1998), (ii) first-order logic (FOL) based mechanisms (Description Logic (DL)) (Hooker 1996; Horrocks and Sattler 2008), and (iii) KIF-based mechanisms (a subset of FOL) (Genesereth and Fikes 1992). Three main criteria can be used describing and comparing these three KR mechanisms. These are: (i) *power expressiveness* defined as the level of variety of language elements to represent efficiently a part of the world; (ii) *reasoning issues* that are features related with the capabilities of the inference engines embedded in the mechanism; and (iii) *pragmatic issues* that are features affecting directly the intention of use of a mechanism due to its utility and easiness of use mainly. These criteria can be also used to compare tools that implement these KR mechanisms (Denny 2002). However, no KR mechanism outperforms to another ones in all criteria. This chapter reports a conceptual design in a generic semantic network. Implementation decision on the final KR mechanism to be used will be realized in next final research stage.

Several methodologies have been reported for designing an ontology. These can be classified in two main categories: (i) methods to design isolated ontologies (Gruninger and Fox 1995; Noy and McGuinness 2008), and (ii) methodologies for designing a full intelligent Knowledge Management Systems (i-KMS) (Heijst et al. 1996; Edgington et al. 2004). In this chapter, we use a methodology based on Noy and McGuinness (2008) given the conceptual design as research goal. In a next research stage, this ontology is planned to be used (computationally implemented) for deploying i-KMSs in the domain of service process standards. The essential tasks for designing the ontology are the following: (i) definition of domain, scope, competency, and design goals of the ontology; (ii) identification of knowledge sources; (iii) initial identification and organization of ontological components (concepts, hierarchy of concepts, interrelationships); and (iv) evaluation and refinement of ontology.

## 3 Theoretical Background on Service Systems Conceptualizations

In particular, three vast research domains on service systems have been: Marketing/Management domain (Levitt 1972, 1976; Lovelock 1983; Shostack 1984; Heskett 1987; Parasuraman et al. 1988; Scheselinger and Heskett 1991; Quinn 1992; Heskett et al. 1994; Vargo and Lush 2004; Lovelock and Gummenson 2004), Industrial and Operations Management domain (Mills and Moberg 1982; Chase and Erikson 1988; Wemmerlov 1989; Cook et al. 1999; Tien and Berg 2003; Tien 2008; Gautschi and Ravichandran 2006; Araujo and Spring 2006; Chase and Apte 2007; Spohrer et al. 2008; Spohrer and Kwan 2009; Mora et al. 2009), and Information Technology domain (Lewis 1976; Pitt et al. 1995; Kettinger and Lee 2005; Rai and Sambamurthy 2006; Demirkan and Goul 2006; Demirkan et al. 2008).

Related research efforts have been also reported on service models and meta-models (Garschhammer et al. 2001; Johnston 2005; Object Management Group 2006 (call for proposals), Jegadeesan and Balasubramaniam 2008; Braun and Winter 2007; Ebert et al. 2007; Black et al. 2007; Alter 2008), and service ontologies (e.g. formal models that enabling reasoning capabilities) (Feier et al. 2005; Baida et al. 2005; MacKenzie et al. 2006; Sheth et al. 2006; The Open Group 2008; Ferrario and Guarino 2008). However, these models have been built uniquely on a single literature (Marketing, Operations Management, or IT) and have omitted fundamental conceptual links to the Systems Approach. Consequently, we claim that while these models are useful for real applications, such schemes still provide a partial view of what is a service and what is a service system. A comprehensive formal model which includes the main common contributions of the three dominant literatures tied with a Systems Approach is required to establish a theoretical robust knowledge bridge. We cannot design efficient, cost-effective and trustworthy service systems when the concept of system is weakly used (Ackoff 1971).

Another extensive historical tracking study on service research by Chase and Apte (2007) reports that scientific studies or interventions on services business are not new. First stage is linked to early 1900, for improving human routines, following the successful cases in the entertainment and hotel/hosting services, via well-designed process and well-defined roles for human participants. A second stage is linked to a clear industrialization of services (Levitt 1972, 1976), the acknowledgement of core services attributes like intangibility, co-production between provider and customer, and simultaneous generation and consumption (Shostack 1984), the extent of customer participation and responsibility in the successful service achievement (i.e. Chase's contact customer model (1978)), the need for a clear service process blueprint where the visible and invisible part of the service process be defined (Shostack 1984), and the management of the demand and supply balance given that the services cannot be produced in advance and stored (Sasser 1976). A third stage is linked to a service strategy view (Heskett 1987), a service profit chain (Heskett et al. 1994), typologies of service systems configurations (Lovelock 1983; Wemmerlov 1989), and quality and guarantee models (Parasuraman et al. 1985; Hart 1988). Finally, a fourth and present stage is mainly related to the concept of information-intensive services (Apte and Mason 1995) and knowledge-based services (Quinn 1992). In particular, Chase and Apte (2007) alert that while the dominance of service sector in the present economy is well recognized, the dedicated research efforts are less than expected.

Hence, while such a vast literature for articulating such *service* and *service systems* constructs have been fruitful, a main standardized scheme has not been reported. Under this complex situation of a variety of definitions, attributes, and interrelationships, we consider that the Systems Approach (Ackoff 1971; Checkland 1983; Gelman and Garcia 1989), can be used to organize such a rich set of insights in an initial plausible integrated formal model (e.g. ontology). According to Mora et al. (2009) the majority of the previous studies provide rich conceptual schemes and models (constructs, attributes and interrelationships) for service system, but these are partial, fragmented, and disperse views by not using the Systems Approach.

Notable exceptions are Chase and Erikson's (1988), Johnson's (1995), Tien's (2008), Spohrer et al.'s (2007); Spohrer's et al. (2008), and Mora et al.'s (2009) studies.

Chase and Erikson (1998) establish the need of open systems logic to understand a service system. Authors (idem) contrast with a closed-system thinking usually perceived in the manufacturing systems. Johnson (1995) develops a systems-based instrument for measuring quality of service composed by three factors: inputs, process, and outputs. Arguments are reported on a more holistic model to capture the complexity of a service system than competitive models. For Spohrer et al. (2007, p. 76) service systems are "... complex adaptive systems made up of people, and people are complex and adaptive themselves. Service systems are dynamic and open, rather than simple and optimized. And there are many different kinds of value, including financial, relationship, and reputation." In Spohrer's et al. study (2008, p. 72) service systems are re-defined as "... a value coproduction configuration of people, technology, other internal and external service systems, and shared information (such as language, processes, metrics, prices, policies, and laws."

Tien (2008) introduces the concept of system of systems (SoS) as a better descriptor of a service system, where the provider and customer entities are systems per se, comprised by the components of people, processes and products. In the domain of systems engineering, the concept of SoS is usually used to make explicit the composition of a complex macro-systems from human-being perceived components like systems per se (Carlock and Fenton 2001). From a theoretical systemic viewpoint, the structure of environment, system and subsystems, can be used recursively.

In Mora et al. (2009), a service is defined as a multifaceted concept that can be mapped to: (i) an agreed and expected flux of interactions between the two entities in the service system, (ii) a property of each entity in the service system that is expected to be positively affected by such interactions, and (iii) an emergent property (e.g. co-generated by the system, and not by individual components) of the service system valued by people but that can be complemented with objective metrics measured automatically by devices. In turn, a service system (idem) is defined as a system comprised of two sub-systems: (i) a *service facilitator* sub-system (e.g. the original service provider), and (ii) a *service appraiser* subsystem (e.g. the initial user's system), that pursues the co-generation of an explicit or implicit agreed and expected service. Thus, because a service system is a *system*, all core foundations from the Systems Approach (Ackoff 1971; Checkland 1983; Gelman and Garcia 1989), that have been derived for all kind of systems, apply on such a real system: (i) the environment, supra-system, system, sub-systems, and components hierarchy; (ii) core properties (emergence, purposefulness, organization, controllability, and wholeness); and (iii) the variety of inherent systemic problems (environment-system-subsystem conflicts).

In this chapter, we update the service system conceptualization reported in Mora et al. (2009) by integrating main updated service literature and redesigning the concept of service systems in congruence with the Tien's concept (2008) of a system of systems (SoS). A working conceptual table (it is not reported here for space reasons but it is available upon request) was elaborated as follows: (i) first, we elaborate an updated skeleton of a service system by using core concepts of the Systems Approach (Ackoff 1971; Checkland 1983; Gelman and Garcia 1989), and previous service system concepts reported in Tien (2008), Spohrer et al. (2008), and Mora et al. (2009); (ii) second, we review integrated literature from the three domain aforementioned, and populate the skeleton; (iii) third, we assess the most consistently supported concepts and attributes in three core literatures, and mark such concepts like essential ones. In this working table, we use the symbols (●, ◘, ◉, ⊙, ○) to assess the following. Likert scale: (●) very high support, (◘) high support, (◉) moderate support, (⊙) weak support, and (○) null support, in each literature. Finally, in the last column, we report the integrated systemic model from these three dominant service literatures. From this working table, we elaborate the Table 1.

**Table 1** The baseline conceptual matrix for service systems

| Core concepts for ontology | | Mapping to the ten essential SSME concepts | |
|---|---|---|---|
| C1.1 | System of service systems | E1 | Ecology of service systems |
| C1.2 | Service system (comprised of service organizations) | E2 | Service system (entities) |
| C1.3 | Facilitator sub-system | E3a | Service entities of a service system (supplier) |
| C1.4 | Appraiser sub-system | E3b | Service entities of a service system (customer) |
| C1.5 | Services (as flux of interactions) | E4 | Interactions of entities |
| C1.6 | Services (as levels of attributes of interest for service systems entities) | E5 | Service measures (quality, productivity, compliance, sustainable innovation/ improvement ) |
| C1.7 | Services (as valued outcomes) | E6 | Outcomes (value propositions) |
| C1.8 | Services (as levels of attributes of interest for service systems entities) | E7 | Service measures (change of status on core attributes in both supplier and customer entities) |
| C1.9 | Processes | E8a | Resources (organizations) |
| C1.9 | People | E8b | Resources (people) |
| C1.10 | Other resources (materials and technology, information and knowledge, capital) | E8c | Resources (technology, information) |
| C1.4* | Appraiser sub-system | E9 | Service system's stakeholders (customer, provider, authorinty, competitor, others (owners, employees, community) |
| C1.3* | Facilitator sub-system | | |
| C1.11 | Regulator-competitor system | | |
| C1.12 | Support system | | |
| C1.13 | Owner system | | |
| C1.5* | Services (as flux of interactions) | E10 | Access rights (privileged access, owned, outright, leased, contracted, shared access) |
| C1.14 | System's envelop (economic, socio-cultural, technological, political-legal and natural-ecological systems) | | It is not considered explicitly in the ten fundamental SSME concepts. |

This Table 1 was populated by (i) selecting the most important common concepts reported in analyzed literatures, and (ii) a viable mapping on the ten initial agreed fundamental concepts in modern SSME research (Spohrer et al. 2008; Spohrer and Kwan 2009; IfM and IBM 2008). Fourteen essential concepts were generated and all of them are mapped to the ten fundamental concepts, except the system's envelop (macro environment) concept which is not explicitly reported in them.

Hence, we consider the set of concepts reported in Table 1 as the essential baseline of constructs for designing a service system ontology. However, further analysis of the ontology, based on development methodologies, suggest that the initial baseline can be iteratively improved and be preceded by a more generic ontology (Chandrasekaran et al. 1999). It will be enhanced in Sect. 4, through the addition of three complementary set of concepts.

## 4 Conceptual Design and Validation of Onto-ServSys

Onto-ServSys is designed through the utilization of a methodology based on Noy and McGuinness (2008). Its five tasks are: (i) definition of domain, scope, competency, and design goals of the ontology; (ii) identification of knowledge sources; (iii) initial identification and organization of ontological components (concepts, hierarchy of concepts, interrelationships); and (iv) evaluation and refinement of ontology.

### *4.1 Task 1: Definition of Domain, Scope, Competency, and Design Goals of the Ontology*

In this task, the domain refers to the knowledge area(s) to be represented in the ontology. Onto-ServSys is an ontology designed for the domain of service systems and systems (in general). Onto-ServSys will cover the essential concepts and interrelationships that have been posed in the three main service systems literatures. Competency of an ontology refers to its functional capabilities for responding inquiries. The generic required inquiries for Onto-ServSys are the following: (a) why a service systems is a system?; (b) how a service system is comprised?; (c) what is a service?;(d) what kind of outcomes can generate a service?; (e) what are the inputs to a service system?; and (f) what are the outputs to a service system?

Finally, design goals must be established to establish generic evaluation criteria and design guidelines. According to Gruber (1993) the following ontology design goals should be pursued: (i) clarity, (ii) coherence, (iii) extendibility, (iv) minimal encoding bias, and (v) minimal ontological commitment. We support first four principles. We consider that while ontologies can be generic and must contain only essential concepts, we consider that usefulness and value are also worthy design goals that must be reached. Under this situation, we sacrifice generality by usefulness. Clarity implies that ontology must be understood without difficulties. We use conceptual maps for this design aim. Coherence implies logical consistency in the definitions and restrictions (via axioms) elaborated in the ontology. It also means conceptual coherence between several knowledge sources. We pursue this design goal via an integrated systematization by using Systems Approach as the shared common vocabulary. Extendibility implies its potential to be used as basis for extensions, adaptations, seeking more specific ontologies. We pursue this design goal with a balance between general and specific content. Minimal encoding bias implies a specific notation linked to a specific KR tool. We avoid it by using a conceptual map representation that can be mapped to frames, KIF or description logic (DL) mechanisms.

## *4.2 Task 2: Identification of Knowledge Sources*

In this task, it is required to locate knowledge sources (human, documents). For Onto-ServSys the main sources are the core literature on service systems from marketing/managerial, operations and industrial management, and IT domains. In the domain of Systems Approach core literature (Ackoff 1971; Checkland 1983; Gelman and Garcia 1989), updated system models (Mora et al. 2003; Mora et al. 2009) are the knowledge sources. Sect. 3 reports it.

## *4.3 Task 3: Initial Identification and Organization of Ontological Components (Concepts, Hierarchy of Concepts, Interrelationships)*

In this task, a list of potential concepts is required at first step. Table 1 is the source of initial concepts to be used. However, three additional sets of concepts are required for completing this initial service system ontology: a set of general system concepts (Table 2), a set of organizational system concepts (Table 3), and set of top concepts (Table 4).

**Table 2** The set of general system concepts

| | |
|---|---|
| C2.1 | General system ( system I, system II) |
| C2.2 | System I (core attributes (emergence, purposefulness, controllability, organization, problematization, wholeness); core events (reactions, responses, self-actions) |
| C2.3 | System II (subsystems, components, relationships) |
| C2.4 | Sub-system |
| C2.5 | Component |
| C2.6 | System of systems (or supra-system) |
| C2.7 | Entourage (immediate environment) |
| C2.8 | Envelope (macro environment) |
| C2.9 | System input-outputs (objective measures (efficiency, efficacy)) |
| C2.10 | System outcomes(subjective measures(effectiveness, ethical, aesthetical)) |

**Table 3** The set of organizational system concepts

| | |
|---|---|
| C3.1 | Organization = system |
| C3.2 | Organizational subsystem = High-Level Business Process (low-level business process (driver), low-level business process(driven), low-level business process (informational), socio-political forces) |
| C3.3 | Organizational low-level process = (activities, socio-political business forces) |
| C3.4 | Organizational socio-political process (social forces, political forces) |
| C3.5 | Organizational activity = (tasks, resources (people, procedures, tools, knowledge, capital)) |
| C3.6 | Service = (human-valued {flux of acts, objective attribute, subjective outcome}) |
| C3.7 | Product = (machine-valued {simple object, complex object}) |
| C3.8 | Organizational system of system = Supra-system (core attributes: purpose, function, inputs, outputs, outcomes, other-organizational systems of the same organization) |
| C3.9 | Organizational entourage (core attributes: purpose, function, inputs, outputs, outcomes, other-systems(customers, suppliers, competitors, regulators, partnerships)) |
| C3.10 | Organizational envelop ( core attributes: purpose, function, inputs, outputs, outcomes, other-supra-systems (technological, economic, legal, social, ecological)) |

**Table 4** The set of essential entities

| | |
|---|---|
| C4.1 | Thing (real, conceptual) |
| C4.2 | Real thing (real (mechanisms, structures), actual (event experienced, events not experienced), empirical) |
| C4.3 | Conceptual thing (individual, social) |
| C4.4 | Real system (natural, artificial, social) |
| C4.5 | Conceptual system (artificial, social) |

From authors' expertise and previous published research (Gelman and Garcia 1989; Mora et al. 2003, 2007) we report in Table 2 the set of concepts for general systems, and in Table 3 the set of organizational system concepts. In Table 4, we report the most essential set of elements (top hierarchy of concepts in an ontology). We use in this chapter a transcendental realist ontology (Bhaskar 2008) combined with fundamental classification of systems from Checkland (1983). Bhaskar' philosophical view has been reported as highly congruent with the Systems Approach (Mora et al. 2007).

Given such a list of concepts, a map of interrelationships, and a hierarchical map is developed. We use a simple but powerful notation to elaborate the map of interrelationships (see Fig. 1). This notation is adapted from Common KADS-based Methodology (Heijst et al. 1996). Such an ontology design is an iterative process due to complexity of several sources.

Figures 1–3 show three partial views of the initial design. In Fig. 1, the essential ontology based on transcendental realist concepts is reported in gray color with the link to the concept of general system.

In Fig. 1, the notation for the different relationships used is also reported (is-a-type-of, can-be-of-type, is-part-of, has(min:max), is-instance-of, and a generic one). In Table 7 (Appendix) an explanation and examples of these conceptual links are

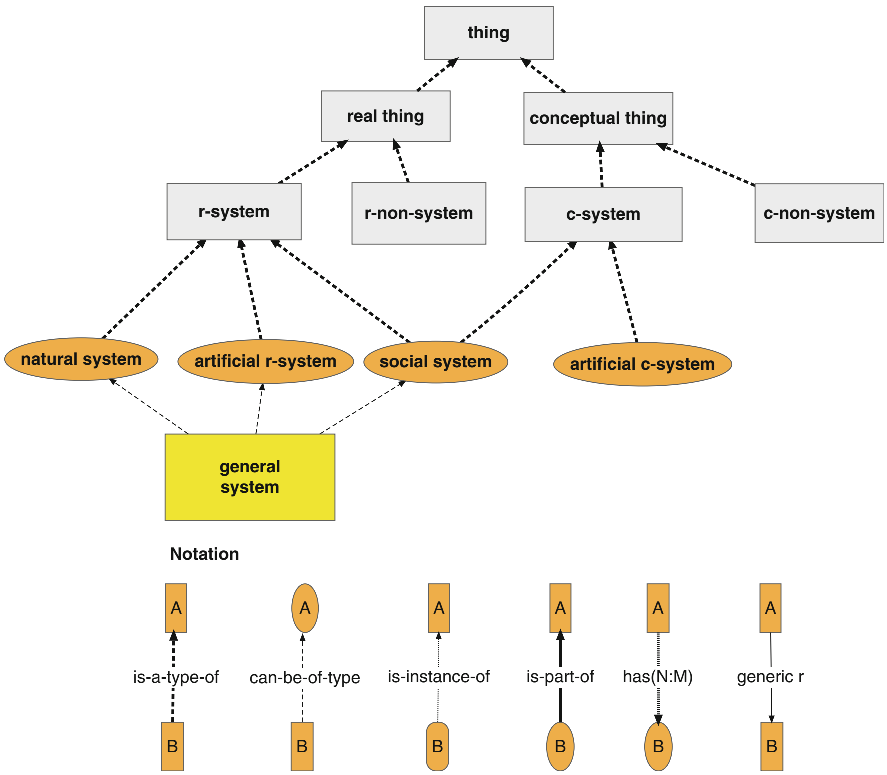



**Fig. 1** Essential ontology of things

reported. In Figs. 2 and 3, partial views (by space limitations) of the service system ontology are reported. Systems concepts are reported in yellow color (light gray), business organizational concepts in blue color (gray), and service system concepts in purple color (dark gray). This initial ontology is represented as a semantic network (Sowa 2000). A semantic network is a graph of nodes (concepts) and edges (binary relationships between concepts). Semantic networks provide simplicity and a rich expressiveness capacity in a high-level modeling mode. We consider such modeling features as relevant before proceeding to a more detailed description of the ontology, where other more powerful inferential mechanisms but also more expressively limitative like description logic (a subset of first-order logic) can be used (Horrocks and Sattler 2008).

## 4.4 *Task 4: Evaluation and Refinement of Ontology*

In this final step, we consider an internal evaluation (conducted by the authors) based on the following criteria (Gruber 1993): (i) clarity, (ii) coherence,

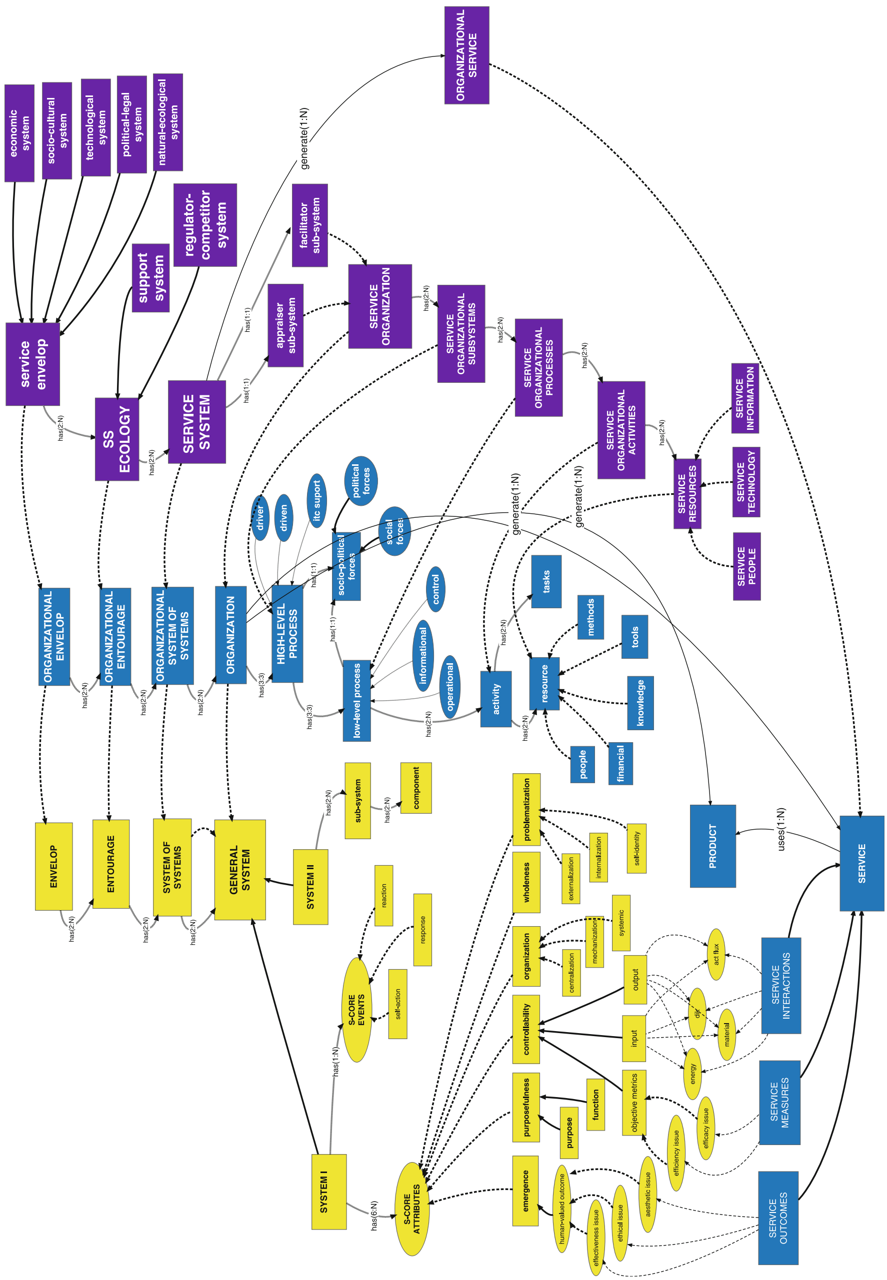



**Fig. 2** Service systems ontology (system and organization system view)

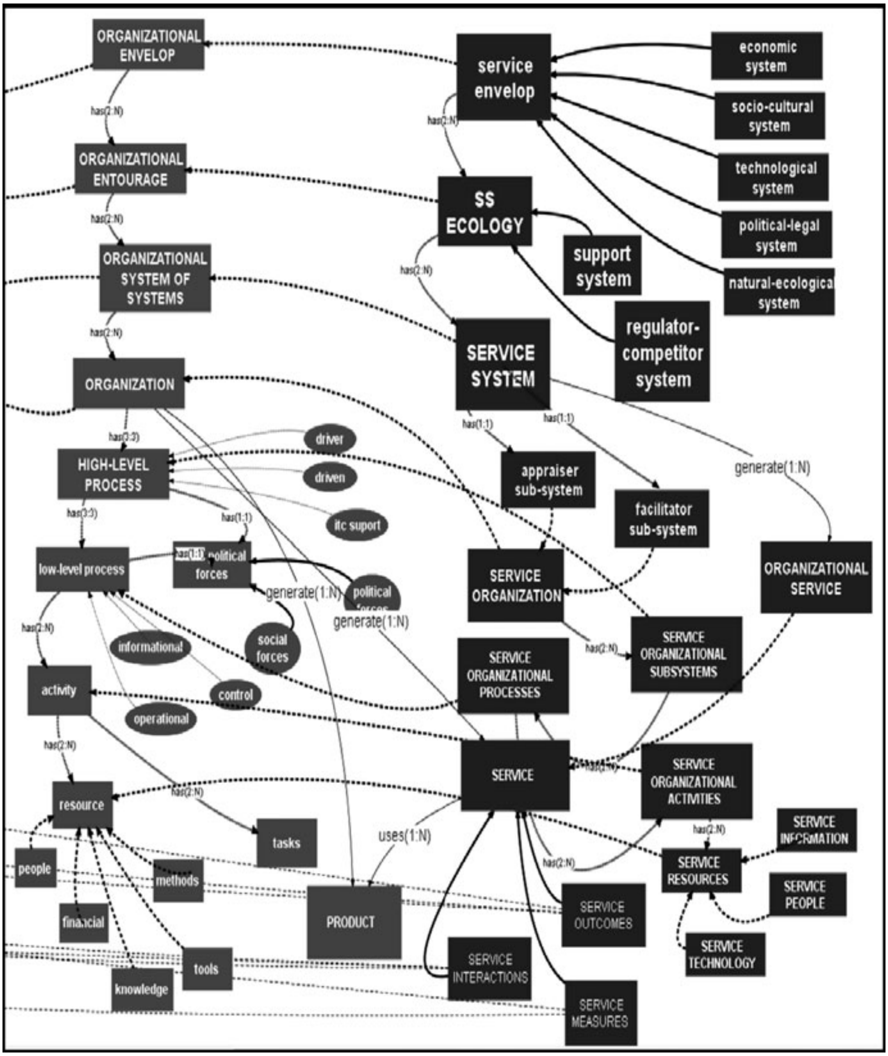



**Fig. 3** Service systems ontology (organization system and service system view)

(iii) extendibility, (iv) minimal encoding bias, and (v) minimal ontological commitment. For this aim, we review the following inquires: (i) is the ontology cognitively clear?, (ii) is the ontology coherent with theoretical sources?, (iii) can the ontology be easily extended , (iv) is the ontology limited to a specific representation?, and (v) is the ontology linked to some philosophical commitment?

Authors, from different backgrounds (Systems Engineering, Computer Sciences, Information Systems, and Mathematics and Systems), verified that this ontology satisfies the clarity principle, because is simple to be understood by audiences in these four disciplines. Given the theoretical sources used in its design (Tables 1–4), authors also consider that this ontology satisfies the coherence principle. The extendibility principle is also achieved given a balance between generic concepts and specific reported in service literature. In this way, additional generic and specific concepts can be used to adapt and extend this ontology. The minimal ontology encoding bias is achieved via a generic semantic network representation, which can be mapped to several KR mechanisms.

Finally, we differ of the ontological commitment principle. While Gruber (1993) suggests as positive criterion to avoid it, we consider that the opposite purpose is more consistent with what an ontology is: the acceptance of what exists in a domain. Thus, we define an ontology as a precise commitment to accept what is considered to be in a domain. For instance, for a transcendental realist ontology (Bhaskar 2008), the commitment is the existence of real and conceptual things. While real things have enduring mechanisms and structures, the conceptual things have only modifiable ones.

A second evaluation conducted by the authors reviewed the competency inquires for which the ontology must provide responses (e.g. the ontology must have knowledge codified for answering them). Competency responses implicitly include a pragmatic completeness criterion. From a formal view, logical completeness implies that the any logical sentence implied in the ontology can be derived by applying logical rules. KIF-based mechanisms (a subset of First-order Logic) makes a trade-off on this attribute (there is not an algorithm to satisfy this attribute in KIF-based mechanisms) versus expressiveness power. However, this mechanism is logically soundness which implies that only valid (truth) derivations can be achieved (Hooker 1996) and a pragmatic completeness is realized through the correct derivation for the competency inquiries.

The six expected competency inquiries are achieved as follows: (a) why a service system is a system? From Fig. 2, a service system is an organizational system of systems (is-type-of(B: service system, A: organizational system of systems)), and it is a type of system of systems, which while it has also several general systems, per se, is a general system (is-type-of(B: system of systems, A: general system)). Hence, a service system has all default elements for a general systems. It has an entourage and an envelope. The entourage attribute in the general system will lead to the derivation of a service entourage (called service ecology) which has the regulator-competitor and support systems. The envelope attribute, in turn, will lead to derive the service envelop that has the economic, socio-political, technological, political-legal and natural-ecological systems.

The second competency inquiry (b) how a service system is comprised?, is achieved as follows: a service system has one facilitator and one appraiser systems. Both are of type service organizations, and a service organization is a type of an organization. From this concept, the elements of an organization can be mapped to the facilitator and appraiser systems. In particular, the people, processes and other resources are part-of a service organization also via the organizational resource concept. It is relevant to note that a service system concept considers the general case of a facilitator entity and a specific market of customers, rather than an individual customer. This specific market segment can be analyzed like a virtual organization. We suggest that this view will help in the design process of a service facilitator system.

The third competency inquiry, i.e., “(c) what is a service?” is achieved as follows: a service is an entity with three sub-types: service outcomes, service measures and service interactions. Service outcomes can be effectiveness, ethical or aesthetical issues, but all of them are human-valued outcomes, which is the emergence of a general system (e.g. the service system). Service measures can be efficiency and efficacy issues but both are objective metrics, which is a part of the controllability issue of any general system. Finally, service interactions can be a flux of actions, energy, material, or data-information-knowledge items. This ontology, thus, supports the 3-dimensional view of what a service is. As a human-valued outcome, a service is type of system outcome from effectiveness, ethical, or aesthetical types. As an objective outcome, a service is a type of system fact or event from efficiency or efficacy type, and as a flux of acts, a service is a type of output in a system.

The fourth competency inquiry, i.e., “(d) what kind of outcomes can a service generate?”, is achieved from a similar reasoning chain reported in the (c) case. It can be derived that a service can generate an human-valued outcome among effectiveness, ethical or aesthetical types.

Fifth and sixth competency inquires, i.e., “(e) what are the inputs to a service system?, and (f) what are the outputs to a service system?”, are achieved because a service system can be assessed as a general system (through several derivations), and it has a system. It also has some s-core attributes, where one of them is controllability. This attribute is made of three concepts, i.e., objective metrics, inputs and outputs. The inputs and outputs could be energy, material, data-information-knowledge, or a flux of acts. Hence, the inputs and outputs of a service system are derived as energy, material, data-information-knowledge, or a flux of acts.

## 5 Conclusions

In this paper, we address the implicit research purpose associated with the existing “service system” literature in order to reduce and manage the cognitive complexity manifested by multiple concepts, attributes, interrelationships, focus of interest, and conceptual layers, through two conceptual tools: a skeleton/frame based on the Systems Approach and a conceptual (and computationally feasible) ontology. Given the inherent complexity, we have relied on main integrative and core studies in the three literatures that have dedicated the greatest efforts to study such concepts. Our purpose is not to design a particular simple model (e.g. around 7–10 constructs) for being empirically tested and statistically derived from the particular associations among these constructs. While we believe this is useful, we also consider that the state of the art on the knowledge of service and service systems, in its new perspective (Spohrer et al. 2007), demands – at present – wider conceptual models, which can be used to select diverse specific models (e.g. conceptual sub-sets of the general model).

Thus, we have reviewed the main contributions and conflicts from service studies on marketing/managerial, industrial and operations management, and IT domains to gather key findings that permit the generation of a more theoretically robust conceptualization of a service system construct. While that the study of services has been underway for more than a century (Chase and Apte 2007), its economic relevance is for the first time seen as critical in the current post-industrial society where knowledge and services are more important than labor and products, despite the fact that the latter are still included and needed by the former. However, while a vast and rich literature has reported valuable knowledge on service and service systems, the core knowledge fragmentations can be identified as follows: (a) the concept of service is perceived differently as acts, events, or an intangible value; (b) the theoretical links from service literature and systems literature have not been fully explored; (c) the systemic structure of service business organizations and service delivering has been further explored in IT domains, rather than in managerial and operations management domains, as a possible consequence of the critical role of computer and communications technologies in the post-industrial society (Huber 1984); (d) a knowledge map on service and service systems has been missing in the literature; and (e) the few reported ontologies have been limited to computer services rather than general service and services systems. Consequently, such a knowledge generation must cope with all features relevant for management and engineering services and service systems, and not uniquely on single aspects. For instance, in the information technology domain, the knowledge of service-oriented technologies has preceded the knowledge of methodologies for designing large-scale and complex service-oriented systems, or the knowledge on standards and model of processes for managing IT as a service has preceded the knowledge of design and building them. We consider that these knowledge gaps lead to knowledge islands between the academicians and practitioners in the same IT domain. If we added another core domain (e.g. marketing/managerial, and/or industrial and operations management) to this IT stream, the cognitive confusion on service and service systems becomes unavoidable.

From a managerial perspective, the core ideas presented in this chapter highlight their relevance to unique aspects of value creating service systems and networks, especially along key agreed SSME performance indicators/dimensions such as service quality, service productivity, service compliance, and service innovation. Modern organizations must develop and maintain a strong learning environment to remain competitive in the modern global economy, continually transforming themselves to embrace change. They must figure out how to disseminate their own internal knowledge, in addition to acquiring knowledge externally. One of the methods for executing this strategy is to elaborate and conceptually validate a formal specification for service systems. The companies who can successfully perform this will become learning organizations. The level of learning in an organization can directly impact its ability to implement new technology and e-business systems, required for keeping pace with competitors.

Hence, we consider that this paper contributes to our academic and practitioner knowledge on service systems addressing the following issues: (i) it presents an original ontology (called Onto-ServSys) that provides integrated conceptualizations and interrelationships on the domain of service systems; (ii) it presents a plausible harmonization of core findings on service systems from three core literatures with core concepts from the Systems Approach, which have been omitted in such literatures; and (iii) it makes available an explicit knowledge model that can be used as an ontology base for further deploying of an i-KMS for describing and comparison process standards and models on services, as well as services systems in general. Given the cognitive complexity to merge disparate literatures on similar real constructs (service, and service systems) but differently conceptualized, we consider that the Systems Approach can provide suitable tools for organizing such concepts and reducing, and managing such a complexity. However, we recognize that this proposal is an initial model, and more detailed ones, and empirical tests on deployed i-KMS are required for a better understanding of this complex concept: a service system.

**Acknowledgements** This research was developed with the financial support of the Autonomous University of Aguascalientes, Mexico (www.uaa.mx) (Project PIINF08-2) and PROMEP (Research Network in Engineering and Management of IT Services (RIGSTI)).

## References

Ackoff, R. (1971). Towards a system of systems concepts. *Management Science,* 17(11), 661–671.

Alter, S. (2008). Service system fundamentals: Work system, value chain, and life cycle. *IBM Systems Journal*, 47(1), 71–85.

Apte, U. and Mason, R. (1995). Global disaggregation of information- intensive services. *Management Science*, 41(7), 1250–1262.

Araujo, L. and Spring, M. (2006). Services, Products, and the Institutional Structure of Production. *Industrial Marketing Management*, 37, 797–805.

Baida, Gordijn, J., Saele, H., Akkermans, H. and Morch, A. (2005). *An Ontological Approach for Eliciting and Understanding Needs in e-Services*. CAiSE 2005 Conference, Porto, Portugal, June 13–17, 3520 LNCS, 400–414.

Bhaskar, R. (2008). *A Realist Theory of Science*, 2nd. Edition. London, UK: Routledge, 1st edition, 1975.

Black, J., Draper, C., Lococo, T., Matar, F. and Ward, C. (2007). An integration model for organizing IT service management. *IBM Systems Journal*, 46(3), 405–422.

Braun, C. and Winter, R. (2007). *Integration of IT Service Management into Enterprise Architecture*. SAC'07, Seoul, Korea, March 11–15, 1215–1219.

Carlock, P. and Fenton, R. (2001). System of Systems (SoS) Enterprise Systems Engineering for Information-intensive Organizations. *Systems Engineering*, 4(4), 242–261.

Chandrasekaran, B., Josephson, J. and Benjamins, R. (1998). *The Ontology of Tasks and Methods.* KAW'98, Banff, Canada, April 18–23, 1–49.

Chandrasekaran, B., Josephson, J. and Benjamins, R. (1999). What are Ontologies, and Why do We Need. *IEEE Intelligent Systems*, 1, 20–25.

Chase, R. and Apte, U. (2007). A history of research in service operations: What's the big idea? *Journal of Operations Management*, 25, 375–386.

Chase, R. and Erikson, W. (1988). The Service Factory. *The Academy of Management Executive*, 2(3), 191–196.

Chaurdhi, V., Farquhar, A., Fikes, R., Karp, P. and Rice, J. (1998). *Open Knowledge Base Connectivity 2.0.3*. Technical Report, AI Center, SRI International, 1–161.

Checkland, P. (1983). O.R. and the systems movement: mappings and conflicts. *Journal of the Operational Research Society*, 34(8), 661–675.

Chesbrough, H. and Spohrer, J. (2006). A research manifesto for services science. *Communications of the ACM*. 49(7). 35–40.

Cook, D., Goh, C. and Chung, C. (1999). Service Typologies: a State of the Art Survey. *Production and Operation Management*, 8(3), 318–338.

Denny, M. (2002). *Ontology Building: A Survey of Editing Tools*. Internet document at www.xml.com. Accessed February 1st 2007.

Demirkan, H. and Goul, M. (2006). Towards the service-oriented enterprise vision: bridging industry and academics. *Communications of the Association for Information Systems*, 18(26), 546–556.

Demirkan, H., Kauffman, R., Vayghan, J., Fill, H., Karagiannis, D. and Maglio, P. (2008). Service-oriented technology and management: Perspectives on research and practice for the coming decade. *Electronic Commerce Research and Applications*, 7, 356–376.

Ebert, N., Uebernickel, F., Hochstein, A. and Brenner, W. (2007). *A Service Model for the Development of Management Systems for IT-enabled Services*. AMCIS Conference, Colorado, USA, August 9–12, 1–8

Edgington, T., Choi, B., Henson, K., Raghu, T. and Vinze, A. (2004). Adopting Ontology for Facilitate Knowledge Sharing. *Communications of the ACM*, 47(11), 85–90.

Feier, C., Roman, D., Polleres, A., Domingue, J., Stollberg, M. and Fensel, D. (2005). *Towards Intelligent Web Services: TheWeb Service Modeling Ontology (WSMO)*. ICIC 2005, Hefei, China, August 23–26, 1–10.

Ferrario, R. and Guarino, N. (2008). *Towards an Ontological Foundation for Services Science*. FIS 2008, Vienna, Austria, September 29–30, 1–13.

Garschhammer, M., Hauck, R., Kempter, B., Radisic, I., Roelle, H. and Schmidt, H. (2001). The MNM Service Model – Refined Views on Generic Service Management. *Journal of Communications and Networks*, 3(4), 297–306.

Gautschi, D. and Ravichandran, T. (2006). Services Science – a master in search of a discipline. almaden.ibm.com, 1–4. Accessed February 1st 2007.

Gelman, O. and Garcia, J. (1989). Formulation and axiomatization of the concept of general system. *Outlet of the Mexican Institute of Planning and Systems Operation*, 19(92), 1–81.

Genesereth, M. and Fikes, R. (1992). *Knowledge Interchange Format: Reference Manual*. Technical Report Logic-92-1, Computer Science Department, Stanford University.

Glass, R., Ramesh, R. and Vessey, I. (2004). An Analysis of Research in Computing Disciplines. *Communications of the ACM*, 47(6), 89–94.

Gruber, T. (1991). The Role of Common Ontology in Achieving Sharable, Reusable Knowledge Bases. In: J. A. Allen, R. Fikes, and E. Sandewall (Eds.), *Principles of Knowledge Representation and Reasoning: Proceedings of the Second International Conference*, (pp. 601–602) Cambridge, MA, USA: Morgan Kaufmann.

Gruber, T. (1993). *Toward Principles for the Design of Ontologies Used for Knowledge Sharing*. Technical Report KSL 93-04, Knowledge Systems Laboratory, Stanford University, 1–23.

Gruninger, M. and Fox, M. (1995). *Methodology for the Design and Evaluation of Ontologies*. Technical Report. Department of Industrial Engineering, University of Toronto, Canada, 1–10.

Hart, C. (1988). The power of unconditional service guarantee. *Harvard Business Review*, 66(4), 54–62.

Heijst, G. van, Schreiber, A. and Wielinga, B. (1996). Using explicit ontologies in KBS development. *International Journal of Human-Computer Studies*, 46 (2/3), 183–292.

Heskett, J. (1987). Lessons in the Service Sector. *Harvard Business Review*, March–April, 118–126.

Heskett, J., Jones, T., Loveman, G., Sasser, E. and Schlesinger, L. (1994). Putting the Service-Profit Chain to Work. *Harvard Business Review*, March–April, 164–174.

Hevner, A., March, S., Park, J. and Ram, S. (2004). Design Science in Information Systems Research. *MIS Quarterly*, 28(1), 75–105.

Hooker, J. (1996). *First Order Logic (Tutorial in)*. Pittsburgh, PA: GSIA, Carnegie-Mellon University, 1–29.

Horrocks, I. and Sattler, U. (2008). *Description Logics: Basics, Applications, and More (Tutorial)*. ECAI, Patras, Greece, July 18–25, 1–74.

Huber, G. (1984). The Nature and Design of Post-industrial Organizations. *Management Science*, 30(6), 928–951.

If M and IBM. (2008). *Succeeding through Service Innovation: Developing a Service Perspective for Education, Research, Business and Government*. Cambridge, UK: University of Cambridge Institute for Manufacturing.

Jegadeesan, H. and Balasubramaniam, S. (2008). An MOF2-based Services Metamodel. *Journal of Object Technology*, 7(8), 71–96.

Johnson, R. (1995). Measuring service quality: a systems approach. *Journal of Services Marketing*, 9(5) 6–19.

Johnston, S. (2005). *UML 2.0 Profile for Software Services*. www.ibm.com/developerworks, April, 1–9. Accessed February 1st 2007.

Kettinger, W. and Lee, C. (2005). Zones of Tolerance: Alternatives Scales for Measuring Information Systems Service Quality. *MIS Quarterly*, 29(4), 607–623.

Levitt, T. (1972). Production-line approach to service. *Harvard Business Review*, Sept–Oct, 41–52.

Levitt, T. (1976). The Industrialization of Service. *Harvard Business Review*, Sept–Oct, 63–74.

Lewis, L. (1976). Service level: a concept of the user and the computer center. *IBM Systems Journal*, 4, 328–357.

Lovelock, C. (1983). Classifying Services to Gain Strategic Marketing Insights. *Journal of Marketing*, 47, 9–20.

Lovelock, C. and Gummenson, E. (2004). Whither Services Marketing? In Search of a New Paradigm and Fresh Perspectives. *Journal of Services Research*, 7(1), 20–41.

MacKenzie, C., Laskey, K., McCabe, F., Brown, P. and Metz, R. (2006). *Reference Model for Service Oriented Architecture 1.0. OASIS Standard*. 1–31.

March, S. and Smith, G. (1995). Design and natural science research on information technology. *Decision Support Systems*, 15, 251–266.

Mills, P. and Moberg, D. (1982). Perspectives on the Technology of Service Operations. *The Academy of Management Review*, 7(3), 467–478.

Mora, M., Gelman, O., Cervantes, F. et al. (2003). A systemic approach for the formalization of the information system concept: why information systems are systems?. In J. Cano (Ed). *Critical reflections of Information systems: a systemic approach*, (pp. 1–29), Hershey, PA, USA: Idea Group.

Mora, M., Gelman, O., Forgionne, G., Petkov, D. and Cano, J. (2007). Integrating the Fragmented Pieces of IS research Paradigms and Frameworks: A systems Approach. *Information Resources Management Journal*, 20(2), 1–22.

Mora, M., Gelman, O., Frank, M., Cervantes, F. and Forgionne, G. (2008a). Toward an Interdisciplinary Engineering and Management of Complex IT-intensive Organizational Systems: a Systems View. *International Journal of Information Technologies and the Systems Approach*, 1(1), 1–24.

Mora, M., Gelman, O., O'Connor, R., Alvarez, F. and Macias-Luevano, J. (2008b). A Conceptual Descriptive-Comparative Study of Models and Standards of Processes in SE, SwE and IT disciplines using the Theory of Systems. *International Journal of Information Technologies and the Systems Approach*, 1(2), 57–85.

Mora, M., Raisinghani, M., O'Connor, R. and Gelman, O. (2009). Toward an Integrated Conceptualization of the Service and Service System Concepts: a Systems Approach. *International Journal of Information Systems in the Service Sector*, 1(2), 36–57.

Noy, N. and McGuinness, D. (2008). *Ontology Development 101: A Guide to Creating Your First Ontology*. Technical Report, Stanford University, 1–25.

O'Leary, D. (1998). Using AI in Knowledge Management: Knowledge Bases and Ontologies. *IEEE Intelligent Systems*, May–Jun, 34–49.

OMG (Object Management Group) (2006). *UML Profile and Metamodel for Services (UPMS) (Request For Proposal).* OMG Document: soa/2006-09-09, 1–69.

Parasuraman, A., Zeithaml. V. and Berry, L. (1985). A Conceptual Model of Service Quality and its Implications for Future Research. *Journal of Marketing*, Fall 49, 41–50.

Parasuraman, A., Zeithaml, V. and Berry, L. (1988). SERVQUAL: A Multiple-Item Scale for Measuring Consumer Perceptions of Service Quality. *Journal of Retailing*, 64(1), 12–40.

Pitt, L., Watson, R. and Kavan, B. (1995). Service Quality: a Measure of Information Systems Effectiveness. *MIS Quarterly*, June, 173–185.

Quinn, J. (1992). *Intelligent Enterprise*. New York, USA: The Free Press.

Rai, A. and Sambamurthy, V. (2006). The Growth of Interest in Services Management: Opportunities for Information Systems Scholars. *Information Systems Research*, 17(4), 327–331.

Sasser, J. (1976). Match supply and demand in service industries. *Harvard Business Review*, 54 (6), 133–140.

Scheselinger, L. and Heskett, J. (1991). The Service-driven Service Company. *Harvard Business Review*. Sept–Oct, 71–81.

Sheth, A., Verman, K. and Gomadan, K. (2006). Semantics to Energize the full Services Spectrum. *Communications of the ACM*, 49(7), 55–61.

Shostack, G. (1984). Designing Services that Deliver. *Harvard Business Review*, January–February, 133–139.

Spohrer, J., Maglio, P., Bailey, J. and Gruhl, D. (2007). Steps Toward a Science of Service Systems. *IEEE Computer*, January, 71–78.

Spohrer, J., Vargo, S., Caswell, N. and Maglio, P. (2008). The Service Systems as the Basic Abstraction of Service Science. In: *Proceedings of the 41st Hawaii International Conference on System Sciences*, January 7–10, Waikoloa, Big Island, Hawaii, 1–10.

Spohrer, J., and Kwan, S. (2009). Service Science, Management, Engineering, and Design (SSMED): An Emerging Discipline - Outline & References. *International Journal of Information Systems in the Service Sector*, 1(3), 1–3.

The Open Group (2008). *Service-Oriented Architecture Ontology*. Draft Technical Standard, 1–112.

Tien, J. (2008). Services: A System's Perspective. *IEEE Systems Journal*, 2(1), 146–157.

Tien, J. and Berg, D. (2003). A case for service systems engineering. *Journal of Systems Science and Systems Engineering*, 12(1), 13–38.

Vargo, S. and Lush, F. (2004). Evolving to a New Dominant Logic for Marketing. *Journal of Marketing*, 68, 1–17.

Wemmerlov, U. (1989). A Taxonomy for Services Processes and its Implications for Systems Design. *International Journal of Service Industry Management*, 1(3), 20–40.

## Appendix: The Conceptual Design Research Method

See Tables 5–7.

**Table 5** Conceptual research activities

| Research activity | Inputs | Process | Outputs |
|---|---|---|---|
| CD.1 knowledge gap identification | *Initial research goals.<br>*Conceptual units of study. | 1.1 Selection of studies by (i) recognition of authors; and (ii) comprehensibility of studies.<br>1.2 Identification of contributions and limitations in studies regarding the research goals.<br>1.3 Relevance validity assessment of the knowledge gaps. | *The confirmed and refined research goals.<br>*The relevant knowledge gaps. |
| CD. 2 methodological knowledge selection | *Confirmed and refined research goals.<br>*Relevant knowledge gaps.<br>*Conceptual units of study. | 2.1 Definition of the research purpose (conceptual exploratory or full design).<br>2.2 Assignation of unit of studies between researchers.<br>2.3 Selection of the design approach (heuristic or axiomatic). | *The research purpose.<br>*The work plan. |
| CD. 3 conceptual design | *Conceptual units of study. | 3.1 Designing of the construct, framework/ model/theory, method, or system/component (not instanced in a real object) by applying the selected design approach. | *The conceptual designed artifact. |
| CD. 4 design data collecting | *Conceptual designed artifact. | 4.1 Identification of conceptual units for testing.<br>4.2 Application of conceptual units for testing.<br>4.3 Face validity from a panel of experts (not involved in the design team). | *The conceptual designed and tested artifact (initially used with test data).<br>2. The face validity assessment. |

(continued)

**Table 5** (continued)

| Research activity | Inputs | Process | Outputs |
|---|---|---|---|
| CD. 5 analysis and synthesis | *Conceptual designed and tested artifact (initially used with test data).<br>*Face validity assessment. | 5.1 Analysis (direct insights) and synthesis (emergent insights) of findings derivable from the designed conceptual artifact. | *The contributions from the conceptual designed artifact. |

**Table 6** Compliance to design research guidelines

| Id | Hevner's et al.'s guideline | How did this research address these guidelines? |
|---|---|---|
| 1 | "Design as an artifact" | A new service system ontology (a kind of formal specification) is generated. |
| 2 | "Problem relevance" | The need of having a set of standardized formal constructs for service system is reported. This concept is fundamental for the advancement of SSME. |
| 3 | "Design evaluation" | Given the scarcity of similar ontologies (formal specifications), the evaluation is realized through the descriptive category by using an informed argument from a panel of experts. This validation is usual in conceptual design of simulation models (e.g. face validation). An empirical validation, will be realized when the artifact (e.g. the ontology) be deployed in an intelligent KMS. |
| 4 | "Research contributions" | Research contributions are satisfied by the (i) designed artifact itself, and (ii) the theoretical linking to Systems Approach and ten service fundamental concepts. |
| 5 | "Research rigor" | Methodological rigor is satisfied through the utilization of the Systems Approach instanced in the design conceptual research method based in Mora et al. (2008b), March and Smith (1995), and Glass et al. (2004). It satisfies also Hevner's et al. (2004, p. 81) criterion for that a problem be considered for design research versus routine design: "Design-science research in IS addresses what are considered to be wicked problems . . .That is, those problems characterized by . . . complex interactions among subcomponents of the problem and its solution". |
| 6 | "Design as a search process" | Design as a process – based on Artificial Intelligence discipline – can be defined as the time-space-economical feasible localization-generation of a feasible node in the solution space under the satisfaction of the goal and related constrain set. For complex problems, this an iterative process guided by axioms – if exist them – or heuristics. This research, given the complexity of the used conceptual pieces, required such a process. |
| 7 | "Communication of research" | Design research is presented for IT academic audience (e.g. the service system ontology), and it is also explained its usefulness for managerial audience. |

**Table 7** Types of conceptual links

| Type of link | Description and example |
|---|---|
| is-a-type-of (B,A) | This link asserts that a concept B is an element of the upper category labeled as concept A. Examples are: is-a-type-of(B: natural system, A: real system), and is-a-type-of(B: emergence, A: s-core attribute). |
| can-be-of-type (B,A) | This link implies that a concept B can be abstractly instanced in a category of type A. Examples are: can-be-of-type-of(B: service measures, A: efficiency issue), can-be-of-type(B: input, A: energy). A can-be-of-type relationship is less restrictive than an is-a-type-of relationship. |
| is-part-of(B,A) | This link asserts that a concept B is a mandatory part of a concept A. Examples are: is-part-of(B: service outcomes, objective A: service), is-part-of(B: system I, A: general system). |
| has(A,min: max,B) | This link asserts that a concept A has between a minimal and a maximum number of concepts B. Examples are: has(A: system I, 6:N, B: s-core attributes), and has(A: service system, 1:1, B: appraiser system). |
| is-instance-of (B,A) | This link implies that B is a particular identified real or conceptual case of a category A. Examples are: is-instace-of-(B: driver process, A: high-level processes), and (B: control process, A: low-level process). |
| open generic link | This generic relationship is open for modelers can assign the required label. Examples are: generate(A: service system, 1:N, B: service) and uses(A: service, 1:N, B: product). |

# A Framework that Situates Technology Research Within the Field of Service Science

**Kelly Lyons**

**Abstract** Service science strives to bring together many disciplines (including computer science, cognitive science, economics, organizational behavior, human resources management, marketing, operations research, and others) in an attempt to study service systems in the following ways: understanding what service systems are and how they evolve; studying how to invest in order to improve management practices in service systems; determining how to create new technologies that increase the scaling of service systems; and, establishing a basis for assessing and relating relevant interdisciplinary knowledge within this emerging field. Academic and industry researchers from separate and currently mostly isolated disciplines are each approaching the field of service science from their own perspectives. This chapter presents a framework that technology researchers can use to understand and articulate how their research relates to the field of service science. The result will better enable technology researchers to relate to and engage with other researchers in the interdisciplinary field of service science.

**Keywords** Framework · Service science · Service systems · Research

## 1 Introduction and Motivation

*Service* is defined as the application of competence and knowledge to create value. Value is realized through interactions and co-creation among *service systems*. Service systems vary in scope (from individuals to businesses, organizations, governments, and nations) and involve people, information, organizations, and technology adapting dynamically and connecting internally and externally to

K. Lyons (✉)
Faculty of Information, University of Toronto, 45 Willcocks St. #314, Toronto, ON, Canada
e-mail: kelly.lyons@utoronto.ca

H. Demirkan et al. (eds.), *The Science of Service Systems*,
Service Science: Research and Innovations in the Service Economy,
DOI 10.1007/978-1-4419-8270-4_10, © Springer Science+Business Media, LLC 2011

other service systems through value propositions. *Service science* strives to bring together many disciplines (computer science, information systems and technology, cognitive science, economics, organizational behavior, human resources management, marketing, operations research, and others) in an attempt to study and understand service systems (Maglio and Spohrer 2008).

Researchers in a variety of fields of study, eager to contribute to the emerging field of service science, are striving to determine how their research fits within this developing space. In this chapter, we present a framework to help researchers in computing and technology fields relate their research to service science. The motivation behind this framework originally came from a workshop on service science, management, and engineering (SSME) where individuals from diverse backgrounds (computer science, marketing, social science, psychology, and cognitive science) tried to discuss their research in the context of service science. They struggled to find a common definition of *service* and had difficulty clearly articulating how their work relates to the emerging field of service science (SSME Workshop 2008). The work being presented and discussed at the workshop was clearly important with the potential to contribute significantly to the service science field and there was much discussion about how each of the different research activities presented might do so. The need for mechanisms to reconcile terminology and relate concepts became quite evident during the discussion.

While it is important to create these kinds of mechanisms for each of the fields of study related to service science, in this chapter, we focus on the general technology area including information systems (IS), information technology (IT), and computer science (CS). A recent article on service-oriented technology and management poses several questions that indicate a desire to better integrate and relate work going on in service-oriented computing and service-oriented architectures to service science (Demirkan et al. 2008). Several open problems are given including understanding the relationship between the business view of service and the corresponding technology elements (Demirkan et al. 2008). There is clearly a need and desire to understand how technology research fields relate to and can contribute to service science research.

One way to help satisfy this need is to introduce mechanisms and frameworks that enable researchers to situate their own work within this emerging field. In this chapter, we present a framework that provides a practical method for positioning past and future IS, IT, and CS research within the service science research domain. The main goal of the framework is to enable researchers in these fields to understand how their research relates to and can contribute to the field of service science. The ability to relate research to service science in this way will enable better collaboration and interdisciplinary activities in service science involving IS, IT, and CS researchers.

Section 2 presents related work on frameworks and research landscapes. In Section 3, we present our framework by describing the service science concepts used to define it. In Section 4, we demonstrate the effectiveness of the framework by using it to situate current information systems research activities relative to the field of service science. In Section 5, we conclude with suggestions for future research and further developments of our framework.

## 2 Related Work

The approach of using frameworks, models, and landscapes to bring understanding to and engagement in research activities has been used in other areas (Grover and Davenport 2001; Brooke 2002; Roth and Menor 2003; Sanders 2006; Kontogiannis et al. 2007). In most cases, the goals are to look back at the evolution and growth of a particular research area and identify future topics of research. In (Sanders 2006), a landscape for talking about and reflecting on the state of research in the area of *design* is presented in response to the recognition that design research was going through a great transformation. The stated goal of the landscape was to provide a view of the existing design research space in order to support conversation and to provoke future thinking and action (Sanders 2006). In (Kontogiannis et al. 2007), a research landscape for service-oriented systems is proposed. They put forward a classification of research issues pertaining to the business, engineering, and operational aspects of service-oriented systems in order to better channel research efforts and enable building on the research of each other. A key reason noted for the proposed classification and landscape is a recent growth spurt in research in service-oriented systems which has resulted in substantial research and significant progress albeit with efforts emerging in several directions and with little coordination.

We are witnessing similar issues in the field of service science with many research efforts in diverse areas progressing along their own paths with little to minimal coordination or formal link to service science research. As the field of service science matures, we see transformations taking place that increasingly require common frameworks on which to base discussions and collaborations.

In (Alter 2009) a service science domain framework is presented that attempts to reconcile many concepts from service science. The complex framework consists of four concentric layers (action, architectural, economic exchange, and industry and society) and is oriented around two axes which create four quadrants within the inner two layers of the framework. Its goals include locating topics from different disciplines relative to the framework, showing synergies between quadrants and links within layers of the framework and locating specific topics in the framework such as service-dominant logic (Vargo and Lusch 2004) and various aspects of software-as-a-service (Dubey and Wagle 2007).

The framework we present in this chapter is simpler and more clearly defined and based on service science concepts. It is proposed specifically to enable researchers in IS, IT, and CS research areas to relate their research to service science, and is straightforward to use for that purpose as demonstrated in Section 4.

## 3 A Framework for Relating Technology Research to Service Science

In this section, we describe the framework based on underlying research and concepts in service science. The methodology we used to define this framework is somewhat unique and it, itself, exemplifies service exchange and interactions among people. A review of service science foundational papers was conducted which resulted in an original version of the framework. This original version was validated and evolved through a series of presentations and interactions. It was first presented, discussed and critiqued at a software engineering research workshop (Lyons 2008a) and an information systems special interest group meeting on service (Lyons 2008c). These discussions brought feedback on the framework from computer scientists, business school academics, researchers in information schools, and people in the IT industry. Further interaction and discussion brought feedback through the use of social computing media (Lyons 2008b) and on-line communities, in face-to-face discussions, and through evaluations and critiques of the framework in a graduate-level introductory service science course (Lyons 2009). The resulting framework which incorporates this feedback from interdisciplinary researchers and practitioners is presented next along with an examination of how foundational service science papers inform its definition.

Recall that the main goal of the framework is to enable researchers from IS, IT, and CS disciplines to situate their research relative to service science foundations. In this section, we show how the framework is defined based on these foundations. According to Maglio and Spohrer (2008):

> Service science combines organization and human understanding with business and technological understanding to categorize and explain the many types of service systems that exist as well as how service systems interact and evolve to cocreate value.

From this fundamental definition, we consider two key aspects of service science: the combination of knowledge from a number of different areas; and, the use of that knowledge to study service systems and the ways in which they interact and evolve to create value. Relating any field of research to service science then requires relating the research to the different knowledge areas and relating the research to service systems and how they interact and evolve to create value.

Therefore, our framework consists of two dimensions: the vertical dimension identifies the knowledge areas or kinds of understanding (business, human/organizational/work practice, technological) used in the research being positioned on the framework; and, the horizontal dimension indicates how the service systems being studied evolve and interact. Figure 1 shows the dimensions of our framework.

We now present a review of some foundational papers in service science and show how the concepts within them support this choice of axes for the framework. We begin with the vertical axis that identifies knowledge and understandings used to study service systems. The University of Cambridge report (IfM and IBM 2008) defines service innovation as a combination of the following: technology innovation; business model innovation; social-organisational innovation; and, demand innovation. Business model innovation and demand innovation can be combined under a broader category of business innovation. These three types of innovation map to the three kinds of understanding on the vertical axis of our framework: technology innovation relates to technological understanding; social-organizational innovation relates to organzational and work practices understanding; and, business model innovation and demand innovation relate to business understanding.

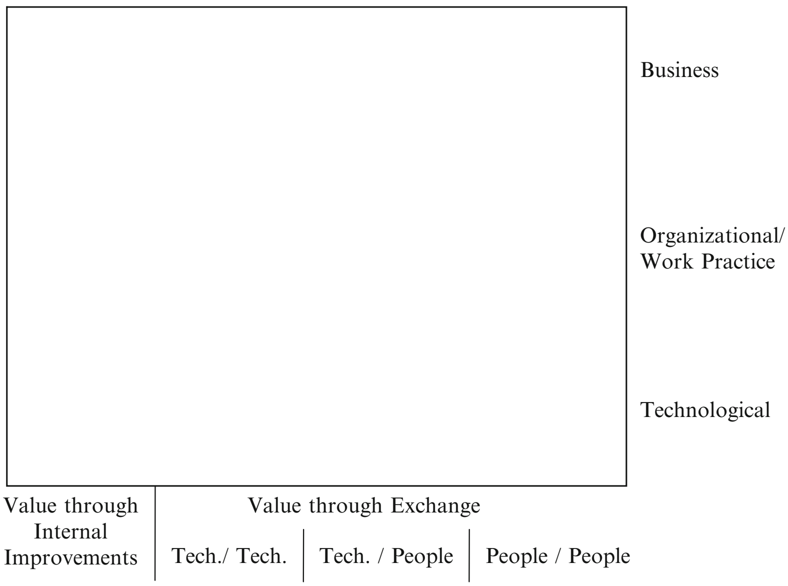



**Fig. 1** The Framework: The vertical axis identifies kinds of understandings used and the horizontal axis identifies how the service systems being studied evolve or interact

de Jong and Vermeulen (2003) identify the following dimensions of service innovation: innovation in the service concept; innovation in the customer interface; innovation in the delivery system; and, innovation in technological options. Innovation in the service concept relates to business understanding in our framework. Innovation in the customer interface is covered by the horizontal dimension of our framework which is described later in this section. Innovation in the delivery system refers to internal work practices and organizational arrangements that are managed in order for service workers to do their work (de Jong and Vermeulen 2003). This innovation concept relates to organizational and work practices understanding in our framework. Service innovation in technological options relates directly to technological understanding in our framework.

Demirkan and Goul (2006) describe a service-oriented enterprise as having several layers: low-level technology and infrastructure layers; the business processes and workflows layer; and, the business strategy layer. These layers map to the technological, organizational / work practice, and business understandings in our framework, respectively.

Spohrer and Maglio (2008) plot topics from academic courses and programs over the last 100 years along three axes (technology, human or social-organizational, and business), arguing that progress towards a greater balance among these three areas is in reaction to the shift to a service economy. These three axes map to the three understandings in our framework. Table 1 summarizes the foundational papers and corresponding concepts as they relate to the three areas on the vertical axis of our framework.

**Table 1** Foundational concepts as they relate to the vertical axis of our framework

| Foundational paper and corresponding concept | Types of understanding used to study service systems: The vertical axis | | |
|---|---|---|---|
| | Technological | Organizational and work practices | Business |
| Maglio and Spohrer (2008) | Technological understanding | Organization and human understanding | Business understanding |
| IfM & IBM (2008) | Technology innovation | Social-organizational innovation | Business model innovation and demand innovation |
| de Jong and Vermeulen (2003) | Innovation in technological options | Innovation in the delivery system | Innovation in the service concept |
| Demirkan and Goul (2006) | IT infrastructure and architecture | Business processes and workflows | Business strategy |
| Spohrer and Maglio (2008) | Technology axis | Human or social-organizational axis | Business axis |

For the horizontal dimension of our framework, we refer back to the definition of service science provided in (Maglio and Spohrer 2008) which states that service science combines various kinds of knowledge to understand service systems and how they interact and evolve. The horizontal axis of our framework identifies how the research being situated addresses the study of service systems by differentiating between research into internal improvements in service systems and research into different kinds of service system interactions.

An important way in which service systems evolve is through internal improvements. In addition to research that addresses improvements in service system interactions, we also consider research that studies back stage improvements (Teboul 2006). Research that studies service system evolution through internal improvements (back stage) in service systems is located on the far left side of our framework.

We now consider how to define the rest of the horizontal axis such that it deals with service system interactions. Value creation takes place through exchange among interacting service systems (Spohrer et al. 2008). In other terminology, value is being co-produced by two or more actors for and with each other and also with other actors (Ramírez 1999). In their revised foundational premises for service-dominant logic, Vargo and Lusch (2008) refer to value creation through resource integration and suggest that individuals and organizations are resource integrators. In all cases, service system interaction involves at least two actors or resource-integrators, one applying competence and another integrating the applied competences with other resources to determine benefit (Spohrer et al. 2008).

The resources identified in (Maglio and Spohrer 2008; Spohrer et al. 2008) are people, technology, information, and organizations. If we consider that organizations contain people and technology and information is shared through people and technology, we can focus on exchange and resource integration between the people and technology resources in service systems.

In order for value to be realized and competences to be applied, two of these resources must exchange something through an interaction. The exchange can take place between two technology resources using automated processes or web services. The exchange can occur when a human resource interacts with or exchanges information through technology, such as in an online banking service. Finally, the exchange can take place through people-to-people interactions such as that which takes place in a hotel service.

An important contribution of our framework is the way in which it reconciles the use of the term *service* in technology literature with service science terminology. In (Glushko 2008), a call is made to unify or define boundaries between these two notions of service, stating that an inability to do so will stand in the way of progress toward a service science. In our framework, we consider that service systems interact through resources which can be technological or human. Therefore, in the context of our framework, research on web services (Alonso et al. 2004) and some aspects of service-oriented computing (Demirkan et al. 2008) address technology-to-technology interactions in service systems.

We now present a review of some foundational service science papers and show how the concepts presented in each support the choice of the horizontal axis for our framework. Wemmerlöv (1989) defines three basic types of contacts necessary for exchange between a service system and a customer in a proposed taxonomy for service processes: (1) direct customer contact in which the customer is physically present during the service process; (2) indirect customer contact in which the contact is mediated in some way by a human or another media form; and, (3) no contact in which the service process does not interact with the customer as in the purchasing activities in a restaurant kitchen, for example. The direct customer contact category (1) is further subdivided into: (1.1) that with no service worker interactions; and (1.2) that with service worker interactions. The subcategory (1.2) maps to the people-to-people interactions specified in our framework and both subcategory (1.1) and category (2) map to our framework's people-to-technology interactions. Examples of interactions of type (1.2) provided in (Wemmerlöv 1989) are giving a lecture or serving food in a restaurant (people-to-people interactions). Examples of people-to-technology interactions of type (1.1) and (2) provided in (Wemmerlöv 1989) include ordering groceries on-line and withdrawing cash from an automatic bank teller.

We note that, in 1989, Wemmerlöv (1989) considered technology as a vehicle for identifying service processes that are rigid (involved with routine technology) and fluid (non-routine technology) and not as an interaction medium; therefore, the technology-to-technology component (necessary to characterize research in service system interactions today) is new in our framework. We also note that Wemmerlöv's category (3) (no customer contact) maps to service system internal improvements in our framework. Example service processes that exhibit no customer contact given in (Wemmerlöv 1989) are processing of information/images or check processing. Further examples of service research that maps to the internal improvements section of our framework include research in service operations as surveyed by Chase and Apte (2007).

**Table 2** Foundational concepts as they relate to the horizontal axis of our framework

| Foundational Paper and corresponding concept | Service system evolution and interaction: The horizontal axis | | | |
|---|---|---|---|---|
| | Internal improvements | Technology-to-technology | Technology-to-people | People-to-people |
| Wemmerlöv (1989) | (3) No contact | – | (1.1) Direct customer contact with no service worker present (2) Indirect customer contact | (1.2) Direct customer contact with service worker present |
| Teboul (2006) | Backstage | Backstage/ Frontstage | Frontstage | Frontstage |
| Glushko (2008) | – | Service architecture | – | Person-to-person services |
| Glushko and Tabas (2008) | Backstage | Provider and customer are both automated processes | Self-service | Person-to-person services |
| Chase and Apte (2007) | Service operations research | – | – | – |
| de Jong and Vermeulen (2003) | – | Innovation at the customer interface | Innovation at the customer interface | Innovation at the customer interface |

Glushko and Tabas (2008) state that,

> A key tenet in the service system perspective is that it emphasizes what is common to person-to-person services, self-service, and services where the provider and consumer are both automated processes rather than focusing on their differences.

The second dimension of the framework presented in this chapter is defined to ensure that this tenet is maintained by equally representing the different kinds of service interactions (person-to-person, person-to-technology – self-service, and technology-to-technology – service through two automated processes) in the framework. Table 2 summarizes the foundational papers and corresponding concepts as they relate to the horizontal axis of our framework.

## 4 Using the Framework to Relate IS Research to Service Science

There are several ways to demonstrate the effectiveness of our proposed framework. In this section, we consider its usefulness as a means for defining an information systems research program in service science. We do this by describing our own research program and some current research collaborations in terms of the framework. We situate our research primarily in the right side of the

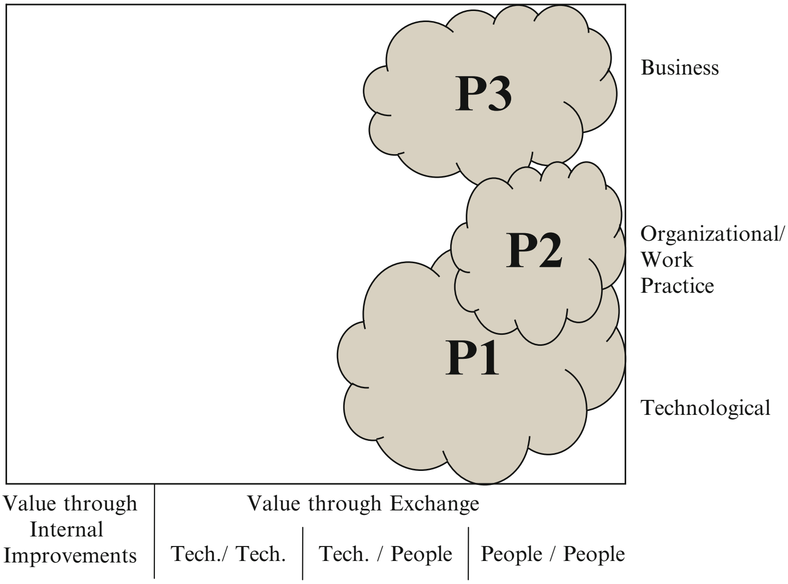



**Fig. 2** Three information systems research projects relative to service science research

framework spanning the vertical axis; that is, in terms of service science, the goal of our research is to bring understanding and innovation in technology, work practices, and business in order to study service system interaction through the exchange or sharing of information and knowledge between people and between people and technology. In this section, three research projects are described and situated within our framework. The positioning of the three research projects relative to service science is shown in the framework in Fig. 2.

*Project P1*: The first project to be described fits in the bottom right corner of the framework. It is based on a method presented by Flor and Maglio (2004) for identifying which aspects of an *offline* service business (i.e., one that does not use technology to mediate interactions with customers) to move *online* (Flor and Maglio 2004). Their method is based on the assumption that successful businesses have well-honed offline practices that can be translated to online practices. They use media-constellation diagrams to model activities in the service processes in terms of movement of information across media and apply their method in a hair salon business.

The goal of our project is to extend their method to identify opportunities to inject social computing practices in a service business. We have applied this enhanced modeling technique to a library service offering which provides access to selected tables of contents of periodicals and access to selected articles from the periodicals. We have studied the current offline processes in this offering through observation and interviews with stakeholders and have used our extension of the Flor and Maglio (2004) modeling technique to identify online social computing practices that will enable sharing of information (e.g., tables of contents) to people through technology and sharing of information (e.g., tags, tables of contents subscription information) among people.

By situating Project P1 on the service science research framework, we can see how it relates to service science research: Project P1 brings understanding in work practices and technology to study how to incorporate technology into a service offering to facilitate both people-to-people and people-to-technology interactions.

*Project P2*: The second project fits in the middle (vertically) and right (horizontally) part of the framework. Its overall goal is to study the use of social computing tools in the enterprise. In this research, we used the network structure of an internal enterprise blog space (where nodes are bloggers and edges are comments made by one blogger on another bloggers' blog) to determine the number of bloggers, number of posts, number of comments, tags, geographic distribution of bloggers, and their position within the corporate hierarchy (Kolari et al. 2007).

We discovered a few interesting characteristics of the structure of this internal blog space: conversations are not limited to peers and employees; conversations span geographic boundaries (primarily among English speaking countries); blog comments are highly reciprocal (people comment on each others' blogs); in-degree approximates authority; and, out-degree approximates connectors. The results point to several interesting questions: can this information be used to identify experts; are blogs enabling a flatter organization; how does employee hierarchy relate to the implicit interconnections created through blogs; how can conversations across geographies be encouraged; and, how can these networks be used to enhance innovation or productivity?

In order to situate Project P2 on the service science research framework, we must think about the service system of an internal blog community and how value is created within it through interaction and resource integration. We define the service system as the organization itself and the blog space as a technological structure that facilitates value creation through people-to-people interaction. In this way, we view the employees as internal customers of the organization that delivers various employee service offerings. Note that some time ago, the notion of internal service marketing was put forward as a future topic of research in service marketing (Fisk et al. 1993). Our research aims to understand how the blog space and structure of interactions enabled through it affect work and work practices within organizations (Kolari et al. 2007); therefore, we place this work in the middle right part of the framework (see Fig. 2). By situating Project P2 on the service science research framework, we are able to articulate how it relates to service science research and better understand the service system involved.

*Project P3*: Finally, we present research within our research program that fits in the top right corner of the framework. In this work, we study business models for web-based service offerings (such as software-as-a-service, social computing tools, and virtual worlds) (Lyons et al. 2009). We looked at the kinds of new business models that are emerging and the impact they are having on the ways in which service offerings are paid for, delivered, and used. Specifically, we considered how the typical roles of provider / customer are changing in the context of emerging online service offerings and in light of a move from a goods-dominant to a service-dominant world (Vargo and Lusch 2004). In these emerging business models, additional third-party entities are key stakeholders and we see co-creation of value among many actors in the online service offerings. In this research, we analyzed three types of online offerings and their corresponding business models. We defined four classes of offering: (1) computational processing and database service offerings, provided as old-style utilities; (2) content providers from the old media (gathered by news teams and shared through newswires) and new media (gathered from the Internet or created by online communities); (3) transactional service offerings for physical products and packaged software information, or media products; and (4) brokerage or affiliate models that help bring partners together to make their own transactions or barter. For each class of offering, we described how value is exchanged in a variety of specific instances. As the ability to design new web-based service offerings grows, we will continue to see a need for innovations in service business models such as those surveyed in this work.

By situating Project P3 on the service science research framework, we see how it relates to service science research: Project P3 describes innovations in service business models and shows how they are being used to create value through exchange among people and between people and technology. This research collaboration includes business school researchers, computer science and information school researchers and benefits from bringing together the complementary expertise in service marketing, information systems, and computer science.

In this section, we demonstrated how the proposed research framework for service science research can be used to help define an ongoing information systems research program in service science. We feel that having a framework within which to discuss the relationship of our research to the emerging field of service science is beneficial in two main ways: it enables us to better associate our different research activities to the field of service science; and, it is useful in helping define collaboration opportunities with complementary research programs and projects in service science.

## 5 Conclusions and Future Work

In this chapter, we proposed a research framework for relating IS, IT, and CS research relative to the field of service science. We discussed the methodology by which the framework was defined and demonstrated the effectiveness of the framework by using it to situate and relate information systems research projects within the field of service science. The implications of our study for researchers include having a common reference point for research discussions and collaborations. Specifically, our framework is a practical tool that helps researchers in IS, IT, and CS reconcile terminology and relate their work to service science research. Researchers can use the framework to define collaborative efforts that span the service science spectrum or focus on specific areas that are under studied. Implications for practitioners include being able to map investments relative to the breadth of service science research in order to identify areas of future focus.

Future work involves extending the framework, conducting further testing and evaluation of the framework, and reconciling it with other related frameworks such as that presented in (Alter 2009). The framework was originally conceived to help situate and relate research from a variety of disciplines to the field of service science but is currently focused on situating technology-related research within the field of service science. Future work will extend and adjust the framework to situate research from other relevant fields: cognitive science, economics, organizational behavior, human resources, marketing, operations research, and others.

There are many ways in which the framework can be further evaluated and tested including using it to situate a variety of IS, IT, and CS research projects, using it to define research collaborations, and determining ways to measure the effectiveness of the framework. Finally, there are many academic programs and courses being developed in service science and it would be useful to map the curricula in those programs within the framework to determine the usefulness of the framework in guiding the design of future such programs.

As the field of service science continues to grow and evolve, the framework should be evaluated and updated to ensure it develops to meet the needs of the service science research and academic communities.

**Acknowledgments** The author wishes to thank the students in her FIS2306 Introduction to Service Science course for their feedback on the framework and the reviewers of this chapter for their valuable input. She also wishes to thank Stephen Perelgut at IBM for his feedback on an earlier draft of this chapter. This research is partially funded by a Natural Sciences and Engineering Research (NSERC) Discovery Grant.

## References

Alonso, G., Casati, F., Kuno, H. and Machiraju, V. (2004). *Web services concepts, architectures and applications from the series: Data-centric systems and applications*. New York, NY: Springer-Verlag.

Alter, S. (2009). Mapping the domain of service science. *Proceedings of the Fifteenth Americas Conference on Information Systems,* San Francisco, California, August 6–9, 2009.

Brooke, C. (2002). Critical perspectives on information systems: An impression of the research landscape. *Journal of Information Technology*, 17(4), 271–283.

Chase, R. B. and Apte, U. M. (2007). A history of research in service operations: What’s the big idea? *Journal of Operations Management,* 25, 375–386.

de Jong, J. P. J. and Vermeulen, P. A. M. (2003). Organizing successful new service development: A literature review. *Management Decision,* 41(9), 844–858, ABI/INFORM Global.

Demirkan, H. and Goul, M. (2006). AMCIS 2006 panel summary: Towards the service oriented enterprise vision: Bridging industry and academics. *Communications of the Association for Information Systems,* 18, 546–556.

Demirkan, H., Kauffman, R. J., Vayghan, J. A., Fill, H.-G., Karagiannis, D. and Maglio, P. P. (2008). Service-oriented technology and management: Perspectives on research and practice for the coming decade. *Electronic Commerce Research and Applications,* 7, 356–376.

Dubey, A. and Wagle, D. (2007) Delivering software as a service. The McKinsey Quarterly Web Exclusive. http://www.mckinsey.de/downloads/publikation/mck_on_bt/2007/mobt_12_Delivering_Software_as_a_Service.pdf

Fisk, R. P., Brown, S. W. and Bitner, M. J. (1993). Tracking the evolution of the services marketing literature. *Journal of Retailing*, 69(1), 61–103.

Flor, N. V. and Maglio, P. P. (2004). Modeling business representational activity online: A case study of a customer-centered business. *Knowledge-Based Systems*, 17, 39–56.

Glushko, R. J. and Tabas, L. (2008). Bridging the 'Front Stage' and 'Back Stage' in Service System Design. *Proceedings of the 41st Hawaii International Conference on System Sciences*.

Glushko, R. J. (2008). Designing a service science discipline with discipline. *IBM Systems Journal, 47*(1), 15–27.

Grover, V. and Davenport, T. H. (2001). General perspectives on knowledge management: Fostering a research agenda. *Journal of Management Information Systems*, 18(1), 5–21.

IfM and IBM. (2008). Succeeding through service innovation: A service perspective for education, research, business and government. Cambridge, United Kingdom: University of Cambridge Institute for Manufacturing. ISBN:978-1-902546-65-0.

Kolari, P., Finin, T., Yesha, Y., Yesha, Y., Lyons, K., Perelgut, S. and Hawkins, J. (2007). On the structure, properties and utility of internal corporate blogs. *Proceedings of the International Conference on Weblogs and Social Media (ICWSM 2007).*

Kontogiannis, K., Lewis, G., Litoiu, M., Müller, H., Schuster, S., Smith, D. and Stroulia, E. (2007). The landscape of service-oriented systems: A research perspective. *Proceedings of the Workshop on Systems Development in SOA Environments (SDSOA 2007), 29th International Conference on Software Engineering (ICSE 2007),* Minneapolis, MN, USA.

Lyons, K. (2008a). Embarking on a research program in service science. *Consortium for Software Engineering Research (CSER) Spring Meeting*, University of Western Ontario, London.

Lyons, K. (2008b). Proposing a research landscape for service science, management, and engineering research, Blog Post, http://moving2academia.blogspot.com/2008/07/proposed-service-science-research.html

Lyons, K. (2008c). A research landscape for service science, management, and engineering research. Extended Abstract, International Conference on Information Systems, SIGSVC, Paris, France.

Lyons, K. (2009). FIS2306 Introduction to Service Science. Syllabus, 2009, http://individual.utoronto.ca/klyons/FIS2306-SS-Jan09/FIS2306-WebSite.htm

Lyons, K., Playford, C., Messinger, P. R., Niu, R. H. and Stroulia, E. (2009). Business models in emerging online services, *Value Creation in E-Business Management,* M. L. Nelson, M. J. Shaw, & T. J. Strader (Eds.), 15th Americas Conference on Information Systems, AMCIS 2009, SIGeBIZ track, San Francisco, California, August 2009, Selected Papers, 44–55.

Maglio, P. and Spohrer, J. (2008). Fundamentals of service science. *Journal of the Academy of Marketing Science, 36*(1), 18–20.

Ramírez, R. (1999), Value co-production: Intellectual origins and implications for practice and research. *Strategic Management Journal*, 20, 49–65.

Roth A V. and Menor L J. (2003). Insights into service operations management: A research agenda. *Production and Operations Management*, 12(2), 145–164.

Sanders, E. B.-N. (2006). Design research in 2006. *Design Research Quarterly*, I(1), 1–8, Design Research Society, www.designresearchsociety.org.

Spohrer J. and Maglio, P. P. (2008). Toward systematic service innovations to accelerate co-creation of value. *Production and Operations Management* 17(3), 238–246.

Spohrer, J., Vargo, S. L., Caswell, N. and Maglio, P. P. (2008). The service system is the basic abstraction of service science. *Proceedings of the 41st Hawaii International Conference on System Sciences*.

SSME Workshop. (2008). E. Stroulia, Organizer. http://ssrg.cs.ualberta.ca/index.php/SSME_-Workshop%2C_Edmonton_March_6-7_2008

Teboul, J. (2006). *Services is front-stage*. New York: Palgrave Macmillan.

Vargo, S. L. and Lusch, R. F. (2004). Evolving to a new dominant logic for marketing. *Journal of Marketing,* 68, 1–17.

Vargo, S. L. and Lusch, R. F. (2008). Service dominant logic: Continuing the evolution. *Journal of the Academy of Marketing Science*, 36(1), 1–10.

Wemmerlöv, U. (1989). A taxonomy for service processes and its implications for system design. *International Journal of Service Industry Management*, 1(3), 20–40.

# Customer-Driven Value Co-creation in Service Networks

**Stephen K. Kwan and Soe-Tsyr Yuan**

**Abstract** Service Dominant Logic (SDL), a contemporary view of services as a foundation of all economic exchange, takes a very high level perspective of provider–customer interaction. The role of the customers in value creation is emphasized but their role in the creation of the value proposition choice sets is not explicitly considered. From another perspective, the notion of value co-creation addressed in existing Service Science studies often assumes the value proposition to be static – i.e., proposition/acceptance happens before the start of service and is not visited again during the service. This paper attempts to connect the macro view of SDL to the system view of Service Science in creating a framework of Service Value Network (SVN) that accounts for both provider and customer driven value co-creation.

**Keywords** Service value network · Service dominant logic · Value proposition · Customer value equation · Value co-creation framework

## 1 Introduction

The system view of Service Science considers a service system as a dynamic configuration of resources to create value, including people, organizations, shared information (language, laws, measures, methods), and technology, all connected internally and externally to other service systems by value propositions (Spohrer et al. 2008). In addition, a service system can be regarded as a resource itself and may be composing, recomposing and decomposing over time. In effect, a service system is comprised of service providers and service clients working together to co-create value in complex service network (Tien and Berg 2003).

S.K. Kwan (✉)
San José State University, One Washington Square, San José, CA, USA
e-mail: kwan_s@cob.sjsu.edu

H. Demirkan et al. (eds.), *The Science of Service Systems*,
Service Science: Research and Innovations in the Service Economy,
DOI 10.1007/978-1-4419-8270-4_11, 

In the current Service Science literature (Qiu 2007) (Vargo et al. 2008), authors often assume the value proposition to be static (i.e., proposition/acceptance happens before the start of service delivery and is not visited again during the service delivery[1]) and the composing, recomposing and decomposing of SVNs are determined based a given static value proposition (i.e., the static value proposition determines the connections and relationships among service participants). Taking the automobile firm example from (Vargo et al. 2008), a customer derives value when he/she actually uses the car and in accessing the firm's maintenance or towing services provided by the firm's suppliers together with the customer's personal driving skills and the public road-ways. In other words, the value proposition is determined by the provider before the value is delivered through a co-creation process between the customer (that may exert private or public resources) and the provider (that engages resources through the collaborative parties in its SVN). This is the basis of the SDL propositions (Vargo and Lusch 2004, 2008).

In this paper, we extend the concept of value co-creation and SVN to consider the view that the customer receiving the value proposition from the provider can be empowered to dynamically enhance more value based on his creation/choice of service network end points. This extension moves the relational aspect of value co-creation (Lusch et al. 2008; Vargo and Lusch 2004, 2008) to a broader view of the customer determining the values and activities in SVN (e.g., see Basole and Rouse 2008). In other words, the resource integration view emphasized the problem-analysis and specification perspective with the given static value proposition from the provider side. This paper addresses the symmetry of providers and customers that can be empowered and drive the new perspective for SVN's design and development (cf. generator-conjecture-analysis in Roozenburg and Cross 1991).

We consider the following questions in this paper: What are the determinants of value co-creation considering both the provider and the consumer versus our proposed customer driven value co-creation? What are the determinants and elements of customer driven-SVNs? How do we describe SVNs? What are the incentives and the methods for service providers to embrace customer-driven SVNs? A value co-creation framework and a SVN model are presented in this paper to address the questions above and expose future research opportunities that would contribute to the discipline of Service Science, Management, Engineering, and Design (SSMED) (Spohrer and Kwan 2009).

The rest of the paper is organized as follows: Section 2 presents a discussion of related literature, the SDL propositions, and contrasting it with the SVN concept. Section 3 presents a conceptual framework of the extended notion of value co-creation. Section 4 presents a model of a customer-driven SVN. Section 5 then discusses implications for future research with concluding comments.

[1] For example, the Interact/Serve/Propose/Agree/Realize (ISPAR) model in (Spohrer et al. 2008).

# 2 Related Literature

## 2.1 Provider Centric SDL

In SDL, service provision and value co-creation are derived from an interactive process and the provider and the customer are considered in an inherently relational context (Vargo and Lusch 2008). In this perspective the provider determines the value proposition but the value is delivered from the collaboration of the provider and the customer established through their relationship (Vargo and Lusch 2008). This is illustrated in Fig. 1 (Lillrank 2008).

Further detailed this relational context in terms of three types of encounters (emotion, cognition, behavior) as shown in Fig. 2.

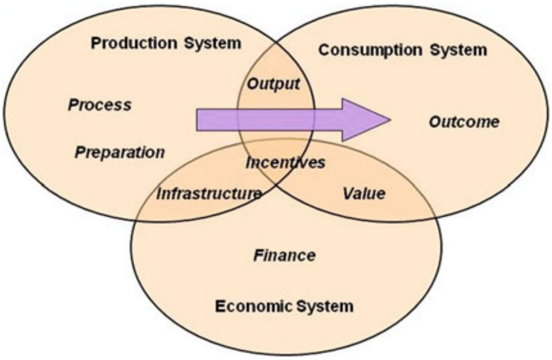



**Fig. 1** The context of value co-creation [adopted from (Lillrank 2008)]

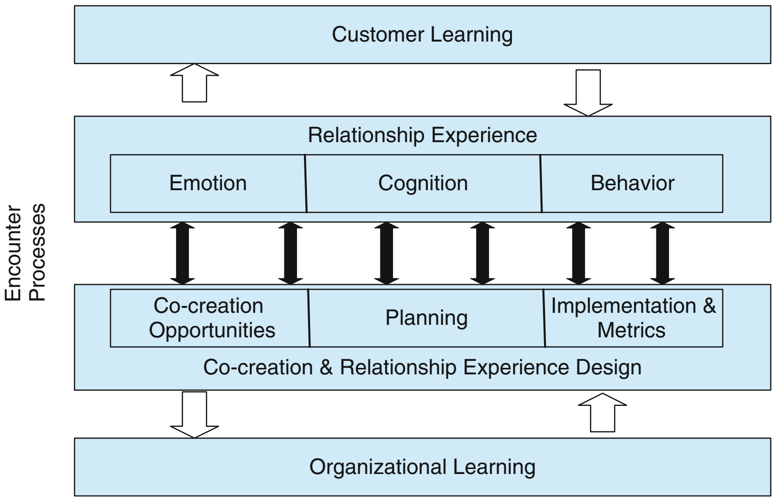



**Fig. 2** Managing the co-creation of value [adopted from (Payne et al. 2008)]

In Fig. 2, the relational context involves the customer's value creation process in performing activities to achieve a particular goal through some information, knowledge, skill or other resources that they can access and use. The relationship also involves the provider's value creation processes by way of the design and delivery of customer experiences through an examination of co-creation opportunities, planning, testing and implementing the customer's encounters (represented by a series of two-way arrows linking the customer processes with the provider processes in Fig. 2). These encounters could be lending emotion, cognition, and behavior support to the customers.

In the following, we attempt to extend the provider-centric SDL view to promote a more prominent role for the customer in driving the value co-creation process.

## 2.2 Provider Centric SVN

A service provider can deliver value by re-sourcing through collaborative parties which unfolds into a value creation network (linear or non-linear). In the case of Nike, Inc. the enterprise does not manufacture or handle the physical movement of its tangible products but leverage information by applying its competences to design products, build brand, marketing, and outsourcing most other functions to the value network (Lusch et al. 2008). In our discussion, we consider this type of networks as a provider centric SVN. The following examines the motivation behind variations of this characterization of SVN that are addressed in various studies.

- *SVN as an entity flow model for offerings and revenues*: SVN is a flow model with economic entities as the basic unit of value creation and offerings/revenues as the materials flowing among economic entities, and the network is the vehicle for broadcasting production coordination information (Caswell et al. 2007). Each entity would examine the value derived from participating in the SVN as opposed to not participating (or participating in another SVN) and would estimate how this participation value changes over time in the business processes (Caswell et al. 2008). This SVN interpretation is a straightforward evolvement from the traditional value chain notion in manufacturing industries to the value-creating network notion in service industries.
- *SVN as a mash-up network*: SVNs are goal-oriented business networks, which provide value through the agile and market-based composition of complex services from a steady open pool of complementary as well as substitutive standardized service modules with the use of ubiquitously accessible information technology. In other words, a SVN works like a mash-up characterized with easy and fast integration (Blau et al. 2009). This SVN interpretation puts the emphasis on the process productivity in SVNs in terms of their composition.
- *SVN as a living system with pattern, structure, process*: A SVN is a living network of tangible and intangible value exchanges characterized with patterns (configuration of relationships between the system's roles), structure (physical embodiment of the patterns, and process (activities involved in the continual embodiment of

the system's patterns of relationships) (Allee 2002). The exchange is the molecular level of economic activity and the patterns of exchanges describe how participants add/extend/convert values to produce the resulting impacts. The network also serves as the primary economic mechanism for value conversion and the value creation dynamics is described in either tangible (good, service, revenue, etc.) or intangible forms (knowledge, benefit, etc.). This interpretation delineated the necessary elements to form a SVN.

- *SVN as a mechanism for competitive innovation*: A SVN is a set of relatively autonomous units that can be managed independently, but operate together in a framework of common principles and Service Level Agreements (SLAs). The relationships among the firms in the network are essential to a SVN's competitive positions (Peppard and Rylander 2006). The structure of the network also plays an important role in firm performance and in industry evolution (Madhavan et al. 1998). The values of the relationships are three folds: (1) customer intimacy (2) product service innovation and, (3) operational excellence. This SVN interpretation considers the extension of the network boundary to incorporate the opportunities for service innovation.

From the descriptions of SVN variations above, we contend that there is a need to extend the scope of SVN from the static SVN boundary to a dynamic SVN boundary in order to incorporate more service value varieties and more service innovation opportunities. This could be attractive to the focal service provider as long as the incentives are sufficient and the cost of operating the network remains affordable (e.g., handled with ICT). This *customer-driven value co-creation SVN problem* is also very challenging for the service provider since it requires the shifting of the control foci to the customer. In the case of Nike, Inc., it can deliver enhanced value to its customers by integrating customers' resources and collaborative parties into its value creation strategy (e.g., sponsoring runners in a marathon as part of a marketing campaign.) An exploration of this problem is conducted in the next sections to lay the foundation for further in-depth research.

There are some other studies related to the customer-driven value co-creation problem. For example, Evert Gummesson (2010) mentioned that co-creation of value should consider expanding the notion of service encounter: (1) In the traditional notion, service encounter refers to face-to-face interactions between a service provider's frontline employee and a customer based on the understanding that services are produced, delivered and consumed during the interactions; (2) However, this notion should be regarded as only a special case in the extended context of the provider–customer interactions; (3) During a service delivery, customers can interact among themselves (i.e., C2C) in addition to customers engaging in B2C/C2B interactions. Other related works in the literature include customer-driven innovation (Pellican and Homier 2005; George 2006; Selden and MacMillan 2006) in which the main idea is to use customers (e.g., their inputs) to identify and define the innovation opportunities and customer segmentation. Anderson warned that customers might consider low cost as the primary determinant in purchases and ignore other parts of the service provider's value proposition (Anderson et al. 2006).

## 3 Extended Value Co-creation Framework

In this section, we examine the notion of value co-creation and explore the opportunities for incorporating the consideration of customer-driven value varieties and service innovation. We will then present a framework to analyze the potential opportunities and illustrate it with a case scenario.

Employed a feedback-loop to represent customer value within the framework of a service profit chain. This representation of the strong relationships between profit and customer loyalty, employee loyalty and customer loyalty, employee satisfaction and customer satisfaction is shown in Fig. 3. The central part of Fig. 3 shows a customer value equation formulating the value of the delivered service as the results created plus the quality of the delivery process (manifested as the quality of the service experience) over the sum of price of the service and other costs in acquiring the service. The provider's value proposition is represented as the denominator of the equation. The customer's determination of value is represented as the trade-off between benefits received (the numerator: results plus quality of service) and costs (the denominator). Note that the customer has no apparent role in determining the value structure in this formulation. The assessment of value from benefits of the results and the quality of the experience are post-hoc determinations.

Harvey (2005) extended the customer value equation further by introducing the element of self-service experience as shown below:

$$Value = \frac{Results + ServiceExperience + SelfServiceExperience}{OverallCost} \quad (1)$$

Harvey illustrated the equation with the following example: If a user is trying to lose weight, the results he/she is seeking is different from those looking for a gastronomic experience. Consequently, the value of the added control over calorie intake that the user gets from preparing a home meal (self-service experience) would out-weigh the enjoyment of a five-star service (service experience) offered

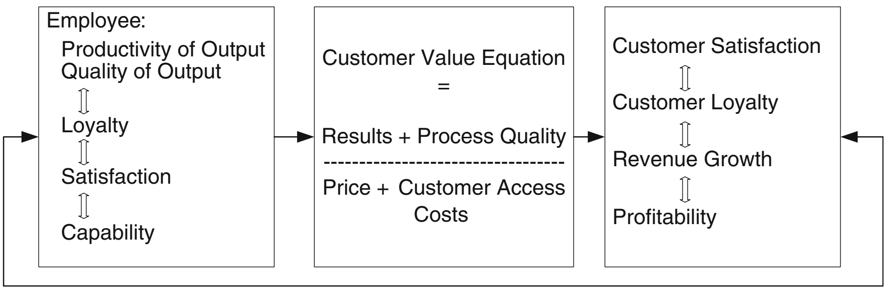



**Fig. 3** Elements of service profit chain [adopted from (Heskett et al. 1997)]

at the restaurant. Instead, the user can ask to take out the materials and prepare a low-calorie meal with the ingredients at home. This value equation advances Heskett's equation by considering potentials for value varieties offered by the provider side by incorporating self-service experience on the customer side.

Another perspective was presented by Goukens et al. (2009) who provided evidences that self-aware customers (those who focus their attention inward) were not only more selective in their information acquisition but also more likely to search for alternatives. In this case, intentional manipulations of customers' self-awareness could prove beneficial by enabling customers to make choices that better match their personal preferences to achieve higher choice satisfaction. In the aforementioned five-star service experience example, the user can acquire good information from his/her social network and then make choices about which five-star services to experience (or in a reverse-auction scenario, create choices and receive bids from five-star services). Taking this perspective of self-aware customers, we extended (1) into the following:

$$Value = \frac{CustomerChoices + Results + (Self)ServiceExperience}{OverallCost} \quad (2)$$

In (2), the additional consideration of customer choices (as supported by the customer's own network) changes the notion of value co-creation as addressed in SDL and SVNs.

## 3.1 The Framework

In this subsection, we propose a framework to analyze the possible scopes of delimiting the variations in SDL and SVN. This framework is based on the determinants of value co-creation as shown in Fig. 4. These determinants include value propositions from the provider and the customer, the provider-centric network, and the customer-centric network. These networks could be organized statically or dynamically.

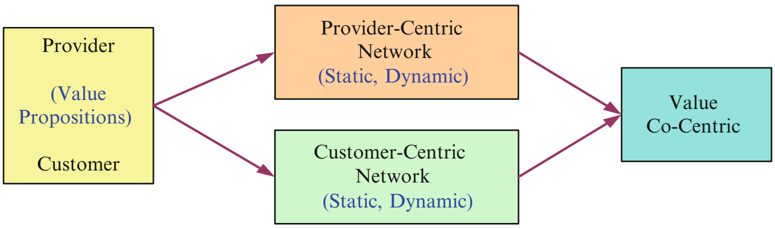



**Fig. 4** Determinants of value co-creation

These determinants of value co-creation are based on the following:

1. Network is a primary economic mechanism for value conversion and for describing the value creation dynamics.
2. The value proposition offered by a provider-centric network may not sufficiently fulfill the needs of customers in terms of their own value determination.
3. Customers might need to expend extra efforts to fill the gap - e.g., with additional self-service (Harvey 2005) or creating new customer choices.
4. This self service or creation of new customer choices could range from a simple labor effort to driving another network (e.g., a customer-centric social network) to engage in dynamic value co-creation to fill the gap.
5. The combined network could enhance customer's value as long as the increase in overall cost does not offset the magnitude of the increase in value in (2). By the same token, provider's value could also be increased because of the expected increase in sale volume (e.g., due to increased customer retention). This could also decrease the cost of offering the service as well as warrant an increase in price because of the service innovation opportunities created. In short, the notion of value co-creation could be extended to incorporate the opportunities for value varieties and service innovation.

The framework incorporates the following scenarios of service network creation:

- *Provider Static*: The service network is already determined by the provider and the end points of the network are known.
- *Customer Static*: The customer does not have any way of altering the end points of the network – they have to select for the predetermined end points.
- *Provider Dynamic*: The service network is created dynamically by the provider. For example, through some cost optimizing algorithm in choosing the intermediate nodes (partners, etc.) This can also apply to the situation where cost is not the only consideration (e.g., reduction in carbon footprint or other sustainability considerations).
- *Customer Dynamic*: The end points of the network are not known ahead of time. The customer creates these end points to maximize their value from the service. That is, the value proposition from the provider only provides some pre-determined value accepted by the customer who then is empowered to enhance the value based on their creation of the service network end points dynamically.

The static cases of value co-creation in which the provider's value proposition is well defined and when the customer accepts, then the outcomes are very much predictable. However, the value co-creation in the dynamic cases is less predictable since extra efforts are engaged either by the provider side or the customer side to achieve extra benefits.

Figure 5 shows the extended framework with the four variations of SVNs and they are schematically represented in Fig. 6.

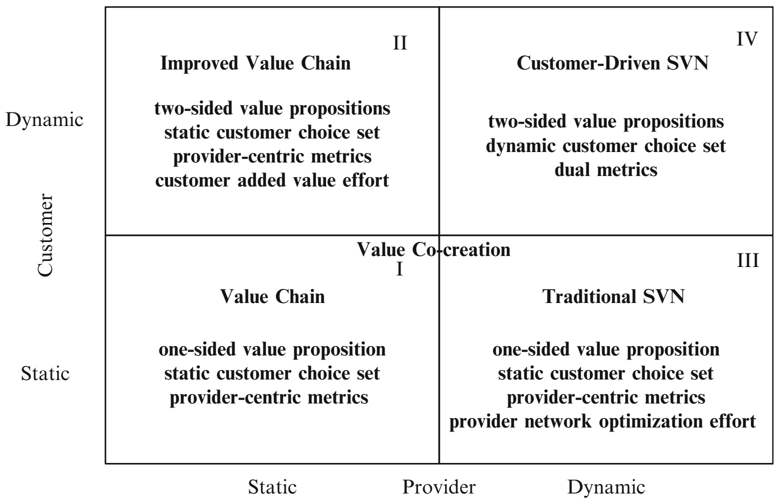



**Fig. 5** Framework of extended value co-creation in SVN

1. *Value Chain* is characterized by a one-sided (i.e., provider) value proposition and thus the value varieties for customer and the metric of service quality are predetermined.
2. *Improved Value Chain* is characterized by two sided (i.e., both provider and customer) value propositions but the customer side has to expended extra efforts to enhance their own value beyond the provider's service quality and metrics.
3. *Traditional SVN* is characterized by a one-sided (i.e., provider) value proposition and thus the value varieties for customer and the metric of service quality are predetermined, but the provider side would expend extra efforts in optimizing the network for the service delivery.
4. *Customer-driven SVN* is characterized by two sided (i.e., both provider and customer) value propositions and the customer side's network will be involved to co-create the value with the provider's network.

The Customer Driven Service Value Network represented in Fig. 6c depicts the customer and service provider as symmetric network integrators and sources of value propositions. The customer's ability to drive the value creation is recognized in these explicit roles which go beyond the notion of customer and service provider as resource integrators expounded in SDL.

## 3.2 Case Scenarios

Scenario 1 – The value proposition from a cable or satellite television service provider to a customer is very simple – programmed entertainment from multiple channels is provided for a subscription fee. This value proposition is static and does

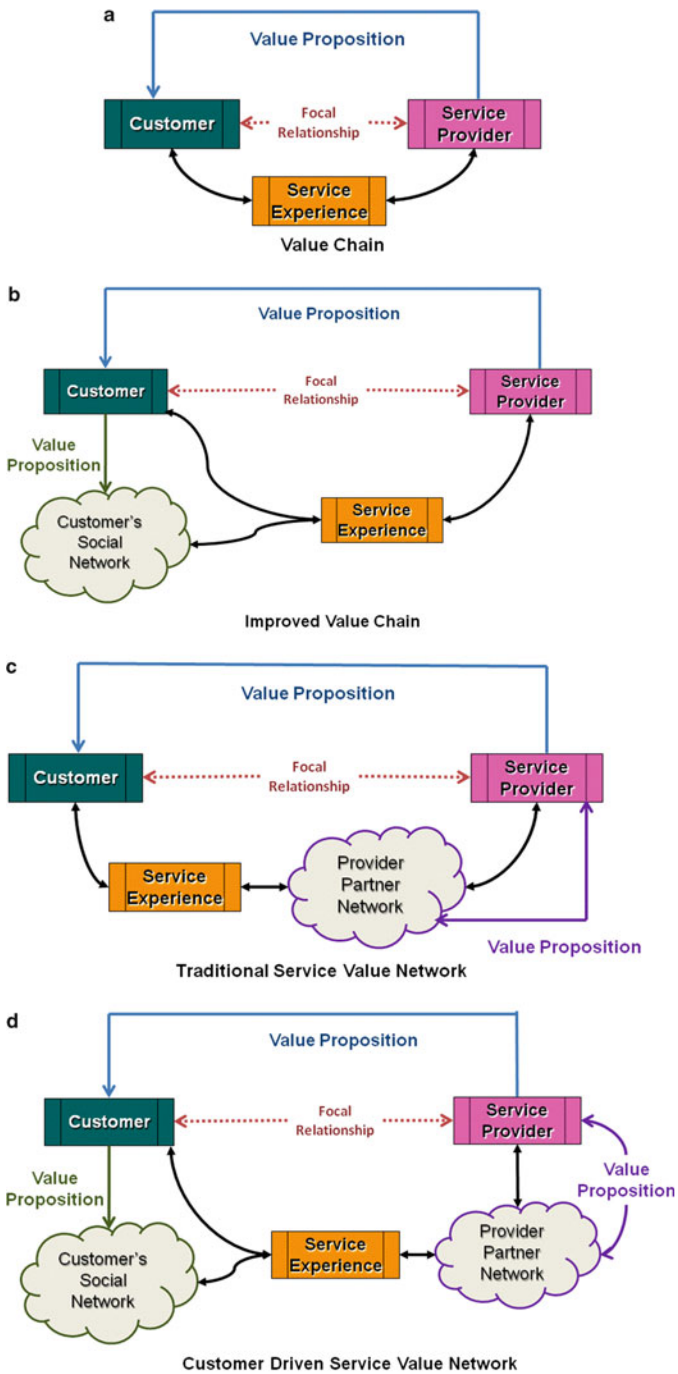



**Fig. 6** Schematics of framework of extended value co-creation in SVN

not change when the customer is receiving the entertainment value. The only role the customer plays is to choose from a program guide based on his/her preferred genre of entertainment. This is true even with programs that are "on demand" where the entertainment choices are deterministic. Recently, some television service providers are also providing broadband internet and phone connectivity as a service bundle (sometimes called triple-play packages). The internet connection provides a parallel channel of communication for the customer. The customer could be connected to his/her internet social network site while watching a TV program.[2] In some cases, the connection interface is displayed on the TV screen. In this scenario, the customer could choose who to share the entertainment value with by connecting to a (sub)group of preferred friends in the social network and invite them to watch the program together. Conceptually the customer is inviting virtual friends to share the entertainment on a virtual couch in a virtual family room. In effect, this sharing increases the customer's value by enhancing his/her social capital[3] and is completely customer-driven. This transforms a traditional value chain proposition to a customer-driven SVN.

Scenario 2 – From the perspective of the TV service provider, the added cost associated with provisioning for the service bundle in Scenario 1 is partially off-set by charging the customer additional service fees. This increase in revenue is insignificant in comparison to the additional revenue that could be garnered from advertising. The traditional value proposition the TV service provider to advertisers is also simple – broadcast ads with certain programs to reach some target audience with certain demographic profile. This is a static 1:M proposition – M being some purported target audience. This proposition is more attractive than the hit-or-miss advertising in newspapers where the demographics of M are even more difficult to ascertain. The value proposition from the TV service provider to advertisers for Scenario 1 is more attractive and could result in increases in advertising revenue. Firstly, the TV service provider has demographic information about its subscribers which could be used to direct targeted advertisements (albeit without violation of the user privacy agreement). Secondly, the TV subscription customer through his/her social network is providing additional connections that will be exposed to the advertisement. In effect, the value proposition from the TV service provider to the advertiser could be phrased as a 1:M:N dynamic proposition. In the extreme case, if it could be done legally within the service provider's privacy agreement with the customer, a 1:1:N dynamic proposition could be the result.

In the above we have described a user-driven value co-creation in scenario 1 and have also shown how the service provider could leverage the customer's social networking connections to enhance revenue in scenario 2.

[2] Lawton (2008) described new television ventures that promise to bring the community-building features of the Web into the living room.

[3] Social capital could be interpreted as an aggregation of social cohesion and personal investment in the community.

# 4 Customer-Driven Value Co-creation in SVNs

In Sect. 3, we described the motivation for customer-driven value co-creation that could be realized through SVNs. This section presents a model to describe the customer-driven SVN in terms of is components and shows how the customer-driven SVN is superior to the other three network variations. This model also inspires some new research issues in Service Science. For the methods to develop customer-driven SVNs, we assume there are appropriate scalable ICT technologies that can be used to control the costs of building a complex network while preserving incentives for the providers.

The salient properties of a customer-driven SVN represented in the model are presented in Table 1. The goals of a customer-driven SVN include service productivity (e.g., the cost of building the network and its relationships), customer satisfaction (e.g., increase in value varieties with more choices such as self-service), and service innovation (e.g., from innovative design of the choices).

The network is built with human tacit knowledge and interdisciplinary theories to be applied to ensure certain solution qualities (e.g., minimized cost, maximized satisfaction, maximized opportunities for service innovation). Moreover, the network development and operation can be managed and facilitated by particularly designed ICT artifacts to minimize the operating cost. Examples of related ICT artifacts include the mechanisms to semi-automate the value co-production process (e.g., Tung and Yuan 2010), the mechanisms to conduct cloud service governance and integration (e.g., Plummer and Kenney 2009), etc.

## *4.1 Model of Customer-Driven SVN*

In this section, we will first provide a representation of the model for customer-driven SVNs, followed by the comparison among the four variations of SVNs shown in Fig. 6 and demonstrate that customer-driven SVN is superior to the other three according to the extended customer value function of (2). The model of a customer-driven SVN presented in the first part is based on the formalism suggested by (Conte et al. 2009) while focusing on the value that could be derived from customer choices in (2).

**Table 1** The salient properties of a customer-driven SVN

| The salient properties | The shared reality of value co-creation |
|---|---|
| Goals | Service productivity, customer satisfaction, service innovation |
| Problem solving strategy | Networked collaborative services |
| Solution requirements | Minimized cost, maximized satisfaction, Maximized opportunities for service innovation |
| Theories | Inter-disciplinary |
| Tacit knowledge | Information, knowledge and decision of people involved |
| Design method | Synthesized artifact |

### 4.1.1 Representation of Customer-Driven SVN

For a focal relation containing a focal provider $v_{Pf}$ to which a focal customer $v_{Cf}$ places the request of service directly (or indirectly) as depicted in Fig. 5, the definition of customer-driven SVN is formulated in terms of its universe and the members of the universe. In a customer-driven SVN universe (G = $(\{V_P \cup V_C\}, E)$, $N^P, N^C, P^P, P^C$), G represents the network of nodes $\{V_P \cup V_C\}$ and edges E; $N^P$and $N^C$ respectively denote the provider-side network and the customer-side network; $P^P$and $P^C$ represent the respective value propositions. In our model, the goal of the network[4] is to maximize customer's value by increasing the opportunities of value varieties and service innovation with reasonable cost as implied in (2). Each instance of value creation dynamics is assumed to have a focal relationship with a focal provider and a focal customer. The descriptions and representations of the members of the universe are itemized as follows.

- $V_P$ : For simplicity we assume that each service is owned by a different service provider. Thus, the set of service providers $V_P$ equals the set of services present in network $G$. A characteristics configuration $A_{Pj}$ of service $v_{Pj}$ is fully characterized with a set of $M$ attributes $A_{Pj} = \{a^1_{Pj},...,a^M_{Pj}\}$ where $a^m_{Pj}$ is an attribute value of type $m$ (e.g., cost).
- $V_C$ : The remaining nodes of G (i.e., nodes excluding those in $V_P$ ). When $V_C$ refers to only the customer's social network, $V_C$ would contain the nodes of $N^C$ (i.e., the customer-side of network). A characteristics configuration $A_{Cj}$ of customer $v_{Cj}$ is fully characterized with a set of $N$ attributes $A_{Cj} = \{a^1_{Cj},...,a^N_{Cj}\}$ where $a^n_{Cj}$ is an attribute value of type $n$.
- $E$: Each edge $e_{ij} \in E$ denotes an integration relationship between either two service providers $v_{Pi}$ and $v_{Pj}$ (i.e. interoperability of offered services and their willingness to cooperate), one service provider $v_{Pi}$ and one customer $v_{Cj}$, or two customers $v_{Ci}$ and$v_{Cj}$. Each edge $e_{ij}$ is annotated with the price $p_{ij}$ where $v_j$ is a successor of $v_i$ ($v_i, v_j \in V_P \cup V_C$). $p_{ij}$ can be zero such as the case of free transfer of intangible offerings (Allee 2008). On the other hand, $p_{ij}$ can incorporate different kinds of cost considerations (e.g., production cost, relationship cost, transaction cost, etc.).
- $N^P$ , $N^C$ : Assume $N_i$ is a network of a subset of connected nodes from $V_P \cup V_C$ that drives the creation of a value choice $(\chi_i)$ for customer $(v_{Cf})$ (the sink of the network). $N_i$ can then be represented with two sub-networks: $N_i = N^P_i \cup N^C_i$, where $N^P_i$ is the provider-side network (containing the focal provider $v_{Pf}$) and $N^C_i$ is the customer-side network (containing the focal customer$v_{Cf}$). The customer-driven SVN can then be a super set composition of the involved candidate networks (e.g., G = $\cup^k_i N_i$).

[4] Described a network as an economic mechanism for describing the value creation dynamics.

- $P^P$, $P^C$: $P^P$is the value proposition of the focal provider $(v_{Pf})$ that is associated with the provider-side's metrics for computing the value of the network G. $P^C$ is the value proposition of the focal customer $(v_{Cf})$ representing the customer-side's metrics and opportunities of new customer choices to be created. For simplicity, the metrics for the provider and the customer are constrained by thresholds of benefit and cost: $\lambda_{Pf}$ and $\alpha_{Pf}$ are the thresholds of benefit and cost for the provider; $\lambda_{Cf}$ and $\alpha_{Cf}$ are the thresholds of benefit and cost for the customer.

The goal of the customer-driven SVN is to maximize customer's value. Without loss of generality, the customer value function is defined as benefits minus costs. The benefit for customer is comprised of the three parts in the numerator of (2) – i.e., results, service experience (could be the assessment of the quality of the (self) service experience), and customer choices. In the universe, we assume a set of candidate networks ($N_i$) which can generate different acceptable value choices $(\chi_i)$for the focal customer $(v_{Cf})$with the reasonable costs $(\alpha_f)$provided through the focal provider $(v_{Pf})$ directly or indirectly. The threshold $(\lambda_{Cf})$ for the values of the choices ($Valueof\chi_i$) is assumed (i.e., $Valueof\chi_i \geq \lambda_{Cf}$). The incurred cost of the value choice ($Costof\chi_i$) should not exceed $(\alpha_{Cf})$ (i.e. $Costof\chi_i \leqq \alpha_{Cf}$). In general, $Costof\chi_i$ can be computed by aggregating the prices $p_{ij}$ along the paths in $N_i$ (i.e., $\pi_i = \sum_{e_{ij}\in N_i} p_{ij}$ ).

For each value choice $(\chi_i)$, $Valueof\chi_i$ then boils down to the consideration of the benefits of the results and the service experience minus the cost, which can then be regarded as a function of the characteristics configuration attributes $A_{Cf} = \{a^1_{Cf},..., a^N_{Cf}\}$, the customer value proposition $P^C$, and the value of the network $N_i$ $(i.e., \varphi(N_i)\ or\ \varphi(N_i^P \cup N_i^C))$. Presented a method to compute the value of a network taking into account the value accrued – i.e., benefit minus cost – due to the transfers of offerings as well as the expected value due to the partners' satisfaction in the various relationships (Anderson 1995). By adopting the greedy approach, the value of the network $N_i = \varphi(N_i^P \cup N_i^C))$ can be considered as a function $\varphi$ of two parts: the value of the provider side's network $\varphi_P(N_i^P)$ and the value of the customer side's network $\varphi_C(N_i^C)$ that can be computed with the Caswell's method. The value of $\varphi_P(N_i^P)$ are bound by the thresholds of benefit and cost for the provider ($\lambda_{Pf}$, $\alpha_{Pf}$). The network values $\varphi_P(N_i^P)$ or $\varphi_C(N_i^C)$ has to be greater than zero for them to be viable and have enough incentives to satisfy both the provider's network and the customer's network in order to sustain the provision of the results and the service experience for the customer. In other words, network viability has to be satisfied in the computation of $\varphi_P(N_i^P)$, $\varphi_C(N_i^C)$ and thus $\varphi(N_i)$.

To represent the customer-driven SVN, we let G $= \cup_i^k N_i$ for k that satisfies $\chi(A_{Cf}, \varphi(\cup_i^k N_i) \geq \max(\chi(A_{Cf}, P^C, \varphi(N_1), \ldots, \chi(A_{Cf}, P^C, \varphi(N_k))$, i.e., the weaker form of super set composition of the involved candidate networks. This representation allows us to maximize the customer value function shown in (2) by considering the customer choices, the results and (self)service experience with respect to the overall cost.

### 4.1.2 Comparing the Four SVN Variations

To compare the four variations of SVN (Value Chain, Improved Value Chain, Traditional SVN and Customer-Driven SVN), we use the benefit parts in the numerator of the customer value function (2) together with the universe of customer-driven SVN (G $= (\{V_P \cup V_C\}, E), N^P, N^C, P^P, P^C)$ with respect to the overall cost:

- *Value Chain*: The characterization of a one-sided provider value proposition and a static provider network structure implies that $V_C, N^C, P^C$ and hence $N_i$ are null. Accordingly, there will be no benefit accrued from the part of customer choices for the customer. Meanwhile, the cost of operating $N^P$ for the provider will be higher than that of Traditional SVN which optimizes the operating cost of $N^P$.
- *Traditional SVN*: Similar to Value Chain, it is characterized by null $V_C, N^C, P^C$ and hence $N_i$. The provider operates $N^P$ by minimizing costs. When assisted by appropriate scalable ICT technologies, some of the costs could be minimal. In the long run, this could lead to lowering the overall cost for the customer when compared with using the Value Chain approach.
- *Improved Value Chain*: Given the characterization of two sided (i.e., both provider and customer) value propositions with the customer's extra efforts expended to enhance their own value beyond the provider's service quality and metrics, $V_C, N^C$, and hence $N_i$ are null. Accordingly, there will be no benefit accrued from the part of customer choices for the customer; meanwhile, the overall cost of achieving $P^C$ will also be increased.
- *Customer-driven SVN*: Given the characterizations of two sided (i.e., both provider and customer) value propositions and the customer side's network will be involved to co-create the value, there will be the three parts of benefit (i.e., results, service experience, customer choices) accrued and the overall cost can be minimized by operating and managing the network with appropriate scalable ICT technologies.

From the above analysis, it is obvious that customer-driven SVN is superior to the other three SVN variations according to the extended customer value function of (2) when the proper ICT technologies are in place to assist the operation of the overall networks.

### 4.1.3 Implications to Service Science

Based on the framework of extended value co-creation in SVN and the customer-driven SVN model (G $= (\{V_P \cup V_C\}, E), N^P, N^C, P^P, P^C)$, there are some research issues that could be explored in the future. In the following, we provide a brief discussion of these issues in light of the four aspects of Service Science, Management, Engineering, and Design – SSMED (Spohrer and Kwan 2009):

- *Design*: With the incorporation of customer value proposition $P^C$, the human-centered design methodologies can be introduced into the study of Service

Science. For instance, Design Thinking is a systematic methodology with seven stages (define, research, ideate, prototype, choose, implement, and learn) that can empower the development of customer-driven SVNs that allow creating choices with empathy meaningful to the customers.

- *Engineering*: To minimize the cost of operating and managing $N^P$ for the service provider, there should be more studies of ICT artifacts specifically designed to facilitate the development and the operation of the customer-driven SVNs. In addition, dynamic ways to combine$N^P$,$N^C$ and enable the communications between the two sub-networks should also be investigated.
- *Management*: Given the value propositions from both the provider side $P^P$ and the customer side $P^C$, new service strategies and quality measurement to ensure the goals of service productivity, customer satisfaction and service innovation should be investigated.
- *Science*: Given $P^C$ and $N^C$ are considered, new service system entities and interactions (e.g., new choice identification) are introduced. Accordingly, different models of the possible interactions and their governance should be explored with simulation and virtual reality experiments.

## 5 Conclusion

In the current unsteady economic environment the business ecosystem is increasing more competitive and complex. Customers are also becoming savvier, demanding more information, access and choices. An example of that is the demand trend for more user-created content on the Internet (oft called Web 2.0 phenomenon). This also led customers to create their own social network based on specific social value propositions and not dependent on static value propositions from the service providers. This paper provides a framework that shows the different variations of service value networks. In particular a model of the customer-driven service value network was formulated and explored. The relationship between the model and the discipline area of SSMED was also discussed.

The customer-driven value network concept extends the contemporary Service Science and SDL propositions to provide the customer a more prominent role in value co-creation. Future research in this area includes empirical studies of customer-driven value networks (such as scenarios described in Sect. 3.2), empirical evaluation of (2), and studies of the behavioral aspects of customers in dynamically generating network endpoints.

## References


Allee, V. (2002) A Value Network Approach for Modeling and Measuring Intangibles. *Proceedings of The International Conference on the Transparent Enterprise Conference*, Madrid, Spain.

Allee, V. (2008) Value Network Analysis and Value Conversion of Tangible and Intangible Assets. *Journal of Intellectual Capital,* 9(1), 5–24.

Anderson, J. C. (1995) Relationships in Business Markets: Exchange Episodes, Value Creation, and Their Empirical Assessment. *Journal of the Academy of Marketing Science*, 12 (4), 346–50.

Anderson, J. C., Narus, J. A., Von Rossum, W. (2006) Customer Value Propositions in Business Markets. *Harvard Business Review*, 3, 90–97.

Anderson, J. C., Kumar, N. and Narus, J. A. (2007) *Value Merchants: Demonstrating and Documenting Superior Value in Business Markets*. Harvard Business Press, Cambridge, MA.

Basole, R. C. and Rouse, W. B. (2008) Complexity of Service Value Networks: Conceptualization and Empirical Investigation. *IBM Systems Journal*, 47(1), 53–70.

Blau, B., Krämer, J., Conte, T., and Dinther, C. V. (2009) Service Value Networks. *Proceedings of the IEEE Conference on Commerce and Enterprise Computing,* Vienna, Austria.

Caswell, N., S. Nikolaou, F., C., Sairamesh, J. and Bitsaki, M. (2007) Estimating Value in Value Networks. http://www.tsl.csd.uoc.gr/media/workingpaper_value_nets.pdf (retrieved January 5th, 2010).

Caswell, N. S., C. Nikolaou, Sairamesh, J., Bitsaki, M., Koutras, G. D. and Iacovidis, G. (2008) Estimating Value in Service Systems: A Case Study of a Repair Service System. *IBM Systems Journa*l, 47(1), 87–100.

Conte, T., Blau, B., Satzger, G. and Dinther, C. V. (2009) Enabling Service Networks Through Contribution-Based Value Distribution. *Proceedings of Americas' Conference on Information Systems (AMCIS)*, San Francisco*, USA*.

Gummesson, E. (2010) The Future of Service Is Long Overdue. In Maglio, P., Spohrer, J., and Kieliszewski, C. A. (ed.) *Handbook of Service Science*, 615–632, New York: Springer.

George, J. (2006) Customer Driven Innovation. http://www.svpma.org/eventarchives/Customer%20Driven%20Innovation.pdf (retrieved January 5th, 2010).

Goukens, C., Dewitte, S. and Warlop, L. (2009) Me, Myself, and My Choices: The Influence of Private Self-Awareness on Choice. *Journal Marketing Research*, 46(5), 682–692.

Harvey, J. (2005) *Managing Service Delivery Processes: Linking Strategy to Operations*, Milwaukee: ASQ Quality Press.

Heskett, J. L., Sasser, W. E. and Schlesinger, L. A. (1997) *The Service Profit Chain: How Leading Companies Link Profit and Growth to Loyalty, Satisfaction, and Value*, New York: Simon & Schuster Publisher.

Lawton, C. (2008) TV + Social Network = ? *The Wall Street Journal*, October 27, 2008.

Lillrank, P. (2008) An Event-based Approach to Services. Presented at the Frontiers in Service Conference. Maryland, USA.

Lusch, R. F., Vargo, S. L. and Wessels G. (2008) Toward a Conceptual Foundation for Service Science: Contributions from Service-Dominant Logic. *IBM Systems Journal,* 47(1), 5–14.

Madhavan, R., Koka, B. and Prescott, J. (1998) Networks in Transition: How Industry Events Reshape Interfirm Relationships. *Strategic Management Journal*, 19, 439–459.

Payne, A. F., Storbacka, K. and Frow, P. (2008) Managing the Co-Creation of Value. *Journal of the Academy of Marketing Science*, 36(1), 83–96.

Pellican, S. and Homier, M. (2005) Customer Driven Innovation: Quicken® Rental Property Manager. *Proceedings of the 2005 conference on Designing for User eXperience*, San Francisco, USA.

Peppard, J. and Rylander, A. (2006) From Value Chain to Value Network: Insights for Mobile Operators. *European Management Journal*, 24(2), 128–141.

Plummer, D. C. and Kenney, L. F. (2009) Three Types of Cloud Brokerages Will Enhance Cloud Services. *Gartner Special Report on Cloud Computing*, November.

Qiu, R. G. (2007) Service Science: Scientific Study of Service Systems. *Proceedings of the 17th International Conference on Flexible Automation and Intelligent Manufacturing*, J Philadelphia, USA.

Roozenburg, N. F. M. and Cross, N. G. (1991) Models of the Design Process: Integrating across the Disciplines. *Design Studie*s, 12(4), 215–220.

Selden, L. and MacMillan, I. C. (2006) Manage Customer-Centric Innovation – Systematically. *Harvard Business Review*, April, 108–116.

Spohrer, J., Vargo, S. L., Caswell, N. and Maglio, P. P. (2008) The Service System is the Basic Abstraction of Service Science. *Proceedings of the 41st Hawaii International Conference on System Sciences*, Hawaii, USA.

Spohrer, J. and Kwan, S. K. (2009) Service Science, Management, Engineering, and Design (SSMED): An Emerging Discipline - Outline & References. *International Journal of Information Systems in the Service Sector*, 1(3), 1–31.

Tien, J. M. and Berg, D. (2003) A Case for Service Systems Engineering. *Journal of Systems Science and Systems Engineering,* 12(1), 13–38.

Treacy, M. and Wiersema, F. (1993) Customer Intimacy and Other Value Disciplines. Harvard Business Review (January–February), 84–93.

Tung, W. F. and Yuan, S. T. (2010) Intelligent Service Machine. *Communications of the ACM:* In Press.

Vargo, S. L. and Lusch, R. F. (2004) Evolving to a New Dominant Logic for Marketing. *Journal of Marketing*, 68 (1), 1–17.

Vargo, S. L. and Lusch, R. F. (2008) Service-Dominant Logic: Continuing the Evolution. *Journal of the Academy of Marketing Science*, 36 (1), 1–10.

Vargo, S. L., Maglio, P. P. and Akaka, M. A. (2008) On Value and Value Co-Creation: A Service Systems and Service Logic Perspective. *European Management Journal*, 26(3), 145–152.

# Towards Service System Governance: Leveraging Service System Grammar to Empower Value Co-creation

**Stefan Puehl**

**Abstract** The integration of customers (often as an additional vendor) into global service delivery with industrialized processes is a challenge: When running software projects for such settings we see with all customers the practical need to harmonize governance – over projects inside an enterprise for a particular customer, over vendors for a particular project, over projects of a particular vendor for different customers. This chapter discusses this urgent need to innovate interactions – while leveraging the service system grammar to organize governance in a multi-sourcing environment with global service delivery. We focus on streamlining the architecture and the design to allow simpler i.e. simple governance in a global service delivery network of multiple service systems. With service perspectives derived from the service system grammar the creation of service systems empowers design and architecture of the service system at the right point in time with the right level of detail. The purpose of this chapter is to describe this shift in approaching service governance.

**Keywords** Service science · Service system · Service governance · Service grammar · Semantic decomposition · Service systems perspectives · Service innovations

## 1 Introduction

This chapter about *service system governance* has five sections: (1) creating service systems ensure context and content fit in a global sourcing environment, (2) service system grammar lays the foundation for simple service system governance, (3) service systems provide the structure to enable detailed accountability,

S. Puehl (✉)
Dell Services, Herriotstrasse 1, 60528 Frankfurt (Main), Germany
e-mail: Stefan_Puehl@dell.com

H. Demirkan et al. (eds.), *The Science of Service Systems*,
Service Science: Research and Innovations in the Service Economy,
DOI 10.1007/978-1-4419-8270-4_12, 

(4) service system grammar establishes service perspectives to allow architecture and design streamlining governance, and (5) service system governance focuses with the service system grammar on the strategy driven control of value creation.

The first section discusses the *service system* in the context of global service delivery and multi sourcing; it explains how that affects the architecture and design of systems to propose a service grammar that allows combining business and technology interests.

The second section lays the foundation of simple service governance introducing the four levels of detail that the *service system grammar* offers: sequence, feedback, human interaction, straight through aggregation. It describes how semantic decomposition of service system behavior coordinates architecture and design.

Section 3 is about the *knowledge worker accountability* for the leading roles in a service system: service owner, business analyst, and technology architect. It describes the situational behavior and how different level of detail and common language derived from the service grammar help defining simple governance.

Section 4 establishes *service system perspectives* to articulate governance visually with defined levels of visibility and interest: (1) the service value chain perspective and (2) the service co-creation perspective to enable a (3) service system engineering perspective and a (4) service system governance perspective.

The last section concludes with the *value proposition* of the service grammar leveraging service system governance because of its embedded service innovation structure to empower and control value co-creation in a service system network.

# 2 Creating Service Systems Ensure Context and Content Fit in a Global Sourcing Environment

## *2.1 Multi-sourcing and Global Service Delivery*

The pressure of virtualization and agility enforces more flexibility on architecture and design combining a more technological minded SOA (e.g. Demirkan and Goul 2006) with a more business driven BPM (e.g. Weske 2008 and Hammer and Champy 1990). We think that the service system abstraction (Spohrer et al. 2008) is actually the most promising approach to deliver services globally in an increasingly complex partner and customer network; (Cohen and Young 2006) found the root cause of poor performance – not at the day-to-day delivery level – but in a lack of effective business-to-business management and governance at a level above day-to-day delivery.

We especially see in CRM and call center automation (e.g. Maglio 2006) a high degree of customization in service processes in contrast to the need of standardization and industrialization of business processes. The *service system* approach encourages a holistic view of service interactions (Alter 2008) that combines both business and technology perspectives. From product logic we move to service logic (Vargo and Lusch 2004). This shifts CRM (or customer interacting) software thinking, too.

Work smarter often means you also have to be quick, flexible, and ready to adapt to the *transforming* world (Champy 2008), hence the need for flexible software development to support the automation of the service systems that is going to be created. The standardization and industrialization of these service processes therefore requires sophisticated governance mechanisms to maintain flexibility where needed. Service systems may formalize or structure the ad-hoc architecture of participation created in the open-source communities. These service systems deliver new services and offerings created by us – and our customer, partners, vendors, and providers. Together these stakeholders form a service system network (Spohrer et al. 2007). Global service delivery is described in terms of a *co-productive view* (Ramirez 1999) that emphasizes customer satisfaction.

Value creation is synchronicly interactive (value constellations); some types of value cannot be measured or easily quantified; diverse types of value are co-invented, combined, and reconciled. Customers (co-) create value with providers; a service framework encompasses all value creating activities considered as co-produced. Essentially, within service networks, multi-sourcing can combine service systems of different vendors together to enhance value co-creation opportunities for the customer.

The value network formed from combining many service systems (the different sourcing partners) creates a new aggregated service system for the customer. We need to organize *service process fusion* (Demirkan and Goul 2006) for the service system we create for our customers, and service process fusion of the service system network we establish to create the customer service system. Therefore, understanding both service systems better increases the quality and customer satisfaction despite the need of protecting certain intellectual assets on each side.

Governance has to be an enabler and accelerator to create new combinations of services, not simply longer value chains. Improved governance mechanisms must improve the overall SLA of the service network for the customer; not simply more efficient services, but also resolving disputes, such as "who pays for non-productive interactions"?

## *2.2 Business and Technology – Architecture and Design*

In global service delivery the relationship between architecture and design for business and technology has to be more explicit due to the service network of sourcing partners and the co-creation of value with the customer (Table 1). We associate with *architecture*: structure, frame of reference, guidelines, principles, standards – the context. With *design* we associate: activities, tasks, logic, algorithm, interactions – the content.

This foundation is the essential start to create new software – or using the broader approach including the end-to-end process view and service portfolio

**Table 1** Leveraging the separation of concerns for architecture and design to structure governance: the high-level starting point for agreeing a common understanding

| | Business | Technology |
|---|---|---|
| Architecture | Common glossary | Shared platforms |
| | Service entity catalogue | Application interoperability |
| | Reference processes | Industry standard roadmap |
| | Alignment and profit | Convenience and reuse |
| Design | Workflows | User interfaces |
| | Organizational roles | Software components |
| | ROI solutions | Cost implications |
| | Customer effectiveness | Automation efficiency |

analysis – to create the new customer service system. Structuring and incorporating both enterprise level and project level mechanisms can result in better governance. Who-is-doing-what ought to be coordinated at a higher level than the mere project level with its inherent timeline pressure of "just execute!" would allow.

In software projects we see confusion regarding the relationship or dependencies between architecture and design; this results in a governance challenge mixing business and technology on the strategic enterprise architecture and on the project solution level. The essential coordination on the enterprise business process level as well on the project technology level is a prerequisite to establish service systems that both integrate and create value for all stakeholders. Only this enables stable operations. A common language is the basis for shared governance in a service provider network environment. The *common language* based on the grammar that structures service systems enables an efficient governance frame of reference.

We want to leverage the grammar of service systems (Puehl and Szczeponik 2009) to explore the structure of service systems that flexibly integrate into value co-creating service networks.

Service systems describe holistically business and technology. By leveraging the service system governance approach, service organizations can enhance their abilities to create a compelling shared level of control for each service system in the value network.

We are therefore researching service systems – its grammar and resulting governance – to:

- Find some structural unity in the controlling diversity of technology and business service processes despite all cultural and organizational differences.
- Industrialize the service governance process to agree to a project governance defining and materializing value creation.
- Establish and simplify project governance consistency with the enterprise governance relevance while e.g. clarifying design and architecture work.
- Standardize the process of service network governance with situational flexibility for customers and providers to facilitate and simplify global service delivery.
- Understand service governance in order to (1) create new service systems and (2) run existing operational service systems.

- Articulate compelling next step service governance recommendations for a certain maturity or level of partnership for the key roles involved.
- Optimize the creation and operation of new service systems in an innovative service system network leveraging service grammar based governance.

## *2.3 Service System Grammar*

Only a common language for describing service systems can ensure a proper understanding of the purpose of a particular service system (i.e. to explain how and why it co-creates value in a service network). Only after understanding the purpose of a service system within a service network effective governance can be achieved.

The provider customer interaction paradigm of a service (in a service value chain) allows a structure or grammar of *service system behavior*, knowing that any effective process only works with a context sensitive and standardized vocabulary. The great advantage of service is: to make it efficient there is no need for a full enterprise information model. The service allows focusing on the customer provider interaction first; the business entities (or products) demanded by that particular service can be determined at a later stage.

We propose *semantic decomposition* of service system behavior as the service value chains grammar with the four levels of detail. Each decomposition level has a specific meaning that contributes to the overall behavior. We use service process modeling as a formalization basis. The service value chain grammar has two parts, two levels of semantic decomposition each:

- The first two levels (level 1 and 2) are *business* related. The business analysis describes the service system's organizational aspects of the service value chain. The business level 1, the business sequence, relates to the overall strategy. Level 2 deals with the business decisions. It holds the *management* aspects of the service system.
- The second two levels (level 3 and 4) are *technology* related. The technology design describes the service system's automation aspects of the service value chain. The technology level 4 relates to the application infrastructure. Level 3 determines the human interaction to link the business decisions to infrastructure. It holds the *engineering* aspects of the service system.

This unifying grammar improves the alignment between business and technology. A technological solution shall ask the business perspective on level 1 and level 2 to prove value through business *effectiveness*. A business solution shall ask for the technological perspective on level 3 and level 4 to prove value through technology *efficiency*.

We then can approach architecture and design challenges one at a time in a constructive order. This reduces the overall governance need. The service system grammar organizes the collaboration between architecture and design (both have business and technology relevance) having an upfront agreed common language established. This structure streamlines the collaboration of architecture and design and results in simple governance that has more potential for *agreement*, because it is simpler and respects the structural separation of concerns and areas of interest.

# 3 Service System Grammar Lays the Foundation for Simple Service System Governance

## *3.1 Service Oriented Governance and Service System Governance*

IT Governance (Weill and Ross 2004) moves enterprise (architecture) governance to service oriented (architecture) governance (Demirkan et al. 2008). Our guidelines integrate service governance into an existing enterprise governance framework. The result is: SOA governance stays technical. Service system governance has the ambition to incorporate both technical and business dimensions holistically.

- There are governance challenges due to *technology*: Shared platforms for application servers, ESB, process engines, external information system usage and integration, hardware virtualizations and clouds, software-as-a-service, etc.
- There are governance challenges due to *business*: partnering, sub-contracting, multi-sourcing, global service delivery – for server administration, software development, testing factories, etc.

Both have in common: isolation fades, interaction flies. Co-creation of value is normal for everyday activities in software development: This materializes, e.g. in combined pricing and compound SLA or OLA. Therefore the service interaction with the customer is essential. We therefore distinguish also for governance purposes between *fluid* and *rigid* service processes (Wemerlöv 1989): without i.e. indirect and with direct customer contact. Due to partnering, i.e. multiple sourcing of one particular service, this is not one absolute separation but may depend on the provider role relationship.

A service system approach does not focus on developing technology solutions. Technology is from an automation perspective an integral part of value creation – not an isolated solution. Service system governance needs to have an approach to relate business to technology and architecture to design. The service system is promoting this at discrete levels of detail. SLA and any other *operational excellence* or service quality are always a combination of technical applications and human operations and then can be defined at these levels.

This is why software development (especially for CRM) shall be addressed together with the service system governance. The common understanding about the major structure at a certain level of detail establishes agreement easier and in the end increases the overall quality due to more creational clarity.

The *service value chain* focuses on the behavior of the service system. A lot of generalization and standardization in modeling focuses on the static product vocabulary. This vocabulary is essentially industry specific, e.g. for financial products or aviation, and even enterprise dependent business entities. Service system behavior in contrast can be more generic using the industry specific vocabulary, e.g. the verb-noun combination for service interactions (defining an activity, the verb, and the manipulated business entity, the noun).

Best practice process models include industry specific and taxonomy based vocabulary. The structure of services systems is determined by the service system grammar using semantic decomposition. The vocabulary gets a grammar. This grammar enables mutual understanding of the service interactions, not only the contractual deliverables or agreed artifacts. This understanding is the basis for simple governance.

### 3.1.1 Level 1 – Service Sequence

The overall behavior of the service system is represented as *service sequences* separating the behavior (the service value chains) into distinct internal and external customer provider interactions, sometimes called by process notation standards as tasks, steps or activities.

The goal of the first level of decomposition is to understand the start and the end – the trigger and the completion – of a service process. It establishes the purpose and ensures in the service network the essential service interactions with the customer (or multiple customers) and potential other partners or providers. It ensures the right scope. In other words (Womack and Jones 2007): Any consumption process that cannot totally solve the problem is unacceptable.

We see in our practical work, especially in the transformation projects weakness to understand start and end of service processes. With a service sequence we find it more efficient to get agreement of what the service processes is actually supposed to do. It is a simple way to communicate purpose and therefore the value.

Governance aspects are the *value chain profits* (Heskett et al. 1994) and the completeness of the value chains for the purpose given while creating the service system. During operations the structure allows the governance to focus on fewer measures: only the purpose needs quantification.

### 3.1.2 Level 2 – Decision and Feedback

*Decisions and feedback* separate the service sequence parts of the service value chain. In graphical notation standards these are represented as forks, gateways, splits, or joins. Decisions and feedbacks decompose the service value chain sequence discovering detailed provider related interactions.

The goal of the second level of decomposition is to understand *alternate scenarios and their choices*. Doing it for a particular service sequence value chain step separates the service system vertically and therefore reduces the "process spaghetti" of wallpaper processes and back-to-square-one behavior.

We see in our practical work difficulties to create proper and local decision structures, i.e. decision frameworks (O'Reilly et al. 2004). Defining a semantic level of detail improves the mapping and structure of the business knowledge with less redundancy and more coherent options.

Governance aspects on this level are the choices and options and its organizational underpinning. Enforcing to make decisions locally (for that particular service value chain interaction) reduces the alternate scenarios. This results in less governance activities (e.g. escalation) while running the service systems and faster agreement while creating the service system.

### 3.1.3 Level 3 – Human Interaction

*Human interactions* are distinct from computerized or automated interactions. Decisions and feedbacks and their decomposed sequence interactions are decomposed into manual and automated interactions.

The goal of the level 3 of decomposition is to establish the *automation* with potential software applications – information systems – and its usage. It includes the decision whether to automate particular steps of the value chain or not. For the same value chain these decisions can vary depending on the organization capabilities, costs, etc.

We often see software projects – in order to be as close as possible to the final user – starting with user interface design. This isolated level of too much detail jeopardizes architecture and design and delays agreement. Having established values (level 1) and the decisions (level 2) first, the user interfaces is better anchored and predetermined.

Access channels – not only backend or self-service applications, but increasingly ESB driven BPM solutions and mobile devices – are then easier to govern during creation. The screen flow can focus on the value creation of short form navigations, e.g. wizards. The service interaction process has already been defined at level 2.

### 3.1.4 Level 4 – Straight Through Aggregation

*Straight through aggregation* allows the technical execution. Automated provider or customer interactions are decomposed into the actual technological execution according to the application infrastructure and the corporate organization.

The goal of level 4 is to incorporate the *corporate information system landscape* – the actual or new information systems, the infrastructure for needed access channels, and external information systems according to the service value chain. This may open different options that can be evaluated in the context of value creation, instead of focusing on the given.

We often see in software projects that integration of the applications needed (besides the new software components written) is late. Technology integration is complex and needs very rigorous scoping. Having understood and agreed what is done manually (level 3) and the value that needs to be created by the actual technology solution is better shaped.

This simplifies the governance and scope for applications executing the services designed, because the application contribution (to the value chain – and therefore profit) can be measured quite directly. The consolidation of infrastructure, shared platforms, clouds, access channel virtualization, or software-as-a-service approach is governed then by content.

## *3.2 Simple Governance Coordinating Architecture and Design*

Jim Champy states it clearly as a warning for all governance approaches (Champy 2008): companies that outsmart their competitors depend on culture to manage behavior. Incumbents use rules and controls. Since the 1980s we struggle with it (De Marco and Lister 1999): What present-day standardization has achieved is a *documentary consistency* among products, but nothing approaching a meaningful *functional consistency*. In other words, standardization has mainly homogenized the paperwork associated with the services or products, rather than the products or services themselves. Value is missed.

Change is constant – flexibility needs a frame of reference. We propose to establish structural stability for solution flexibility with the service system grammar. Governance manifests in documentation and communication (report and announcing). Using process models we formalize this documentation reflecting reality as good as possible (Table 2).

Astonishingly enough, based on a given business architecture there is a comparable high amount of business design and technology design required to formulate relevant technology architecture.

We see that design bridges business architecture and technology architecture. Governing this structure enables simple service governance. The structure of the system determines the coordination of *influence* for that particular system. The structure is known before. The conflicts are determined and can be foreseen: during creation or operations the interest can be articulated – having value co-creation as the leading principle. This duality of responsibility is essentially a matter of value and common language.

**Table 2** Discussing the separation of concerns leveraging the service system grammar

| | Business – Management | Technology – Engineering |
|---|---|---|
| Architecture – context | Level 1: Service sequence | Level 4: Straight through aggregation |
| Design – content | Level 2: Decisions and feedback | Level 3: Human interactions |

The critical challenge on consumption and provision processes is: include all the significant activities at a scale that can be understood at a glance (Womack and Jones 2007). Governance processes are often like manufacturing sausages – you only like the result, but not the process. With the service grammar we can establish more structure and relationship at the right level of detail.

We believe the reason for the often observed reluctance to share service processes is: they are at one level of detail and therefore exposing too much cooperate knowledge; they are exposing the acting units. To control service process interaction *visibility* is therefore a prerequisite to co-creation of value. Leveraging the service grammar's different levels of detail reflect the growing partnership of the sourcing relationship. This results in service governance interactions with simpler rules for each level of detail. Governance service processes are like ballet: the easier the performance (the execution), the harder the preparation.

The simple rules provide the guidelines within which managers can pursue opportunities. *Strategy* then, consists of the unique set of strategically significant processes and the handful of simple rules that guide them (Eisenhardt and Sull 2001). In service systems these rules are stated at the service value chain level (level 1) focusing on co-creation.

## 4 Service Systems Provide the Structure to Enable Detailed Accountability

### *4.1 Knowledge Worker Accountability*

Governance in practice is about ownership. Service system governance is about service system *ownership*. If now a human being, a person is the service system, we call it accountability. The challenge lies not simply in formally modeling the technology or organizational interactions, but in modeling the people and their roles as knowledge workers in the system (Maglio 2006). Standard knowledge management is failing – making the knowing-doing gap worse – because they treat knowledge as a tangible (Eisenhardt and Sull 2001). Service system governance has to respect the intangible; service system governance has to take into account the human knowledge worker as the bearer of an intangible asset in the service value chain.

Knowledge management combined with accountability, i.e. the respect of what a knowledge worker does, and a culture of support or empowerment results in simple governance. Service system governance therefore explicitly embeds *knowledge management*: importing knowledge, problem solving, experimenting, and implementing and integrating – to create values, skills and knowledge, management systems, and physical systems (Leonard 1995) one at a time.

Making services tradable requires the regulation of access to maintained socio-technical capabilities which may involve a variety of models of interaction (Araujo and Spring 2006). This is especially true in global service delivery where specializing and "virtualizing" of activities sharpen the professions and formalize their activities or service interactions. The decomposition level of detail determines the responsibility in a service system. Service system governance is assigning artifacts at a certain level of detail. This is a better way of separation of concern than merely task based (e.g. using a RACI) control. Governance cannot be pressure or complete control; these knowledge workers would go elsewhere to find an environment that fit their needs.

### *4.2 Service Owners*

Service owners are service system owners. This is a little different from the domain owners e.g. in SOA. Domains are defined along a functional areas or technological disciplines or subsystem types. "The domain owner manages the direction of the domain and the business relationships between the domain and business units, as well as other domains. The domain owner also helps business process owners in various business units understand the business application of the Services within the domain. This person also tracks the usage of Services for management purposes and ROI calculations" (Bloomberg 2004).

We actually think that the domain is better represented as a service system, because you can combine service systems into a new service system and you can describe *service system networks*. Domains are one-dimensional. This then allows a recursive hierarchy of service system owners in contrast to a matrix of domains. The semantic decomposition helps to break down the accountability – in a network, not in a purely hierarchical manor.

Service owners in global multi-sourcing service delivery deal with: relationship, performance, and contract (Cohen and Young 2006). In big settings each area may have its own manager under the service owner. Often the technology owner (mostly an *application* owner) and the business owner (sometimes the *process* owner) are separate depending on the application governance and ownership in an enterprise architecture governance setting. Ideally, the service governance is catered for by one service owner accountable for the service.

Governing the services directly – having networks and decomposing it according to the service system grammar – creates simpler rules: it leverages the service process interactions in a service system network that can be organized more flexibly than static domains.

### *4.3 Business Analysts*

Business analysts derive services from requirements. Within a given architecture these consultants, experts, managers make *content* work. These service process interactions are linked into the service value chain. The service system grammar structures the creation of the service system from co-creating value. Having the right granularity the hand-offs and collaboration with the technology architects is much more efficient.

Especially in global service delivery – when roles are more strictly defined – known and confirmed expectations are essential for success. It is rare that business analysts are also fully literate in technology, making these hand-offs even more important. The service system grammar lets the business analysts focus on the value co-creation, not just mapping processes, separate from the engineering aspects of technology. This serves their interest better than demanding everything together – in one step. The service value chain is also cleaner when business analysts focus on business. Governance is simple, because acceptance is focused and accelerated.

Our experience shows that confirming level 1 with the senior management, often the business process representatives of the relevant organizational units, is easier than a flat "process map" with all detail possibly available. Level 2 – the operational decision design – agreed with the business unit's experts when the unit head are "fine with it". Both are done by business analysts.

## *4.4 Technology Architects*

Process modeling is often done by technology architects; their main focus is technology architecture not business processes – or service interactions. When process modeling is done by business analysts their focus is the business process map, not their possible implementation or execution. In software projects the business teams and the technology teams have to collaborate for success, no real business solution today works without technology; no excellent information system without focused business value.

The *context* of the service system – and its grammar – supports the often underestimated communication effort between the teams and helps their mutual understanding with its a-priori grammar for service value chains. This reduces the synchronization gaps and double modeling risks. Both teams – business and technology – describe service system behavior using service process modeling in the service value chain. Measurements can be aggregated on each level of detail.

## *4.5 Organization Behavior*

Situational behavior (Hersey et al. 2008) has two dimensions: the task dimension and the relationship dimension. Service networks and service systems neatly represent these two dimensions of situational behavior. This is the behavior for creating service systems and for operating service systems.

The decomposition addresses the different types of *complexity* (Diao 2007) at different levels of detail focusing divide-and-conquer or slice-and-dice content design approaches towards aggregated behavior in the architectural context. The business grammar focuses on the collaboration model and the decision model of service interactions while the technology grammar focuses on the automation model and execution model leveraging shared information. This structure implies and organizes directly a *work split* (task dimension) between owners, analysts, and architects – and their service interactions (relationship dimension) – and therefore governs implicitly their situational behavior.

The service sequence (L1) addresses collaboration complexity. The service sequence determines the separation of internal and external business collaboration of the service value chain. Decisions and feedback (L2) address the decision complexity. The decisions and feedbacks determine the separation of the business governance and service interactions of the service value chain. Human interactions (L3) address the execution complexity. The human interactions determine the separation of manual interactions and automated interactions of the service value chain. Straight through aggregation (L4) addresses the shared information and persistency complexity. Straight through aggregation determines the computational diversity.

The goal of service system governance is to articulate a common understanding in a service system network and inside a service system. The grammar using semantic decomposition tackles the needed *trade-offs* one at a time, prominently, regarding (1) reputation and image, (2) internal coordination, and (3) over- or under-engineering (Porter 1996). Service system grammar allows governing these directly.

The sequence (L1) determines the purpose, defining start and end. Decomposing it into decisions and loop-backs (L1-L2) ensures that the system's *reputation* and the external image of the behavior are consistent with the strategy for that particular service system, because the governance is established for that particular value chain purpose. Decomposing decisions and feedbacks into manual work and automation (L2-L3) ensures internal *coordination*, because the roles are introduced for particular decisions. Decomposing manual work and automation into straight-through aggregation (L3-L4) ensures that the service system establishes no over- or under-*engineering*, because the technology and their applications are considered for a particular service execution while sharing these services.

The service system grammar is a predefined structure for creating and for combining service systems into service networks, thereby linking the service value chains of the participating service systems together focusing on situational behavior. Sharing the same language (due to the service system grammar and agreed industry specific vocabulary) facilitates mutual understanding without compromising on asset visibility selection the appropriate level of detail – between different roles in one service system and the same roles in different service systems.

# 5 Service System Grammar Establishes Service Perspectives to Allow Architecture and Design Streamlining Governance

## *5.1 Service System Perspectives*

Our experience in modeling service processes, designing and architecting information systems in a multi-sourcing environment shows that it is important to separate the actual value creation from the service interaction to achieve it. We therefore propose two *primary* service system perspectives:

- Service value chain perspective deals with the service decomposition of one particular services system: it is the *task* dimension of organizational behavior: the service processes – answering: Which service *features* do we need?
- Service co-creation perspective deals with the service interaction inside a service system or service interactions between service systems: it is the *relationship* dimension of organizational behavior – answering: How do we understand their service *interaction*?

Both primary perspectives depend on each other to model service systems. There might be a couple of *secondary* service system perspectives, most prominently an engineering perspective looking at the technical execution and support of services systems and the governance perspective.

The service value chain perspective may have different *angles* (or types): Service value chain perspective for the customer, for the provider, or for the service owner (creating the secondary governance perspective). Taxonomies are known for these angles (Wemerlöv 1989) spanning between the degree of divergence, from standard to customized, and the degree of customer contact, from no contact to direct contact.

The line of *visibility* (Bittner 1993) separates the onstage contact person from the backstage – or front-office from back-office – or access channel from backend. This line of visibility is also needed to protect *assets* while interacting with customers and partnering providers. The visibility compilation facilitates cooperate *communication* and therefore is a means of governance. Service perspectives compile this visibility level based on the service system grammar.

Design and architecture *tooling* moves to collaboration using one repository, in a Web 2.0 community fashion (e.g. Decker et al. 2008), or in an EAM fashion (e.g. Telelogic 2008) or process modeling tools (e.g. Adonis 2008). An increasing amount of people need to be informed and need to contribute to actually architect and to design the service systems. The time of the one isolated “mapper” of processes documenting every detail in one flat diagram is over. Service system perspectives help to remove the graphical complexity and present a targeted audience the right amount of detail.

## 6 Service Value Chain Perspective

The service value chain focuses on the service system behavior to create value. Situational behavior can be generalized and consolidated using semantic decomposition as the grammar proposes. The service value chain perspective is supporting this separation of concerns for all four semantic *decomposition* levels (Fig. 1).

General behavior is captured at the service sequence (L1). Using verbs only focuses on the behavior and allows the standardization for different contexts. Defining the industry specific and solution related business entities applies the general behavior to a particular context. These are basically context free *behavioral patterns* (and used here as an illustration). We use BPMN as a notation for service processes, UML activity diagrams or any other flow charting can be utilized.

Essentially the service value chain perspective supports decomposition the own service systems behavior using the service system grammar graphically for a model of the *inside*:

- Semantic decomposition articulates actual, relevant *service processes*. Grammar and verbs (the behavioral part of the vocabulary) are predefined to ensure consistency and to find commonality. Grammar is a vital part to apply these types of reference models that focus on behavior – and not on business entities, e.g. analyzing entity lifecycles.
- Semantic decomposition reduces the risk of isolating the analysis due to very specify *business entities*. The service processes not only industrialize the provider's behavior: the provider's service sequences are collaborating with the

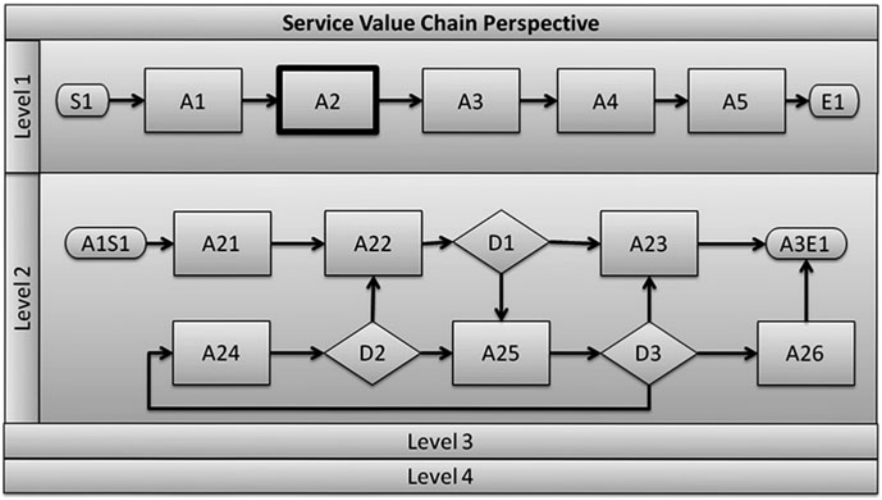



**Fig. 1** Service value chain perspective leveraging the semantic decomposition of the service grammar (Two levels with their respective activities A1, A21, etc. are conceptually visualized together so that the detailing diagram and the level above can be inspected at the same time.)

customer's service sequences. This creates the services the provider's service system is offering its customers.

Combining two decomposition levels graphically create simple angles of the service value chain perspectives: the architecture perspective L1-L4, the design perspective L2-L3, a business perspective L1-L2, and a technology perspective L3-L4.

## 6.1 Service Co-creation Perspective

The service co-creation perspective focuses on the service *network* behavior to co-create value. Value chains of distinct service systems – and most importantly: customer and provider of one service system – need to agree on interaction: that is the service co-creation perspective visualization. The interactions with the customer are established to ensure customer satisfaction.

The service co-creation perspective is supporting this separation of concerns for all levels of service *interactions*. That means what is provided – the message, the offer, deliverables, i.e. tangible stuff – can be decomposed as well to facilitate mutual agreement (Fig. 2).

Interaction can happen at different levels of detail – not always is the partner or customer value chain known. Provider co-creation perspective is at the level needed (e.g. level 4) while the customer co-creation perspective might be educated guessing at level 1. The service co-creation perspective is basically the model of the *outside*; it models how shared information is organized between customers and providers – and consequently between different partnering providers.

Service interaction can bridge over different levels of semantic decomposition; this allows interaction with the explicit choice of visibility. Different types of people or organizations can create different relationship visualizations, i.e. different angles of the service co-creation perspective. A level of *shared information* is also needed to establish simple governance, essentially sharing information between the system owner and its executing provider. For creating service systems these first-hand provider roles are business analysts and technology architects – ideally on customer side as well as on provider side.

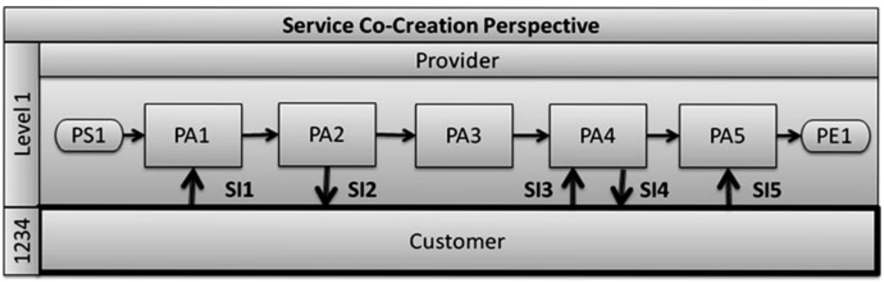



**Fig. 2** Service co-creation perspective for customer interaction without customer visibility (The customer is added to see the interactions of the provider service value chain, here on level 1.)

## 6.2 Service Engineering Perspective

Enterprise architecture ends in a solution architecture and vice-versa. *Information system* or application landscapes, technological service portfolios are organized to create an overview of the technological capabilities of the provider (and even the customer if needed). Executing in service system networks only works with a certain degree of technological interoperability. Projects span over more than one application over more than one provider.

The engineering perspective therefore links the L3 and L4 levels of the service system structure to existing or planned information systems and access channels.

This visualizes the technology *resources* to support management and strategy for engineering. The engineering perspective links technology resourcing to support technology roadmaps, information system portfolio planning, and the creation of new service systems – while linking the resourcing to the service value chain (architecture angle). The design angle shows what shared information can be provided by whom.

For creating service systems with software projects these information systems are repositories, registries, essentially tooling for modeling and reporting to share the needed information at the appropriate level of detail (to code, to deploy, to test, to install hardware, . . .).

Other perspectives e.g. to visualize the *management* of the service system might be incorporated, not the information systems but the organizational structure into the service value chain perspective and into the service co-creating perspective.

## 6.3 Service Governance Perspective

The governance perspective essentially adds the service system owner as a third value chain to the customer and the provider service value chain (Fig. 3) to understand this influence in the relationship with other service system owners. While creating service systems e.g. the governance aspects are about sharing information with technology resources like tooling for modeling or reporting.

The governance perspective is a combination of the value chain perspective and the co-creation perspective to achieve the impact governance has on the execution of the service system. Service system governance can be separate, collaborative, or embedded. We believe that a separate owner with own service processes can more effectively act in increasingly complex and often confusing service system network situations. *Decision rights* to be effective need simplification to agree faster: for the governance for the service system itself, for governance with customers, for governance with partners.

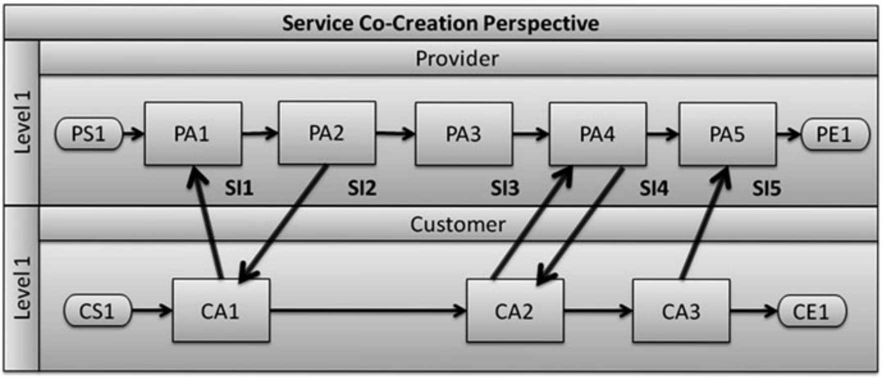



**Fig. 3** Service co-creation perspective for customer interaction with customer visibility (The customer view details conceptually the customer behavior to create explicit service interactions with the customer value chain.)

Behavioral patterns for simple governance may help as a start, like: Check–Decide–Confirm service sequence. The sequence e.g. can decompose for decision making and feedback into:

- Check – audit, analyze, ensure, review, understand, or inform.
- Decide – delegate, agree, defer, or escalate.
- Confirm – explain, empower, consolidate, announce, or feedback.

Situations are e.g. (driver) legal regulations, corporate policies, SOX, PCI, ergonomics, budgets, or go-life to govern (subject) change, execution, options, or readiness for (severity) compliance, plausibility, completeness, relevance, or consistency.

The governance perspective for the service value chain perspective – or in short: *profit* governance – and governance perspective for the service co-creation perspective in short: *collaboration* governance – depend on each other. Global multi-sourcing service delivery governance asks for the following service processes: (1) relationship strategy, (2) responsibility, especially at hand-offs, (3) integration as a theory of interaction, (4) equity regarding value and funding, (5) audit and assessments monitoring performance, and (6) leadership (Champy 2008). Our experience is that establishing communication and feedback is the greatest challenge in such a virtualized environment where customer "cannot touch shoulders" of key contributors.

Service system grammar is good in crystallizing behavioral patterns at the right level of detail. This improves governance structure; it makes governance simple targeting the decision rights to the relevant people. Depending on the level of visibility the amount of information is shared with increasing relationship intensity, i.e. *trust*.

Simple governance embeds knowledge management: the guys checking and deciding know. Different level of detail can be adopted into the situation needed. Structural *agreement* – interactions are known – is easier for the same approach in the sensitive area of governance and power.

The governance perspective coordinates the different service owners (of call centers, front-office, back-office . . .), and technology representatives, e.g. application owners, maintenance heads, or data center directors. Other perspectives e.g. to visualize *transformation* to communicate change, optimizations, and innovation might be needed. This would not only include different people – decision makers – but also different value chains for the same purpose.

# 7 Service System Governance Focuses with the Service System Grammar on the Strategy Driven Control of Value Creation

## *7.1 Service Innovation Structure*

The governance of the service system creating the new service system influences the sustainability of the value creation of the new service system. Innovation is a climate of participation. Service processes articulate cooperation behavior, organizing work. Communicating these service processes is becoming a key to change and innovation. There are two stages of innovation (Table 3): (1) managing key activities, and (2) creating an innovative climate focusing on people and structure (Jong 2003).

The reality of creating service systems has changed. The focus on pure software solutions is gone; operations and maintenance, as influential organizational units, are major stakeholders due to the simple fact of being a substantial efficiency driver after creation. The combination of service processes and service technology has become a reality. The style of creating the service systems moves from an onsite one-vendor consulting project in which each consultant and customer more or less was able to gather and to design the requirements, to architecture the business and the technology solution, to design software for the service processes, and to code (and test) the solution has gotten less common over time. Work split is extreme: coding is done offshore, even test factories virtualize continuous validation of the information systems. Design and architecture are still often done onsite but mostly

**Table 3** Structuring an innovative climate

| | People | Structure |
|---|---|---|
| Managing key activities | Involvement of operations people (the front-line)<br>Presence of subject matter experts (product champions)<br>Management support | Funnel tools<br>Multifunctional teams<br>Availability of resources<br>Pre-launch testing<br>Market research |
| Creating an innovative climate | External contacts<br>Sharing information<br>Autonomy of employees | Strategic focus<br>Training and education<br>Internal organizations and task rotation<br>Information technology |

by the service providers. This requires a changed approach to governance; this requires different governance.

The governance of delivering and creating service systems influences the governance of the service system itself while using it. This sounds trivial but is often enough astonishingly underestimated. Both are service systems. The same governance approach ought to be applied. The service grammar simplifies its structure.

Viewing collaboration through this broader lens highlights how it can be used to support a firm's strategy. It forces managers to understand the competitive implications of partner selection, by assessing their merits along multiple dimensions, instead of only one. And it helps firms understand where to use collaboration, in terms of the parts of the innovation value chain where a focus on cost versus differentiation is most appropriate (MacCormack et al. 2007).

The service value chain and the service co-creation perspective help to analyze innovation from the transactional (course of action, plan) and from the collaborative (relationship, governance) angle. Simple governance ensures that the service value chain and the innovation value chain actually match.

## *7.2 Embedded Value Proposition*

Simple governance is smart governance; it outsmarts competition because it creates value with partners. Service system governance is simple governance if it is leveraging the common language based on a service system grammar. Service system governance does not need to separate the governance of the service from the governance of the product. This can be done at the right level of detail – with the *visibility* possible (starting with none but defined service interactions, moving to Level 1, . . .) in the service system network.

We believe the best value proposition in such a complex setting of interests is to demonstrate the own service system governance at the lowest level of detail needed to prove it works. This motivates the service *interaction* governance.

What is then the strategic value? It arises from focusing on key strategic processes and developing simple rules that shape those processes – a pattern that creates network effects or economies of scale or scope – the result can be a long term competitive advantage (Eisenhardt and Sull 2001). A service systems grammar is the essential ingredient to use the common language that reduces governance.

Changes – and their resulting *trade-off discussions* – for engineering are therefore easier (with less impact, having less level of detail to look at), than for coordination or even reputation. This makes operational efficiency in engineering less interruptive (coordination and reputation are staying consistent). Integration of technology remains the biggest engineering challenge and change has a high impact. With this grammar for service value chains the danger that engineering is misused for internal coordination or even reputation is reduced because of distinct levels of detail visualizing the fit of services.

The service system paradigm therefore facilitates the communication between business and technology teams due to the simple fact that the grammar for the service value chains structures the agreement procedure – the service system governance process. Bringing business and technology together early seems to be common sense, but the actual challenge is the *effort of communication* and the level of alignment needed to create the service system. The value chain grammar postulates a priori a semantic level of detail to structure agreement of the people involved.

The right level of detail enables the teams to focus on the actual challenge aligning business and technology in a service system to actually provide value for customers. The business sequence (L1) then is often nearly pure business, while the application portfolio (L4) is mainly technology. The agreement process can then use the decomposition level for decisions and feedbacks (L2) for the operational *effectiveness* of the service value chain and the automation and manual work split (L3) for the organizational *efficiency* to model achievable, executable behavior. In the very end, L2 and L3 see more iterations than L1 and L4. You can expect the most intensive discussion for internal coordination (in joint workshops): decisions, feedbacks, and the impact of manual work and automation.

The grammar allows these workshops to stay at a *consistent* level of detail. With its derived service perspectives it visualizes the audience *relevant* level of detail to deal with the challenges for creating the service system – including a simple service system governance to run it sustainably.

## 8 Conclusion

We propose that simple governance in value networks needs a structure that can be articulated and understood at different levels of detail – by all relevant stakeholders. This is what the *service system grammar* can provide. This *structure* has to combine business and technology aspects. The service system grammar is doing so while coordinating architecture and design interactions – respecting and coordinating the key knowledge worker roles.

Further research is needed to enable and to encourage organizations to exchange their governance mechanisms leveraging certain *visibility* levels. We find out: only sharing the content to be governed enables e.g. software development in a multi-sourcing global service delivery setting. With *service perspectives* the content empowers and controls the communication and the governance for innovation and for excellence.

## References

Adonis. (2008). Adonis Community Version. http://www.adonis-community.com Accessed October 2008.

Alter, S. (2008). Service System Fundamental. *IBM Systems Journal* 47, 71–85.

Araujo, L., and Spring, M. (2006). Service, Products, and the Institutional Structure of Production. *Industrial Marketing Management,* 35, 797–805.

Bittner, J. (1993). Managing the evidence of services. In: Scheuing, E., and Christopher, W. (Ed.), *The service quarterly handbook*. New York: Amacom.

Bloomberg, J. (2004). SOA Governance – Reengineering IT governance, http://www.zapthink.com/report.html?id=ZAPFLASH-10272004. Accesses October 2007.

Champy, J. (2008). *Outsmart! How to do what your competitors can't.* Upper Saddle River, NJ: FT Press.

Cohen, L., and Young, A. (2006). *Multisourcing – Moving beyond outsourcing to achieve growth and agility*. Boston, MA: Harvard Business Scholl Press.

De Marco, T., and Lister, T. (1999). *Peopleware – Productive projects and teams*. New York: Dorset House Publishing.

Decker G., Overdick H., and Weske, M. (2008). Oryx – An Open Modeling Platform for the BPM Community. http://bpt.hpi.uni-potsdam.de/pub/Public/GeroDecker/bpmdemo2008-oryx.pdf. Accessed October 2008.

Demirkan, H. et al. (2008). Service-Oriented Technology and Management: Perspectives on Research and Practice for a Common Decade. *Electronic Commerce Research and Applications* 7, 356–376.

Demirkan, H., and Goul, M. (2006). Towards the Service Oriented Enterprise Vision: Bridging Industry and Academics. *Communications of the Association for Information Systems* 18, 546–556.

Diao, Y. (2007). Using control theory to improve productivity of service systems. *IEEE International conference on service computing*.

Eisenhardt, E., and Sull, D. (2001). Strategy as Simple Rules. *Harvard Business Review on Advances in Strategy*, 79, 95–122.

Hammer M., and Champy, J. (1990). *Reengineering the corporation*. London: Collins.

Hersey, P. et al. (2008). *Management of organizational behavior*. Upper Saddle River, NJ: Pearson.

Heskett, J. L. et al. (1994). Putting the Service Profit Chain to Work. *Harvard Business Review*, 3, 164–170.

Jong, J. (2003). Organizing Successful New Service Development: A Literature Review, *Management Decision*, 41, 844–858.

Leonard, D. (1995). *Wellsprings of knowledge*. Boston, MA: Harvard Business School Press.

MacCormack, A. et al. (2007). Innovation through Global Collaboration: A New Source of Competitive Advantage. *HBS Working Paper* 07-079.

Maglio, P. (2006). Service Systems, Service Science, SSME, and Innovation. *Communications of the ACM*, 49(7), 35–40.

O'Reilly, C. et al. (2004). The Ambibedextrous Organization. *Harvard Business Review* 82, 74–81.

Porter, M. E. (1996). What is Strategy? *Harvard Business Review* 11, 61–78.

Puehl, S., and Szczeponik, W. (2009). The Grammar of Service Systems – Towards the Alignment of Business and Technology. In: *First International Symposium on Services Science*, Logos Verlag Berlin, 39–47.

Ramirez, R. (1999). Value Co-production: Intellectual Origins and Implications for Practice and Research. *Strategic Management Journal,* 20, 49–65.

Spohrer, J. et al. (2007). Steps Toward a Science of Service Systems. *IEEE Computer Society* 40, 71–77.

Spohrer, J. et al. (2008). The service system is the basic abstraction of service science. *IEEE Proceedings of the 41st Hawaii international conference on system sciences*.

Telelogic. (2008). Telelogic System Architect – Enterprise Architecture and Business Process Analysis. http://www.telelogic.com/products/systemarchitect/systemarchitect/index.cfm. Accessed October 2009.

Vargo, S. L., and Lusch, R. F. (2004). Evolving to a New Dominant Logic for Marketing. *Journal of Marketing,* 68, 1-17.

Weill, P., and Ross, J. W. (2004). *IT governance*. Boston, MA: Harvard Business School Press.

Wemerlöv, U. (1989). A Taxonomy of Service Processes and Its Implications for System Design. *IJSIM* 1 3, 20 –39.

Weske, M. (2008). *Business process management – concepts, languages, architectures*. Berlin: Springer.

Womack, J. P., and Jones, D. T. (2007). *Lean solutions*. London: Simon & Schuster.

# Service Science: The Opportunity to Re-think What We Know About Service Design*

**Chris Voss and Juliana Hsuan**

**Abstract** The evolution of service science or Service Science, Management and Engineering – SSME, provides us with a platform to critically review the area of service design. The drivers for this include the lack of cross-disciplinary writing on service design, the limitations of the treatment of service design as an extension of product design and the dominance of B2C and neglect of B2B design. Three perspectives are used: service delivery systems, service architecture including modularity and platforms, and the service supply chain/network. Empirical examples are provided and a service modularity function is developed. It is argued that an important role of SSME is to be able to link the operationally based service architectures and resulting design methods and information system (IS) architectures, and that there is a need to develop a combined view of the physical, organisational, and IS architectures of services.

**Keywords** Modularity · Service design · Service architecture · Service science · Service systems

## 1 Introduction

The challenge of developing a new concept of service science (or Service Science, Management and Engineering – SSME) has triggered a wide range of thinking by both academics and practitioners alike (Maglio et al. 2006; Spohrer et al. 2007; Hefley and Murphy 2008). From an observer at the interface, it would seem to have gone through a number of phases. The first was to broadly define the scope of the

*This chapter has been developed from a paper prepared for the Cambridge SSME meeting and from the resulting academic paper: Voss C.A. and Hsuan J. 2009. Service Architecture and Modularity, Decision Sciences, 40(4): 541–569.

C. Voss (✉)
Management Science and Operations, London Business School,
Regent's Park, London NW1 4SA, England
e-mail: cvoss@london.edu

H. Demirkan et al. (eds.), *The Science of Service Systems*,
Service Science: Research and Innovations in the Service Economy,
DOI 10.1007/978-1-4419-8270-4_13, 

field. This has been done, though as SSME begins to mature, this scope has been questioned and it can be argued that it is rather narrow and could be expanded. The second phase in which many including the lead author of this chapter participated, was to argue that before a totally new field was developed it was important that the depth of existing knowledge be recognised and brought into the arena. It would now seem that this stage is well on the way and diverse and multi-disciplinary sets of knowledge from systems, operations, marketing and engineering are being brought together.

We believe that part of the next phase in the evolution of service science is to use it as a platform to hold up a mirror to this accumulated and diverse knowledge and to address some of the core areas both of service within the scope of SSME and the broader area of service management. Rather than just propose existing knowledge areas that should be addressed in the development of SSME, we propose to use it as a platform to critically examine one important area of service – service design.

## 2 Why Service Design Needs Re-examining

In addressing service design the starting point is our own, non-computer systems, knowledge base of service design and product architecture. We identify a number of drivers that collectively cause us to see a clear need to re-examine service design. Our first observation is the narrowness of much writing on service design, particularly from a marketing perspective. The prime focus in this area is the service concept and design of the interface between the service and the customer to maximise customer satisfaction, positive word of mouth and repeat business. The operations management literature tends to take the reverse and broader view with a focus on the design of the service delivery process to effectively deliver the service concept (Roth and Menor 2003).

One of the dilemmas of service design is whether it is a product or a process that is being designed? The dominant models in the service design literature implicitly treat the development of new services in a similar manner to that of a product and use frameworks drawn from product development (see for example (Bessant and Davies 2007)). However as Voss and Zomerdijk (2007) point out, although there is much new product development in services, much is actually design and development of new service processes and/or systems. We therefore argue that for much of the area of service design a manufacturing-based, product development paradigm is inappropriate. Given that the process is the product in many services, we should still draw on our knowledge from products, but adapt it. A third issue that we identify is that the dominant literature on service design is based on B2C services. This raises the question as to whether the knowledge base of B2C service development is equally applicable for the design and development of B2B services. A final issue that follows on from this is the diversity of services. This is a challenge both for defining the scope of service science and for developing knowledge and processes for service design more generally. We propose three perspectives that may help move service design forward; a service delivery system perspective, an architecture perspective and a service supply chain/network perspective.

## 3 Service Delivery System

As stated earlier, operations management researchers have examined the operational processes and choices that are required to deliver value and the service concept. Roth and Menor (2003) have developed a comprehensive framework setting out these choices. They argue that these consist of three areas; the structural which includes the physical structure, the technology and the operational planning required to deliver a service; the infrastructural which include the people, systems and processes and then the integration. It is probably the latter where the interface and importance of SSME becomes apparent. Integration requires design of physical, organisational and technological coordination mechanisms. They also position this in the context of the service supply chain. Their framework for service delivery system design is shown in Fig. 1.

This framework provides a useful model for thinking about service design in the context of SSME. The service concept may be developed in a traditional way through marketing, though the role of the user in co-design and co-production is

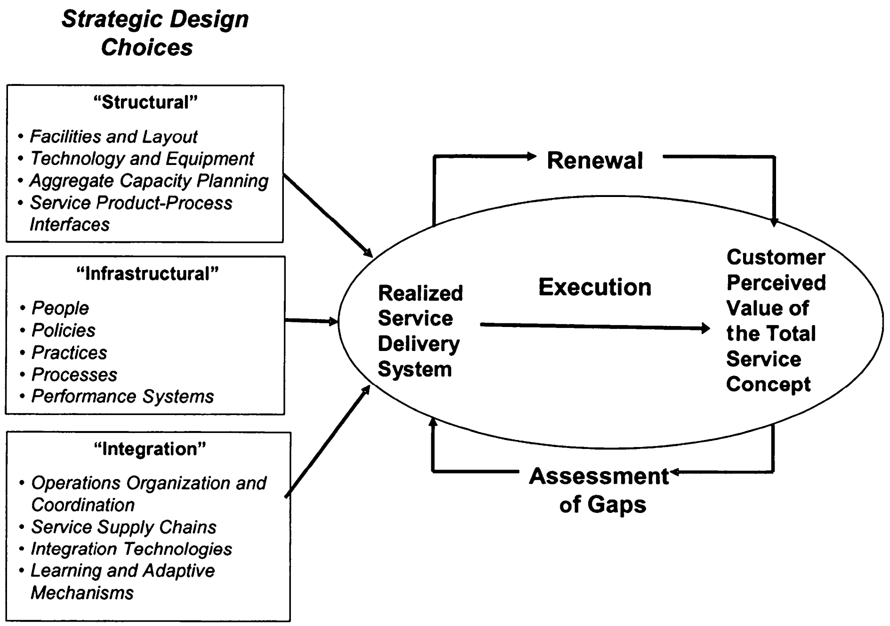



**Fig. 1** Service delivery system design framework – source Roth and Menor (2003)

becoming increasingly important. However, the design of the delivery system must involve not just marketing and users, but computer systems, operations and human resources. The challenge in rethinking service design is in part how do we bring this diverse group together effectively.

In the following sections we examine a number of important perspectives, before returning to SSME and service design. We next examine a complementary element to this – Service Architecture and in particular how it enables us to think about service modularity and design areas such as service outsourcing.

## 4 Service Architecture

We propose that one way forward that can potentially bring together the differing views on service design is through consideration of service architecture. Product architecture can be considered as the arrangement of a product's functionality elements into a number of physical building blocks, including mapping of functional elements into physical components and the specification of interfaces between interacting physical components (Ulrich 1995). Menor et al. (2002) state that understanding the architecture of a physical product helps developers partition the development work content, and also helps developers understand the potential interactions between different parts (modules) of the product. This helps development managers plan the coordination of different organisational functional groups and task teams associated with specific modules.

There has been growing study of product architecture, particularly in the context of modularity. Modularity refers to the scheme by which interfaces shared among components in a given product architecture are standardised and specified to allow for greater reusability and commonality sharing of components among product families. Modularity provides the basis for customisation, provides economies of scale and scope, and can help structure products to facilitate outsourcing. However, there are also costs associated with modularity, in particular those associated with coordination (Mikkola 2006). Menor et al. (2002) argue that the product architecture serves as a means of making the product concept quite specific, and allows a shared understanding of the new product between multiple disciplines (marketing, design engineering, and operations). They see developing and applying the concepts of architecture and modularity to New Service Design (NSD) projects and the NSD process as a major research opportunity and may be a useful tool to integrate the "front" and "back" ends of the NSD process.

An important way of looking at product architectures is to distinguish between modular and integral product architectures (Mikkola 2006), see Table 1.

Modular product architecture designs provide the foundation for flexible platforms, as they allow the realisation of product variations. These designs intentionally create independence between components. This is accomplished by standardising interface specifications. That is, the components can be disassembled and recombined into new configurations. Product variants can be realised with less

**Table 1** Characteristics of modular and integral product architectures (Mikkola 2006)

| | Modular product architecture | Integral product architecture |
|---|---|---|
| Design criteria | Commonality sharing | Maximum performance |
| Component boundaries | Easy identification | Difficult identification |
| Redesign to architecture | Without modification | With modification |
| Interfaces | Decoupled | Coupled |
| Outcome | Economies of scale | Craftsmanship |
| Product variants | High | Low |
| Nature of components | Standardised/generic | Customised/dedicated |
| Component outsourcing | Easy | Difficult |
| Learning | Localised/Dispersed | Interactive |
| Synergistic specificity | Low | High |
| Component substitutability | High | Low |
| Component recombinability | High | Low |
| Component separability | High | Low |
| Nature of innovation | Autonomous | Systemic |
| System design strategy | Decomposition | Integration |

difficulty as changes in one component do not lead to changes in other components, and physical changes can be more easily varied without adding tremendous complexity to the manufacturing system. The motivation behind this strategy is to gain cost savings through economies of scale from component commonality, inventory, logistics, as well as to introduce technologically improved products more rapidly. It also allows the firm to make product changes easily such as upgrade, add-ons, product line extensions, and cosmetic adaptations. This, in turn, enables firms to listen to customer feedback and alter their systems accordingly by substituting some components while retaining others.

With Integral product architectures, on the other hand, modifications to any one component cannot be done without requiring the redesign or reconfiguration of the other components. Performance via state-of-the-art innovation is the key objective, which can be prohibitively costly for complex systems. Integral architectures tend to have many unique components making the redesign of the architecture difficult due to the complex one-to-one relationship shared with other components. The tightly coupled interfaces of integral product architectures require new product development (NPD) and manufacturing activities to be carried out concurrently. This means the learning becomes interactive making component outsourcing difficult.

We see this categorisation as potentially applying equally well to service design, and in particular to B2B services. For example third party logistics (3PL) has providers with both modular and integral service architectures. A challenge in developing our ideas about modular service architecture is to understand the degree to which some of the important elements in product architecture translate into service architecture. These elements include the nature of the interfaces, the degree of coupling and substitutability, the degree of standardisation and uniqueness, and the nature and number of components. Operationalising these dimensions is difficult in product design (Mikkola 2006), and we anticipate that the same to be true for service.

## 5 A Hierarchical View of Service Architecture

We draw on our recent work on service architecture to show how a service architecture and the associated modularity might be represented (Voss and Hsuan 2009). In bringing operational, marketing and service systems views together, we take a systems and decomposition view of service architecture (Sanchez 1999; Simon 1962). The functionalities of the service system are decomposed into individual functional elements to provide the overall service delivered by the system. At each level of decomposition the architecture can be either integral or modular (Mikkola 2006). When we compare services with products, we find different ways to look at decomposition. Whereas the top level of product architecture is the product itself, the top level of a service architecture can be seen as the industry. A service system can be analysed at each level from the industry level down to what one might think of as the discrete service module. In exploring the architecture of services we illustrate through four levels, even though it may be possible to subdivide into many more than these four.

The levels are as follows:

0. Industry
1. Service company/supply chain
2. Service bundle
3. Service package/component

*Level 0 – Industry*
The study of industry architectures is growing especially in the area of service industries. An example is the mortgage banking industry, which has been undergoing a major shift from an integral model, in which all services are provided by the mortgage bank, toward a more modular industry architecture in which specialist firms have emerged and mortgage banks now perform a narrower, market-facing role (Jacobides 2005). Once an industry architecture becomes stable, a system of interfaces develops. At the industry level, these interfaces often consist of regulatory frameworks, rules, standards, and technological specifications that allow different players to connect (Jacobides et al. 2006). Interfaces can be both proprietary and open. The move to modular industry structures emphasises the growing need for SSME approaches to industry IT systems (Spohrer et al. 2007).

*Level 1 – Service company/supply chain*
In contrast to industry-level architecture, at the company level an organisation has the ability to design its own architecture. As with products, a modular architecture enables a firm to consider outsourcing some of its services or service processes to others (or to be a supplier of services to others). Hence, architecture at this level should be considered not just at the level of the firm but also at the level of its supply chain, both upstream and downstream. A parallel trend toward both shared services and service outsourcing is apparent. Outsourcing has become an increasingly important consideration for all businesses, and can only be realised when a system can be decomposed in such a way that the interfaces of the components are well specified

and standardised, which is a central focus of modularisation strategies (Mikkola 2007). Effective service outsourcing requires clear knowledge of both the process architecture of services and the interfaces between them. A common configuration at the company level is the multisite service organisation. Examples include firms such as banks, department stores, general retail outlets, restaurants, and auto-repair garages. Typically the architecture for such an organisation will consist of a core plus a set of standard modules deployed across many sites. Another configuration is product-based, in which a series of modular products are developed, often sharing the same components and information systems, as in financial services.

*Level 2 – Service bundle*
At this level of disaggregation, we consider the individual service bundles that comprise the company's Level 1 service offering. Each bundle can be viewed as a set of modules. One example is a modular approach to the designing of service packages for the elderly (de Blok et al. 2010). A Dutch network of care providers for the elderly delivers a variety of care and service packages. They offer three kinds of modules: a basic module common to all services, a set of modules that can be configured for each segment, and a further set of modules that allows for customisation at an individual level. These customisable modules are in turn composed of modules or elements at Level 3. Similar configurations of company-level architecture can be found in B2B services such as 3PLs.

*Level 3 – Service package/component*
The service component can be treated as the smallest building block or module of a service system. A number of important characteristics of these building blocks contribute to the nature of the overall systems architecture. These include standardisation, uniqueness, degree of coupling, and replicability.

The cruise industry provides an apt illustration of the four levels of service architecture decomposition (Fig. 2). Level 0 features the various players in the industry, some of whom are cruise line companies, others of whom are independent

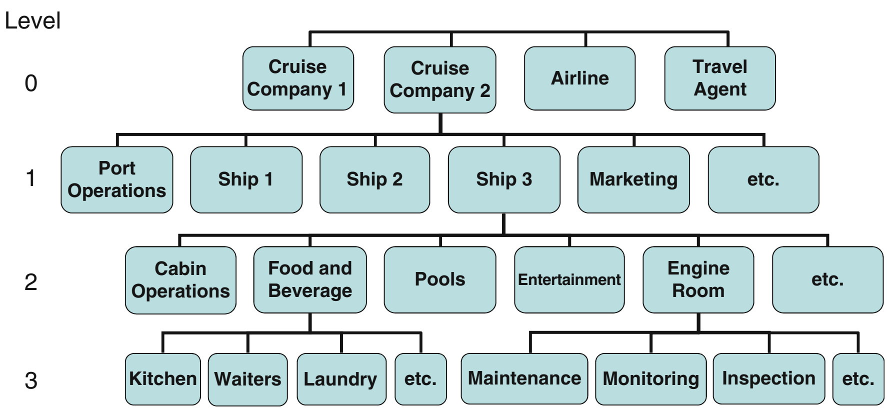



**Fig. 2** Hierarchical decomposition example of sea cruise services (Source: Voss and Hsuan 2009)

of the these companies. Level 1 is that of an individual cruise line company. The firm operates a number of cruise ships and has marketing services and port operations services, as well as back-office, procurement, and other services. Some of these services may be outsourced, building a service supply chain. Level 2 reflects the level of the ship itself. Each ship has an architecture consisting of a variety of guest services such as swimming pools, restaurants, night clubs, and cabins. There are further services associated with the running of the ship and its interface with shore visits, and so forth. These guest services may be standardised and thus easily replicated across all the ships of the fleet, or they may be custom-designed for that ship. Further, these services may be unique to the company and not easily imitated, or they may be standard, that is, similar across all firms operating in the industry. Finally, at level 3, each of these services can be broken down into a further set of service components, such as the individual elements of food and beverage (into kitchen, waiters, laundry, etc.) and of engine room (into maintenance, monitoring, inspection, etc.).

## 6 Modelling for Service Design Decision Making

In the dynamics of services, sustained competitive advantage is hard to achieve. Within the frameworks of service architecture and modularity, there are three areas that can contribute to competitiveness. The first is the possession of unique service modules or elements that are not easily copied in the short term by competitors. The second is the ability to exploit these through replication across multiple services or multiple sites. The third is the possession of a degree of modularity, which in turn supports both customisation and rapid new product development. Service designers face architectural choices regarding the nature and the degree of modularity, the nature of interfaces, and the degree of uniqueness. It has been argued that customising a firm's offering to meet the diverse needs of individual consumers is relatively more important for satisfying service customers than for satisfying consumers of goods (Anderson et al. 1997). The thorough understanding of the architecture of a service can facilitate design for effective customisation.

In designing or re-designing services to gain sustainable competitive advantage, managers face many decisions. These include the choice of integral or modular architectures, the degree of uniqueness or replicability required at each level, whether to build a service platform, and the location and nature of key interfaces. Managers require tools to enable them to support decisions such as whether to increase uniqueness at the expense of modularity.

Analytic approaches can provide powerful tools to help managers assess design alternatives. One such tool is the Service Modularity Function (SMF) (for a fuller description see: Voss and Hsuan 2009). This provides a means of articulating and quantifying the degree of service modularity. It also allows firms to examine the sensitivity of service packages with respect to changes in unique services.

$$SMF(u) = e^{-u^2/2Nf}$$

$u$: number of unique services
$N$: number of all services (unique and standard)
$f$: replicability factor

The SMF can be interpreted as follows. Because we take the decomposition approach, all services are treated as systems. These service systems have standard and unique service elements. The degree of service modularity varies exponentially with respect to the total number of services ($N$), the number of unique services ($u$), and how these unique services can be replicated across service families ($f$).

Standard services are those services that are routinised and abundant in the industry. Such services are common in multisite service providers such as fast food and retailing. For example, most retail bank services are very similar (despite their marketing claims), partly driven by the need for intercommunication between banks. The goal of standard services is usually to achieve agility, that is, the ability to respond rapidly and effectively to changing market demands.

Unique services ($u$) are those services that are unique within the firm and difficult to copy in the short term by competitors. Such services provide heterogeneity that makes replication difficult. This is particularly evident in firms (and supply chains) in which knowledge and information sharing is tightly controlled, such as consulting firms. With the increase in outsourcing and off-shoring activities by firms, the survival of firms has become less predictable due to services that are too generic and price sensitive. Organisations are thus looking to uniqueness as a source of sustained competitive advantage.

The replicability factor ($f$) provides an indication of how easily a service can be reproduced. A standard service can be easily copied and replicated. However, the competitive advantage of service design is related to the replicability of unique services. Service innovations are constantly being introduced by organisations, but not all of these innovations get replicated. Replicability is particularly important in the context of multisite and multi-service organisations, which seek to leverage their service innovations through delivery across different sites and in different services. For example, Cameron Macintosh Ltd. was the first to realise the power of the mass replication of uniqueness in stage shows, and they have successfully replicated a number of stage shows (modules) such as *Phantom of the Opera*, *Cats*, and *Misérables* across multiple countries and multiple languages.

SMF captures the idiosyncratic elements of organisations, internal as well as external. Service bundles might be modular within an organisation, but unique within another. Simply replicating a new service without understanding the "interfaces" of the other organisations can worsen organisational communication (both in quality and frequency), which can be extremely costly. This may have tremendous implications for multinational corporations that are considering outsourcing services to low cost countries.

SMF might also guide the managers to reflect on strategic implications of unique services that are dependent on scarce resources (such as procurement of qualified officers – captains, chief engineers, marine engineers, and specialized technical crew). Studies show that, in 2010, there will be a shortage of 5.9% in the total work force of officers required to man the world fleet. This trend is further complicated with the continuous increase in the number of fleets of 1% per year (BIMCO/ISF 2005). It implies that Cruise Company 2 (example in Fig. 2) should consider not only on how to compete with merchant ships in human resources recruitment but also on how to train these officers so they can man as many cruise liners as possible. This has direct implications for the replicability of such unique service elements into new ships.

## 7 Platforms

The role of platforms is becoming more widely considered in the service design. A platform can be considered an evolving system made of interdependent pieces that can each be innovated upon (Gawer and Cusumano 2002). A *platform* embodies an *architecture* plus a set of *rules*; that is, the protocols, rights, and pricing terms that govern transactions (Eisenmann et al. 2006). Platforms can be both proprietary and shared (e.g. broad standards); and that product architecture – both the high-level platform design and the interface designs that determine how subsystems work together – can have a profound impact on the structure of an industry and on the nature of follow-on innovation. It is particularly useful when the interfaces are open – that is, when the platform leader specifies publicly show how to connect components to its platform (Eisenmann et al. 2006). Modular platform architectures can be particularly useful in the development of new services (Meyer and DeTore 2001). Financial services often have IT based platforms on which they can continuously innovate and add new services.

An example of platform and module architecture is that of multi-channel retail banking. The platform is at two levels. First, an IT platform common across all channels and second a set of different channel platforms. These two platforms support the delivery of a wide variety of product modules each of which contains multiple products (see Fig. 3).

The product modules illustrate some of the characteristics of modular architecture described by Mikkola (2006). In the bank studied, there was careful attention to the interfaces between the products so that they could be bundled is such a way that the bundling added value to the customer, created uniqueness for the bank's products and led to higher customer retention benefits for the bank (Done et al. 2001).

## 8 Service Supply Chain/Network

Our next argument is that service design must move from designing an individual service to taking a supply chain perspective. Despite the well established field of supply chain management both in practice and research, service supply chains have

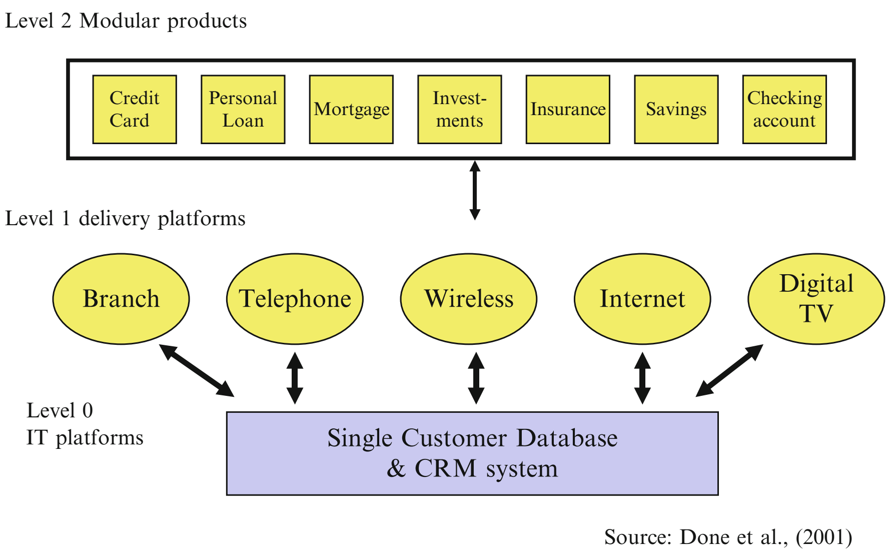



**Fig. 3** Platform and module architecture – retail banking

received scant attention. There are many reasons for this. Most attention has been paid to service procurement and service outsourcing, but usually looking at just one connection in the complex network that makes up a service supply chain. In addition there are many difficulties that are less common in product supply chains. These include the difficulty of developing clear specifications, outcome measurement is often hard to do and responsibility for the supply chain is often distributed across the organisation. Service supply chains have a number of particular organisation aspects that need to noted in service design, these includes suppliers frequently interacting directly with customers, fellow customers playing important roles and particular roles such as intermediaries integrators, technology enablers and consolidators.

In this context an SSME approach plays an important role. As services take place and are enabled by a complex network of players, design involves designing for and within a complex system. This is only likely to be most effective when there is linking of multiple contributors to the design of the service system, paying particular attention to the design of linking mechanisms and systems and the roles and interplay between them.

## 9 The Challenge of Diversity

Although there are substantial differences between products in areas such as complexity and technology, the implications of these differences for product design are relatively clear. This is not the case in service. Services are characterised by

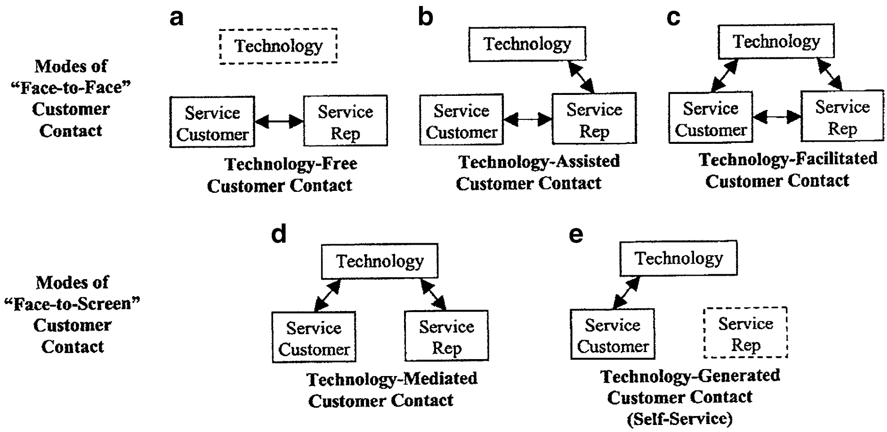



**Fig. 4** Service typology – technology mediated customer contact (Source: Roth and Menor 2003)

a high degree of diversity. There have been many service categorisations, often made to facilitate marketing, none of which is robust across different many applications. One of the core concepts for service design is the concept of the front office and back office, which is particularly powerful in B2C services. Another categorisation is the nature of the interaction between customer, technology and service provider (see Fig. 4). This leads to two related challenges. The first is the development of design concepts and models that are robust and that are applicable in a very wide variety of services. The second is the development of categorisations that are broad enough, but at the same time capture the distinctive nature of different sorts of services. The development of SSME is a good example of where such a categorisation may be required. There is parallel growth of study of new areas of service from the servitisation of manufacturing, product service systems to services of the sort offered by organisations such as IBM and HP. The development of definition of scope and of categorisations within this scope could be a major step forward in consideration of service design.

## 10 Service Architecture and Service Oriented Architecture

An important role of SSME is to be able to link the operationally based service architectures and resulting design methods and information system (IS) architectures. Meyer et al. (2007) argue that in modular service architectures, coordination becomes increasingly important, and support for this can come from parallel IT systems.

Arguably, the concepts of modularity and the importance of interfaces had their foundation in information systems. Like the service architectures described above, these systems are increasingly becoming platforms that provide support for many services in a modular manner. This has led to the development of service-oriented architectures (SOAs), which essentially are modular IS architectures that allow customisation at various levels of service architecture. The creation of SOAs has led to a number of practical and theoretical implications. First, there is a large and growing systems literature on service modularity and architecture that promises to be of benefit to the wider area of service research and innovation (including this volume). Second, there is a need to develop a combined view of the physical, organisational, and IS architectures of services. For example, in contexts where services are primarily IT-based an SOA will likely map directly onto the physical service architecture. However, IS architectures may not map so directly onto an integral platform supporting a range of modular services. Furthermore, SOA is still in its infancy, and realists point out that many difficult technical problems must be solved before SOA can become the backbone for a new strategic architecture (Rettig 2007).

## 11 Towards a Future Agenda

We have argued that there are a number of reasons why we need to re-think what we know about new service design and development (NSD). We have argued that service science provides us with a mirror upon which to base this re-thinking. We have proposed that service product and process architecture, service platforms together with tools such as the SMF provide a basis for this. There are many unanswered questions. In particular, can the models of product architecture and modular products; be brought together with the models of modular processes and process platforms. In addition, can it successfully address both the systems view of architecture and the marketing and operations concepts of service design? If these concepts can be fully developed, operationalised and made measurable, we will make a major contribution to service science in a way that can be relevant to a wide range of services.

**Acknowledgement** This research has been funded by the ESRC, grant RES-331-25-0027, through the Advanced Institute of Management Research.

## References

Anderson, E. W., Fornell, C., and Rust, R. T. (1997). Customer satisfaction, productivity, and profitability: Differences between goods and services. Marketing Science, 16(2), 129–145.

Bessant, J., and Davies, A. (2007). Managing Service Innovation, *Innovation in Services, DTI Occasional Paper no 9*: 61–96: UK Department of Trade and Industry.

BIMCO/ISF. (2005). Manpower 2005 update. Coventry, UK: Warwick Institute for Employment Research.

de Blok, C., Luijkx, K., Meijboom, B., and Schols, J. (2010). Modular care and service packages for independently living elderly. *International Journal of Operations and Production Management*, 30(1), 75–97

Done, A., Schmeer, F., and Voss, C. A. (2001). *The Woolwich Bank, Project Lifestyle*. Cranfield: European Case Clearing House

Eisenmann, T., Parker, G., and Alstyne, M. W. V. (2006). Strategies for two sided markets. *Harvard Business Review*, 84(10), 92–101.

Gawer, A., and Cusumano, M. A. (2002). *Platform Leadership: How Intel, Microsoft, and Cisco Drive Industry Innovation*. Boston: Harvard Business School Press Books.

Hefley, B., and Murphy, W. (2008). *Service Science, Management and Engineering: Education for the 21st Century*. New York, NY: Springer.

Jacobides, M. G. (2005). Industry change through vertical disintegration: How and why markets emerged in mortgage banking. *Academy of Management Review*, 48(3), 465–498.

Jacobides, M. G., Knudsen, T. R., and Augier, M. (2006). Benefiting from innovation: Value creation, value appropriation, and the role of industry architectures. *Research Policy*, 35(8), 1200–1221.

Maglio, P. P., Srinivasan, S., Kreulen, J. T., and Spohrer, J. (2006). Service systems, service scientists, SSME, and innovation. *Communications of the ACM*, 49(7), 81–85.

Menor, L. J., Tatikonda, M. V., and Sampson, S. E. (2002). New service development: Areas for exploitation and exploration. *Journal of Operations Management*, 20(2), 135.

Meyer, M. H., and DeTore, A. (2001). Perspective: Creating a platform-based approach for developing new services. *The Journal of Product Innovation Management*, 18(3), 188.

Meyer, M. H., Jekowsky, E., and Crane, F. G. (2007). Applying platform design to improve the integration of patient services across the continuum of care. *Managing Service Quality*, 17(1), 23.

Mikkola, J. H. (2007). Management of product architecture modularity for mass customization: Modeling and theoretical considerations. *IEEE Transactions on Engineering Management*, 54(1), 57–69.

Mikkola, J. H. (2006). Capturing the Degree of Modularity Embedded in Product Architectures. *Journal of Product Innovation Management*, 23(2), 128–146.

Rettig, C. (2007). The trouble with enterprise software. *MIT Sloan Management Review,* 49(1), 21–27.

Roth, A. V., and Menor, L. J. (2003). Insights into Service Operations Management: A Research Agenda. *Production and Operations Management*, 12(2), 145.

Sanchez, R. (1999). Modular architectures in the marketing process. *Journal of Marketing*, 63(4), 92–111.

Simon, H. (1962). The Architecture of complexity. *Proceedings of the American Philosophical Society, 106*, 467–482.

Spohrer, J., Maglio, P. P., Bailey, J., and Gruhl, D. (2007). Steps toward a science of service systems. *Computer*, 40, 71–77.

Ulrich, K. (1995). The role of product architecture in the manufacturing firm. *Research Policy*, 24(3), 419.

Voss, C.A., and Hsuan, J. (2009). Service Architecture and Modularity. *Decision Sciences Journal,* 40(4), 541–569.

Voss, C. A., and Zomerdijk, L. (2007). Innovation in Experiential Services an Experiential view. *Innovation in Services DTI Occasional Paper no 9*, 5, 97–134, UK Department of Trade and Industry.

# Service Science Learning: Exploring the Challenge of Cross Disciplinary and Academia–Company Collaboration

**Jos G.A.M. Lemmink and Jayanta Chatterjee**

**Abstract** Several authors have claimed that there is an increasing demand for multidisciplinary and cross-disciplinary work in service science, management and innovation. Especially in the service area there is a need to break down the barriers between disciplines. At the same time here is evidence that joint multidisciplinary work by authors in academic journals is only increasing marginally. Another weakness is the lack of real academia–company interaction. Service sector companies have accumulated significant experiential knowledge base and tacit insight from their engagements with many real life applications and successes, but these have often not been studied by academicians for abstraction and understanding of principles. This calls for more study as well.

As academia cannot bridge the gap alone with their traditional curricula, there is a most important role for new learning approaches incorporating cross disciplinary and academia–company learning at the group level. In this case, bringing the group approach to learning means contributions from a wide area of disciplines and participation from academia as well as from companies. Problem based learning (PBL) seems to be an approach that provides the necessary structure for systematic goal oriented collaboration while encouraging new paradigms to emerge.

**Keywords** Service science · Service systems · Inter-disciplinary research · Multi-disciplinary teaching · Problem based learning (PBL) · Service innovation

## 1 Introduction

Taking a closer look at the field of new service development and innovation several authors claimed that there is an increasing demand for multidisciplinary and cross disciplinary work. Especially in service there is a need to break down the barriers

J.G.A.M. Lemmink (✉)
School of Business and Economics, Maastricht University,
6200 MD, Maastricht, The Netherlands
e-mail: j.lemmink@maastrichtuniversity.nl

H. Demirkan et al. (eds.), *The Science of Service Systems*,
Service Science: Research and Innovations in the Service Economy,
DOI 10.1007/978-1-4419-8270-4_14, 

between disciplines. At the same time here is evidence that joint multidisciplinary work by authors in academic journals is only increasing marginally. The first author on this paper has published an overview of all articles published in the International Journal of Service Industry Management between 2000–2005 (Lemmink 2005). The focus of the overview was to assess the extend of cross-disciplinary research. Of the papers that explicitly addressed cross-disciplinary research, most of the 187 authors are members of marketing departments (59), followed by business (58), management (38) and consumer sciences (32).

In order to get some idea of collaboration we counted the number of bilateral co-operations between different departments in the authors' teams. Relevant information was traced from 86 articles. Twenty of them were single-authored. The remaining 66 articles were written by more than one author. In total the number of bilateral relationships between authors was 141. From these 141 pairs of authors, only 40 were cross disciplinary. Adding the number of single-authored articles leads to a preliminary conclusion that from 161 authors only 40 (25%) were involved in cross-disciplinary collaboration. The overview paper concluded that "based on the intrinsic qualities of theories and models from disciplines like marketing and operations management, we should be able to put more effort into collaboration." This logical opportunity however does not translate into "reality" in terms of research publications even today, the percentage of multidisciplinary papers in IJSIM, definitely has gone up between 2005–2009 but it still awaits the surge that one expected since the SSMED movement galvanized major industry–academia fora. There is still lack of good results for academia–company collaboration, and only stepwise progress has been made by setting up joint private–public initiatives.

This paper starts with the premise that this lack of intense inter-disciplinary research in the domain of service systems is not only because Service is still largely considered as another sector of the economy after Industry/Manufacturing and Agriculture. Not only because it is still not seen as the most compelling business logic or as a meta-perspective about which economic activities are all about but also because of the way the subjects that constitute the holistic view of SSMED are taught or learnt today.

The pioneers of this movement are eloquent in desiring an integrative approach to theoretical and practical foundations. Spohrer and Kwan (2008; pp. 2–3) were among the first to equate the original description of the field Service Science Management, Engineering and Design (SSMED) as Service Science and then cited a comprehensive list of important previous literature written between 2005 and 2007. They elaborated on three foundational concepts that underlie the service systems worldview, namely service systems, value propositions and governance mechanisms. At this level, academicians from various disciplines will not have many issues to debate. However when we start with the definition that Service Science, Management, Engineering and Design (SSMED) or Service Science for short, "is an emerging discipline aimed at understanding and innovating service systems" (Spohrer and Kwan 2008; p. 5) and then elaborate the constituent terms as follows we enter the realm of the pedagogical challenges in terms of curriculum design and delivery and learning styles across these constituent disciplines.

Let us first look at these four sets of fundamental questions that SSMED seeks to answer:

- Science (use historical facts to learn, devise models, and measure predictions): What are service systems, how have they naturally evolved to present, and how might they evolve in the future? What can we know about their interactions, how the interactions are shaped (value propositions, governance mechanisms), and the possible outcomes of those interactions both in short-term and long-term?
- Management (use future possibilities to learn, devise strategies, and measure progress): How should one invest to improve service systems and service value networks?
- Engineering (today's and the foreseeable future's best use of resources, especially technical and information resources): How can the scaling of service systems be improved by the invention of new technologies (and environmental infrastructures) or the reconfiguration of existing ones?
- Design (today's and the foreseeable future's best use of resources, especially human and organizational resources): How can one best improve the experience of people in service systems?

To an extent some of the pedagogical issues were identified in the Cambridge Manifesto (http://www.ifm.eng.cam.ac.uk/ssme/) but the beginning of the problem can be viewed in Svobodovas' (2008) presentation at ECSS, which contained an elaborate description of the need for T-shaped professionals. However, if one goes through the websites of the 130 universities worldwide who are piloting SSME curricula and programs, academic administrators will recognize that Engineering and Technical universities might have added a few courses on human aspects of service systems but the curriculum remains heavy on analysis. On the other hand Management schools or Design schools might have added courses on design of systems or product-service-systems design. As a result the primary emphasis remains on courses that nourish creativity, craft and various soft skills.

## 2 Exploring the Learning Challenge

For a critical understanding of this problem one can refer to Kolb's (1984) work and many subsequent authors who were inspired by Kolb's Experimental Learning Theory (KELT) (e.g., Holman et al. 1997). The following diagram (Fig. 1) proposes the pedagogical and learning style differentiation among the constituent disciplines of SSMED. If we conceptualize SSMED as facilitating the problem-solving process by and with the customer then service innovation will mean a process of knowledge development and deployment. Thus the pedagogy has to be process oriented, constructionist (as opposed to instructionist), embracing both convergent and divergent thinking, analytic-synthetic, operating in both theoretical and practical domains simultaneously or at least interactively.

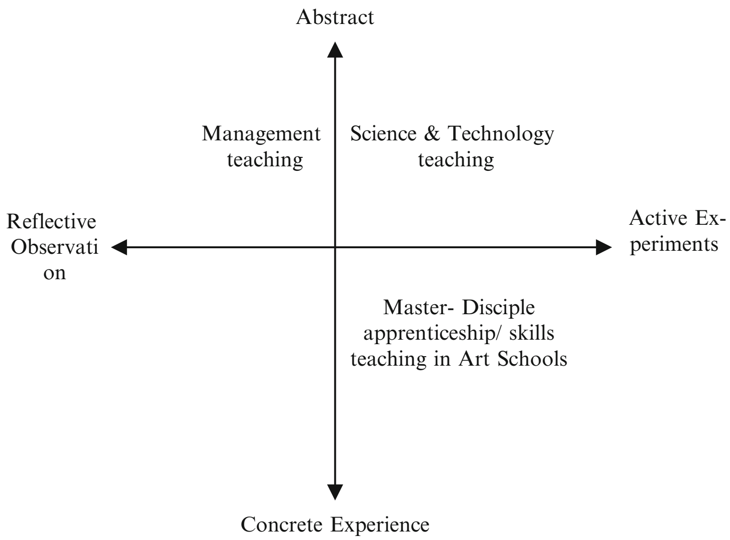



**Fig. 1** SSMED Learning styles and Pedagogical Differentials (adapted from KELT Design Teaching 1984)

As a result of these pedagogical variances, learning styles are shaped differently by Technology, Management/Social Science and Design oriented approaches. For example, managers seek solutions that are readily accepted by most and so they tend to innovate within rules set by large/influential customers and shareholders. Thus, most often, managerial preferences gravitate towards incremental innovation. On the other hand, designers are taught/encouraged to break rules and be not overly concerned with what has happened before. So the learning style differentials bring about different thinking styles, different behavioral styles and discourses. Service Innovation needs the requisite variety of all the quadrants because even while offering a radical new experience, it needs to be based on fundamentals of familiarity and comforts, efficiency of the routine and aim for superior economic returns.

In the next diagram (Fig. 2) we propose a pedagogical model of Project based or Problem based Learning (PBL: Wilkerson and Gijselaers 1996) that can help deliver the promise of SSMED through a student centric process of learning to manage that paradox of creating innovative service experience while exploiting the economics of efficiency and modularity. Such ambidexterity demands simultaneous deployment of contradictory capabilities of exploiting current competences while exploring new domains in terms of customer delight.

This experimental model being tried at the Indian Institute of Technology, Kanpur is inspired by service learning (*Academy of Management Journal, Learning and Education* 2005, Vol. 4.3). At its core it is about creating opportunities for students to apply theory they learn in the class to critical social problems and needs. It is based on action learning that engages students in the wider community around to extend "What is possible" to "What is necessary to meet the challenge".

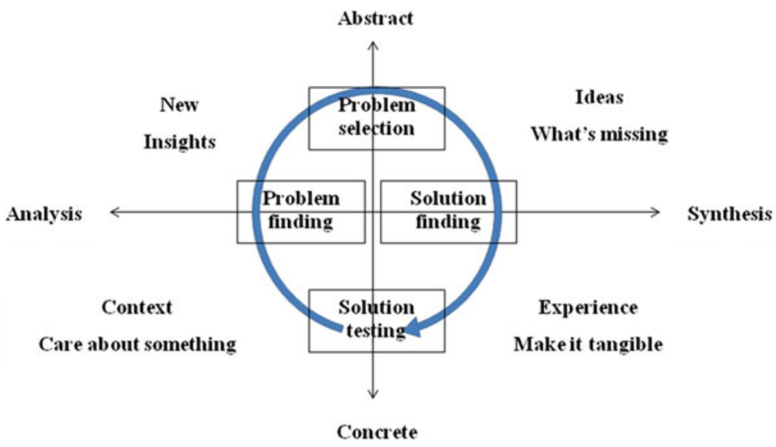



**Fig. 2** SSMED Learning styles and pedagogical differentials (inspired by Beckman and Berry (2007) and WE CARE

Academy of Management coined an acronym WE CARE (Welcomed, Evidence based, Complementary, Action-oriented, Reciprocal and Epistemic). Each of these terms seem to be important for integrative SSMED pedagogy. It is important here to focus on creativity through generative projects. We know now that learning is not a linear process (Kolb and Kolb 2005) so SSMED teaching need not be linear either.

Technology/Engineering curricula, across most top universities of the world, have increasingly converged with that of science and mathematics, over the last five decades, based largely on the engineering science model. Four years of undergraduate engineering courses, partly due to the Grinter (1956) model, mostly rely on 2 years of intensive natural sciences and mathematics teaching. The focus remains on analysis where technological problems are interpreted and addressed through scientific principles. Engineering and technology education thus have steadily moved away from practice and practical skills to the theoretical principles (Dutson et al. 1997). The epistemological approach in science and technology teaching is thus systematic questioning where known, proven principles are applied to analyze a problem to reach verifiable truthful answers or solutions (Dym and Little 2003). This convergent thinking inspired by Aristotelian hierarchy of questioning procedure is good to reveal facts based on truth value providing a specific set of answers to a given question. Questions that are asked by creative designers or innovators, on the other hand often come from an opposite premise: for any given question, there exist or could exist multiple alternatives, some known and some to be imagined regardless of being true or false. The innovators' questions are often interested to uncover the unknown possibilities through a divergent thinking process. This divergent thinking process has been investigated by many (Eris 2004) through survey as well as quasi-controlled laboratory experiments. The Concept-Knowledge (CK) theory of teaching conceptual design thinking (Hatchuel and Weil 2003) argues that design concepts need not start with truth value emphasis whereas engineering knowledge seekers usually rely on that only. Design innovation thinking is thus seen as a series of continuous transformations from the concept domain to the knowledge domain.

The dialectical continuum between this science based convergent engineering teaching-learning and creative conceptualization based design thinking-learning somewhere in between needs management teaching-learning to maintain the flow from concept to knowledge and then onwards to actionable knowledge. Management teaching and curricula across different business schools thus cover subjects relying on systematically asking convergent questions (market research or fundamentals) as well as subjects built upon deep reasoning questions, strategy, to generative questions based subjects (management of innovation). In our experimental pedagogy, learning is context-dependent and calls for both the faculty and the students to link classroom theory to real world experiences (Reynolds and Vince 2004).

In service business, new creative ideas are not enough, to usher in innovation, they must be realized at the points of contact and must pass social (user/customer) evaluation (Annabile 1996). And then to cross the tipping point such service innovations must exploit current competencies of the organization while exploring and incorporating that of others (customers/suppliers) (Gladwell 2000; Godin 2001). Johansson (2006) in his book *The Medici Effect* provides numerous examples how breakthrough ideas most often happen when we bring concepts and expertise from one field (convergent facts) into new, unfamiliar territories (divergent linkages) and more current research (Agarwal and Selen 2009), shows how such collaborative practices can be integrated into a dynamic capability building framework for elevated service offerings. However as these researchers point out, collaborative organizational practices emanate from collaborative organizational learning, which necessarily needs organizational relationship capital building. That relationship capital building among professional colleagues coming from different disciplines remains a challenge because multidisciplinary collaborative learning itself is not part of our current conventional higher education system. At Undergraduate level even finding time table slots for multidisciplinary open electives pose many scheduling challenges as each (of engineering, science, business or social science) discipline encourages its faculty members towards deeper and deeper specialization thus initiating demand for more and more focused departmental core and elective teaching slots.

## 3 Integrative Problem Based Learning

The conceptual spanning of the continuum around all the four dimensions of service science in the new pedagogy will often lead to inter-disciplinary tension. This tension has not been dealt with specifically in the current SSMED literature except for articulating the need for T-shaped professionals. But one can build that integrative new approach on the earlier experience of designing and delivering

Engineering System Design curricula at MIT, Stanford or Aalborg University during the 1960s and 1970s. The 1994 review of the Aalborg model (Christopherson et al. 1994) on one hand can direct us to the strength of the problem based inter disciplinary pedagogy and on the other hand it can provide a framework for managing the paradox of a new style pedagogy that aims at teaching-learning of innovation.

The longitudinal study done at MIT from 2000 to 2005 to assess its Conceive-Design-Implement-Operate (CDIO) initiative and the charter of the Design Factory at Aalto University, Finland (http://www.aaltodesignfactory.fi) based on the PDP course of Helsinki University of Technology also provide us with the process of developing new pedagogy with that of a fresh approach to research in a new domain like SSMED.

## 4 Problem Based Case Examples

Figures 3–5 represent the results of a quasi controlled experiment (led by Atul Sultane and V. Nachiket, 2009 Master of Design students) at IIT Kanpur, where critical social concern, system design principles and technological possibilities were brought together in a multi-disciplinary project based learning project and students were encouraged to build different scenarios and narratives through experiential field trips. The resultant solution of a cycle van based potable water delivery service is novel and locally practicable solution based on a low environmental impact, modular upgradable system that serve the unserved while creating possibilities for further service co-creation involving the rural citizen customers of India.

*1.1 Billion people don't have access to clean water. In India, diarrhea alone causes more than 1600 death's daily.*
*Water sources are at a distance. Women must devote hours to meet the basic need of the family. They need to walk 3 to 5 km daily to get water for their family. This is very laborious task.*
*Taking this into account, we made a need statement i.e. to find a service innovation for ease of access to potable water.*

**Fig. 3** Integrative PBL pedagogy applied for service innovation in a quasi controlled experiment (problem finding and selection)

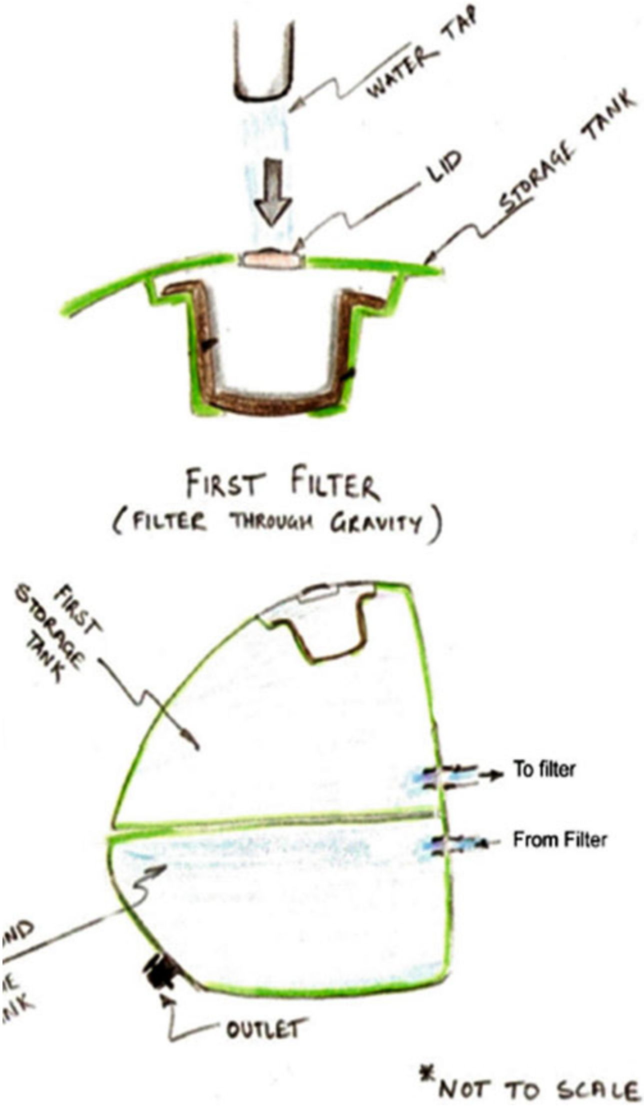



**Fig. 4** Solution development using product-service-system design approach

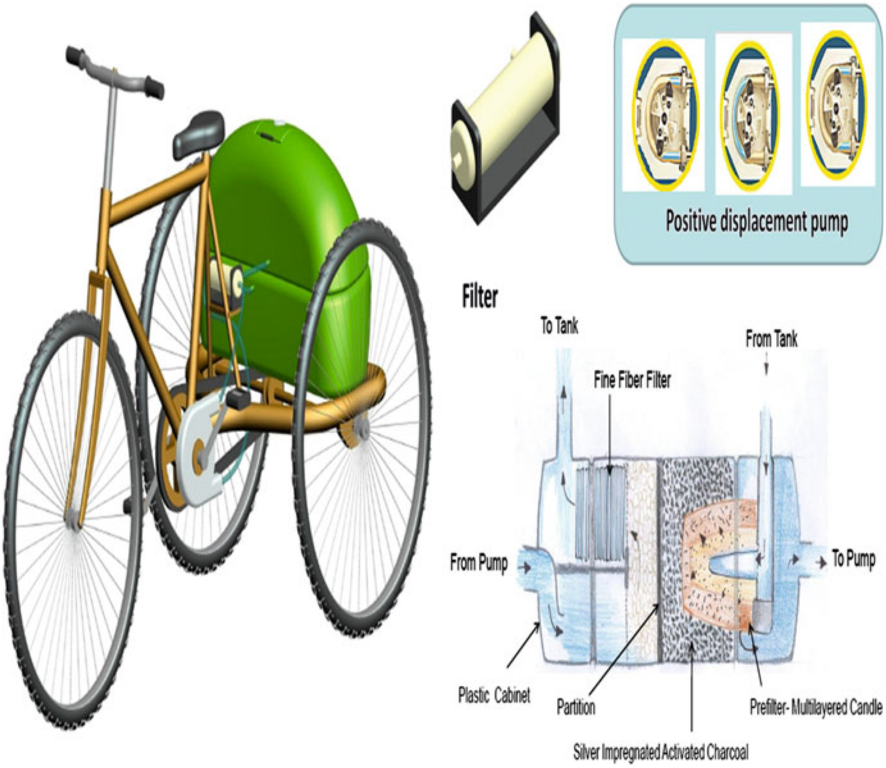



**Fig. 5** Service Innovation and solution testing prototype based on Interdisciplinary PBL

## 5 Conclusion

In the white paper entitled "Succeeding through Service Innovation" (2008, p. 5), University of Cambridge, it was proposed that "the changing global landscape of business and society can be described as a very large global service ecosystem". Current eminence of "service dominant logic" looks at "all firms as service firms" (Vargo and Lusch 2004). Yet due to this lack of interdisciplinary discourse on pedagogy, "design as a discipline currently has almost no participation in the service sector. In many ways most of our service-related daily experiences are devoid of thoughtful design, except in their tangible aspects" (Pinhanez 2009). The lack of interdisciplinary discourse has often created wrong metaphors and the lack of deeper understanding of the power of multi-disciplinary design thinking have excluded the possibilities of illuminating insights into complex business problems. These issues have been felt by many over the last 10 years (Liedtka 2000; Verganti 2006) but the curricular silos have avoided innovational confluences. Perhaps the development of more socially inspired and thematically integrated choices for interdisciplinary topics and new experiments on learning methods can create the agile SSMED professionals who can bring about the new era of service innovation by moving easily between the abstract and the concrete and between analysis and synthesis. Initiatives in this direction should be the responsibility of both academia and the corporate world. However the most important driver will be the discovery of other disciplines. As academia cannot bridge the gap with their traditional curricula, there is a most important role for new learning approaches incorporating cross disciplinary learning at the student group level. Via similar cases and learning approaches like PBL as mentioned before we trust that academics will be encouraged into more seamless exploration across the current academic silos and unleash the boundless potential for service innovation.

## References


Agarwal, R. and Selen, W. (2009). Dynamic capability building in service value networks for service innovation, *Decision sciences*, 40 (3), 431–475.

Annabile, T. (1996). *Creativity in context*, Westview Press, Boulder.

Beckman, S. L. and Berry, M. (2007). Innovation as a learning process, *California Management Review*, 50 (1), 25–56, Fall.

Cambridge White Paper. (2008). *Succeeding through service innovation*, University of Cambridge Institute for Manufacturing. (www.ifm.eng.cam.ac.uk/ssme/documents/080428ssi_us_letter.pdf accessed on 12/09/2009).

Christopherson, E., Coupe, P. S., Lenschow, R. J. and Townson, J. (1994). *Evaluation of civil and construction engineering education in Denmark*, Centre for Quality Assurance and Evaluation of Higher Education in Denmark, Copenhagen, Denmark.

Dutson, A. J., Todd, R. H., Magleby, S. P. and Sorensen, C. D. (1997). A review of literature on teaching design through project oriented capstone courses, *Journal of Engineering Education*, 76 (1), pp 17–28.

Dym, C. L. and Little, L. (2003). *Engineering design: A project-based-introduction*, 2nd edition, John Wiley, New York.

Eris, O. (2004). *Effective inquiry for innovative engineering design*, Kluwer Academic Publishers, Boston, USA.

Gladwell, M. (2000). *The tipping point*, Little Brown, NY.

Godin, S. (2001). *Unleashing the idea virus*, Hyperion, NY.

Grinter, L. E. (1956). Report on the evaluation of engineering education, *Engineering Education*, 46, pp 25–63.

Hatchuel, A. and Weil, B. (2003). A new approach to innovative design, *Proceedings International Conference on Engineering Design*, Stockholm, Sweden.

Holman, D., Pavlica, K. and Thorpe, R. (1997). Rethinking Kolb's theory of experiential learning in management education, *Management Learning*, 28 (2), pp 135–148.

Johansson, F. (2006). *The medici effect*, Harvard Business School Press, Boston.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*, Prentice-Hall, NJ, USA.

Kolb, A. Y. and Kolb, D. A. (2005). Learning styles and learning spaces: enhancing experiential learning in higher education, *Academy of Management Learning & Education*, 4 (2), pp 193–212.

Liedtka, J. (2000). Strategic planning as a contributor to strategic change: A generative model, *European Management Journal*, 18 (2), pp 195–206, April.

Lemmink, J. (2005). The need for more multidisciplinary research, *International Journal of Service Industry Management*, 16 (1), pp 7–9.

Pinhanez, C. (2009). Services as customer-intensive systems, *Design Issues*, MIT, 25 (2), pp 3–13.

Reynolds, M. and Vince, R. (2004). Critical management education and action based learning, *Academy of Management Learning & Education*, 3 (4), pp 442–456.

Spohrer, J. and Kwan, S. K. (2008). *Service Science, Management, Engineering and Design (SSMED); Outline & References* (http://www.col.sjsu.edu/ssme/ssmed.pdf accessed on 12/10/2009).

Svobodovas, L. (2008). *The challenge of SSME* (www.informatics-europe.org/ECSS08/Papers/svobodova.pdf accessed on 12/10/2009).

Vargo, S. L. and Lusch, R. F. (2004). Evolving to a new dominant logic for marketing, *Journal of Marketing,* 68 (January), pp 1–17.

Verganti, R. (2006). Innovation trough design, *Harvard Business Review*, 84 (12), pp 114–122.

Wilkerson, L. and Gijselaers, W. H. (Eds.) (1996). Bringing problem-based learning to higher education: Theory and practice. *New directions in teaching and learning*, Jossey-Bass quarterly sourcebooks, number 68. Jossey-Bass Publishers, San Francisco.

# An Engineering Perspective on Service Science*

**Duncan McFarlane**

**Abstract** This article focuses on the way in which engineering, as a discipline, can most effectively interact with the services sectors generally, and with service science in particular. This perspective is proposed in order to balance the relatively limited recognition of both engineering as a contributor to service science and also services as an application area for engineering developments. The article is structured as a response to a series of questions relating to the current and potential future role engineering can best support the evolving area of Service Science, Management and Engineering

**Keywords** Engineering · Education · Research · Service systems · Management · Product service systems · Curriculum · Vocation

## 1 Introduction

This article focuses on the way in which engineering, as a discipline, can most effectively interact with the services sectors generally, and with service science in particular. The need for a greater examination of the engineering – services linkage is motivated by a number of important issues:

(a) *Service sectors as a dominant employer of engineers*: The service sectors are dominant in most western countries employing between 70–90% of the workforce (Paulson 2006). Even for students studying engineering, a career in the

---

*Preliminary material relating to this article has been presented at a number of public fora on future challenges for service science: International Service Science Workshop, Cambridge, UK, July, 2007, Sponsored Seminar, NICTA, Engineering Department, University of Melbourne, March, 2008 and UK Manufacturing Professors Forum, July, 2008.

D. McFarlane (✉)
Institute for Manufacturing, University of Cambridge,
Alan Reece Building, 17 Charles Babbage Road,
Cambridge CB3 0FS, UK
e-mail: dcm@eng.cam.ac.uk

H. Demirkan et al. (eds.), *The Science of Service Systems*,
Service Science: Research and Innovations in the Service Economy,
DOI 10.1007/978-1-4419-8270-4_15, © Springer Science+Business Media, LLC 2011

service sectors is most likely. In Australia, by way of example, up to 57% of engineering graduates find jobs in the service sector.[1]

(b) *Increasing requirements to optimise service design and delivery*: Service businesses are facing unprecedented constraints on their operation and significant pressure to optimise their processes. This is the case whether it be cost cutting in government, space constraints in retail or leisure or environmental constraints in transportation. Even more broadly, there are increasing calls for greater innovation to be introduced into the provision of services.[2] The engineering profession is equipped with numerous tools for systematically addressing these challenges.

(c) *Evolution from product to service provision in the industrial sector*: Many manufacturers or providers of equipment are increasingly re-organising themselves as [asset based] service providers for economic or strategic reasons.[3] The motivations for these changes ranges from the need to tighten and sustain customer links (e.g. office equipment, mobile electronics), to a lack of profitability in product sales (e.g. automotive or civil aerospace) to a customer mandated shift. In the latter case, by way of example, the UK Ministry of Defence has mandated that its prime suppliers make a shift from parts and equipment contracts to so called availability or performance based contracting.[4] This evolution of new so called complex engineering services (see Ng et al. 2011), coupled with the ever growing industrial asset management offerings in oil, utilities, and construction industries formally establishes a need for engineering discipline in service domains.[5]

## 2 Challenges for Engineering in SSME

Having established that there is a clear need to clarify, articulate and extend the role of engineering in the services sector, the remainder of this short article raises four simple questions that need to be addressed if the links between the engineering discipline – and academic engineering departments in particular – and the services

[1] 2004–2005 Graduate Placement Data, Centre for Policy Studies, Monash University, Australia.

[2] This issue has been argued in a number of reports including: a) Taking services seriously - How policy can stimulate the 'hidden innovation' in the UK's services economy, NESTA Research Report, May, 2008, b) IfM and IBM, (2008). Succeeding through Service Innovation: A Service Perspective for Education, Research, Business and Government. Cambridge, United Kingdom: University of Cambridge Institute for Manufacturing. ISBN: 978-1-902546-65-0, c) Science and Technology-Led Innovation in Services for Australian Industries, Report of the PMSEIC Working Group, Australia, 2008.

[3] See the references provided in Baines et al. (2007).

[4] The recently completed Service Support Solutions: Strategy and Transition [S4T] Programme coordinated by Cambridge University and funded by BAE Systems and EPSRC [2008–2009] was established specifically to examine this shift in the UK Defence industry. www.ifm.eng.cam.ac.uk/s4t/

[5] Conversely, this evolution also challenges traditional manufacturers to embrace the rather foreign areas of services marketing and strategy amongst others.

sector are to be improved. It is intended that these comments might form a blueprint for the way in which engineering might increase its profile in those sectors which dominate our economy.

*(1) How can the engineering discipline – and academic engineering departments in particular – best prepare graduates for a vocation in the services sector?*

A useful way to consider this question is by way of comparison with the evolution of manufacturing engineering as a discipline. Fifty years ago there was no recognized discipline of manufacturing engineering, there were few text books and little systematic coverage within the academic engineering curriculum. The same might be said of the role of engineering in services – or service engineering – today.

To begin to address this issue within an engineering department, a three level approach is needed:

- *Increased Service Awareness*: Introducing service issues and examples into core engineering courses.[6]
- *Service Course Modules*: Developing engineering-oriented course modules that can be integrated into industrial, manufacturing, and systems engineering courses.
- *Post Graduate Education*: Providing Masters' streams rich in service content.

By way of example, in the UK, at Cambridge, initial trials of a service engineering module within a manufacturing engineering course have indicated a significant enthusiasm on the part of students to embrace service sector challenges, while at the same time finding an increased customer service perspective to be helpful in viewing more traditional industrial domains.[7]

More broadly the capabilities and career paths for tomorrow's service engineers need to be defined. In the UK there are currently no Institutional committees focusing on the engineering issues in the services sector, and hence little institutional support.

The evolution of service engineering differs in one way from that of manufacturing engineering; in that there already is a recognized base for service education – predominantly within business and management schools. This raises a second question:

*(2) To what extent are existing service science courses relevant to engineering and engineers?*

Service science courses have historically been run within business and marketing schools,[8] and they therefore focus on issues most relevant to business undergraduates

---

[6] For example, statistics can be taught with service-oriented (e.g., healthcare, retail, etc.) examples in addition to agriculture and manufacturing (Ledolter and Swersey 2007)

[7] A two day service systems module has been run in 2008 and 2009 within the Cambridge University Engineering Department, Master of Philosophy in Integrated Systems in Manufacturing and Management.

[8] For example, in the USA, leading service science courses are offered by Robert H Smith School of Business, University of Maryland, Wharton School at University of Pennsylvania, Arizona State – Cary School of Business, Jenkins School of Management, NC State University.

and graduates. Key topics covered include services marketing, customer relationship management, service strategy, and service operations management (This content is reflected in key text books in the area as well e.g. Gronroos 2000; Lovelock 2007). For mature graduate engineers, this style of content may be educational, but at an undergraduate or immediate postgraduate level. A further issue for engineers undertaking a business school service science course is that – in general – much of the taught material is analysis-oriented rather than synthesis-oriented. That is, a course provides tools/methods for examining past and present behavior, rather than providing tools/methods for designing and implementing future solutions. More recently, service science has also been offered by computer science/IT departments.[9] Here the taught content has a more technical flavour, with some significant focus on the synthesis of new service solutions. However, beyond general introductory material there is a heavy focus on information/internet services and the underlying architectures to deliver these. Such courses are unlikely to be immediately accessible to all but the most IT oriented engineers.

The following steps can be taken in order to increase the relevance of existing service science course to engineers and to improve their accessibility for engineers:

- *More Relevant Examples and Case Studies:* The complex engineering services domain is an ideal area to focus on as services, for example, in defence, petrochemical, utility industries, provide the challenges faced in more conventional service sectors mixed with those more typically faced by engineering undergraduates (e.g. the challenge of achieving specified customer service levels while maintaining and upgrading complex equipment over its effective life).
- *Course staff with academic or industrial engineering background:* A relatively obvious proposal. Mixing an engineering background into the course delivery team will immediately ensure greater accessibility for engineers.
- *A mixed analysis-synthesis approach to Service Science:* Introducing curriculum that supports the design, modeling and improvement of services and their underlying components. Such an introduction would compliment existing service course material, and would generate graduates armed with the ability to innovate and generate new service offerings – with or without a technical content. Potential tools to support such course additions will be discussed in question (3) next.

*(3) Are engineering tools and techniques widely used in the design, operation or evaluation of services?*

While there have been notable efforts to demonstrate that it is possible to deploy industrial engineering principles within services operations,[10] these have often focused only on methods from the operations management domain and tend to be demonstrated in simple service scenarios. Hence there appears to be significant

[9] See for example, Department of Computer Science, Carnegie Mellon University, University of Manchester School of Informatics, Manchester, U.K., Information School of UC Berkeley.

[10] See, for example, sections on service operations and technologies within Johnson, Clark (2008).

further opportunity for the deployment of engineering principles, approaches, and tools in the design and delivery of services.

Some key engineering methods[11] that could be readily adapted or extended and applied to services include[12]:

- *Computer Aided Design*: Development of repeatable, systematic software tools for service design and for design of products from a service perspective.[13]
- *Information Models and Architectures*: To date there are few information systems specifically developed to manage service operations – most borrow heavily from systems developed for industrial information management.
- *Manufacturing Engineering Tools*: A number of methods exist which could support service delivery (Critical Path Analysis, Theory of Constraints, Responsiveness Analysis), service quality (Statistical Process Control, Motorola 6-Sigma Methods, Quality Circles), service resource support (Total Productive Maintenance, Cause and Effect Analysis,).
- *Process Modelling and Simulation*: The development of systematic methods for describing and emulating service process can contribute to the optimisation of these operations.

A further set of tools, associated with supply chain analysis and optimisation,[14] has the potential to be adapted to service supply chains, once the issues in converting from the analysis of the flow of goods to the management of resources in completing a service can be satisfactorily resolved.

Referring to the motivating issues from the beginning of this article, the engineering methods described above might equally be deployed a) in the standardisation and optimisation of conventional services (e.g. better information management in healthcare, more reliable and versatile transportation, tourism with greater energy efficiency, reduced cost government services) or b) in the support of organisations migrating from equipment or parts sales to the provision of complex engineering services. In the latter case, companies are seeking to systematise their overall service development delivery in the same way that they have previously done with their product development and production.

In summary, key steps that can be taken in order to ensure a broader take up of engineering methods and tools in services are:

---

[11] The reader is referred to a number of core manufacturing engineering texts which provide overviews of many appropriate engineering tools and techniques which are broadly applicable to services. See for example: Rembold, U, (1994), Kalpakjian, S, (2001), Montgomery, D (2009), Boucher, T (1996).

[12] It is not intended to imply here that the methods described have never been used in the service domain but more that their use is not commonplace and could be more prevalent. Also, clearly the list of methods given here is not exhaustive.

[13] We note that, by way of example, the UK Integrated Products and Services [IPAS] project [2005–2008] and other related projects have examined issues of use in service in the design of aircraft engines and their subcomponents.

[14] See Simchi-Levi et al. (2010) or Christopher (2004) for example.

- *A Toolbox for Complex Engineering Services*: Development of a comprehensive set of tools that support the development and delivery of complex engineering services. By implication this would involve combining existing service analysis tools with an adaptation of engineering tools in order to meet the challenges of forming this type of service.
- *Develop and collect case studies*: The provision of illustrative examples sourced from across multiple service domains showing the use of engineering tools and methods
- *Guidelines for Use*: Produce practitioner accessible workbooks/reference books which not only describe tools but provide guidelines for their us.

In addition to addressing the education issues in the first two questions, enacting some of the steps required for broader adoption of engineering tools and methods will fall to the academic domain working in partnership with industry.

*(4) Is there sufficient research of an engineering nature being applied to service sectors?*

This is a complex question to address. It is clearly true that there is a significant level of research funding being made available for the engineering development of equipment and technical systems that are used in the service sector. In the UK alone there are significant programmes which fund academic work in partnership with industry for example in the development of transportation vehicles,[15] airport information infrastructure,[16] new methods of energy generation, and transmission,[17] new medical equipment,[18] new techniques for waste disposal.[19] Each of these pieces of work (and many others) is of a fundamental engineering nature and the results are expected to support one or more key service sectors, but in general, the research is somewhat decoupled from the notion of the service to be provided and is viewed as a technical challenge. In fact, researchers in these areas are often unaware that their work contributes directly to one or more service sectors. There would be significant benefit in simply enabling the drawing together of existing engineering research that contributes to services in order to ensure maximum visibility and that maximum synergies are achieved.

In contrast to the significant amount of basic engineering research supporting different service sectors, there is far less research being undertaken in which contributes to the improvement of the overall design, delivery and performance of services (and their supporting systems) being addressed by the engineering

[15] For example Southampton Railway Systems Research (SR2), University of Southampton.

[16] For example, TINA: The Intelligent Airport, University of Cambridge, University of Leeds, University College London.

[17] For example, Institute for Energy Research & Policy, University of Birmingham.

[18] For example, Health and Care Infrastructure Research and Innovation Centre, University of Loughborough.

[19] Engineering issues in waste disposal are examined for example at Geoenvironmental Research Centre (GRC). This is based in the Cardiff School of Engineering, in Cardiff University, Wales UK.

community. This is typically research of an integrating nature, providing tools and guidelines to draw together aspects of the service system, supporting services from initial concept through to sustained delivery. There is a clear analog with the type of research that has supported manufacturing developments for many decades. Even today, the UK government funds a large number of Innovative Manufacturing Research Centres (IMRCs) which focus on multi-disciplinary, innovative, and broad reaching programmes supporting the UK manufacturing industry.[20] The European Union funds a range of similar activities in manufacturing, drawing together researchers from different regions. These programmes involve engineering researchers in conjunction with researchers from numerous other disciplines which are required to undertake research into complete service solutions. It is this mix of disciplines in research that the services domain would benefit from, and to date there have been few significant programmes in the UK that have addressed this despite the clear importance of the service sector to the UK economy.[21]

Apart from a lack of relevant funded research, there are other disincentives which act as barriers to involving engineers in service research. For example – until recently – there has been a shortage of quality journals in which engineering researchers could have service research outputs published. This is now being addressed with an increasing number of new service science related journals and also with prominent journals beginning to run special issues on service science,[22] but remains a challenge in many journals. On a more positive note, there are a number of ways in which service research can address engineering researcher needs, is provided in Table 1.

Achieving a more comprehensive involvement of engineering research in improving innovation and performance in services can be addressed in the following ways:

- *Greater awareness of existing research contributions*: Making a study of the many different engineering contributions that are already made to the service sector and presenting these through a high profile report or industry forum.
- *Lobbying funding bodies for integrated research in services*: Through coordinated industry/university actions, make representations to appropriate funding bodies to ensure that research is commensurate with the scale of the services sectors in the economy and that funding is deployed in such a way to maximise the level of innovation and performance improvement in key service sectors.
- *Incentivising Engineering researchers to become involved*: Ensuring that new service journals achieve a consistently high quality of publication, encouraging meaningful special issues in key high profile journals, and more generally increase the awareness of opportunities for engineers to become involved in service research.

---

[20] In the UK there are currently 16 EPSRC sponsored IMRCs funded between £1.5M and £14M of which ten are based in engineering departments.

[21] The S4T and IPAS Programmes mentioned earlier in footnotes 7 and 17 respectively are exceptions

[22] Key journals covering service systems development include Journal of Service Science, Journal of Service Science and Management, International Journal of Service Science.

**Table 1** Researcher incentives for involvement in service research

| | Needs of the engineering researcher | | | | |
|---|---|---|---|---|---|
| Features of service research | Research funding | Interesting problems | Recognition/ Promotion | Impact in society | Publication |
| Alternative, new source of funding | • | | | | |
| Means of engagement with key business sectors | | • | | • | |
| A source of problems needing fundamental analysis | | • | | | |
| An alternative to manufacturing as a technology outlet | • | • | | | |
| An opportunity to collaborate with other disciplines | | | • | | • |
| Alignment of research with key issues in public domain | | | | • | |

## 3 Engineering for Future Service Models

Thus far this article has addressed the role of engineering in services as they are delivered today. The final section now seeks to examine the engineering role in addressing future models for services.

There are many views and perspectives on the way services may evolve over the next 10–15 years. Rather than triggering a debate as to the most appropriate models here, we simply present a set of characteristics of future service models that are being discussed in one or more sectors and will then identify engineering capabilities that might be called on to support these.

A. *Performance or Output Based Service Agreements*: Service models in which the provider is paid only on the basis of the provision of a service above a specified performance level [e.g. UK Defence Industry – provision of military effects].
B. *Highly Customised Service Provision*: The provision of services – in volume – for which the service delivered is actually tailored to each individual customer [e.g. Healthcare – provision of genetic based drug therapy].
C. *Reconfigurable Services*: Service delivery systems that are able to reconfigure in a simple, cost effective manner to meet changing needs [e.g. Airports – ability to change service offerings depending on changing mix of airlines].
D. *Fully Automated Services*: Services that can more effectively deliver through automation of both information and actions [e.g. 24/7 Security – automated surveillance, monitoring, alarming, response].
E. *Rapid Service Design*: The ability to generate new, innovative, cost effective service offerings rapidly and comprehensively [e.g. Telecommunications where competition and new technologies emerging create a need for providers to offer continually revised consumer information services].

**Table 2** Engineering inputs to future service model development

| | Future service model | | | | | |
|---|---|---|---|---|---|---|
| Engineering input | A | B | C | D | E | F |
| Information engineering | • | • | • | • | • | • |
| Design engineering | | • | • | | • | • |
| Maintenance engineering | • | | | • | | |
| Operations management | • | | | | | |
| Systems engineering | | • | • | | • | |
| Mechanical engineering | | | • | • | | |
| Risk, cost engineering | • | • | • | | • | • |
| Technology development | | • | | • | | |
| Environmental engineering | | | | | | • |
| Project management | • | | • | | • | |

F. *Carbon Neutral Services*: Services when the design specification includes a requirement for zero net carbon emissions to be integrated into the design of the service [e.g. Tourism where additional payments to a 3rd party to achieve carbon offsetting can make travel packages uneconomical.

In some cases, the characteristics are present in existing services but they have been included as they represent significant innovative changes for services in one or more sectors. Because space is limited, Table 2 provides a set of linkages between recognised engineering disciplines and the six sets of characteristics A–F. It should be emphasised that in addition to the engineering inputs identified below, significant inputs from other disciplines would be required.

What is clear from Table 2 is that there are many opportunities for engineering to make a constructive contribution to the development of future models for services, and that key areas of information, design, systems and risk engineering are likely to central elements in this evolution.

Hence, in terms of research and practice, the engineering discipline has substantial potential for contributing to the development of future service models. This is simply a reiteration of the discussions around Questions (3) and (4) but emphasises the need for involvement in the planning (as well as development) stages of future service development. It is worth noting finally, that the time frame for the development of a complex piece of equipment such as defence equipment, aircraft, and medical equipment is often measured in tens of years[23] while a new service development is often expected to be achieved in the space of 1–2 years or even months. These different time frames have serious implications for the engineer, as legacy technology and equipment will invariably play a role in the design of a new service.

[23] For example, typical development of military equipment can take over 15 years from concept to production.

# 4 Summary

This article has taken a pragmatic approach to seeking ways to increase the involvement of the engineering discipline in the support of the service sectors that dominate our economy. Making recommendations that cut across education, practice and research and which apply to both current and future service models. The thrust of the recommendations support the recent shift – driven by IBM and others – from the notion of Service Science to that of Service Science Management and Engineering (SSME) as being a rather better reflection on the services domain.

**Acknowledgements** The author wishes to acknowledge the sponsorship and support of BAE Systems, the UK Royal Academy of Engineering and the University of Cambridge for their support of this work. Further, the author would like to thank the University of Melbourne and National ICT Institute, Australia in particular for their support during a sabbatical visit in 2008 when much of this work took place.

## References

Baines, T. et al. (2007) State-of-the-art in Product Service-Systems: Proceedings of the Institution of Mechanical Engineers, Part B. *Journal of Engineering Manufacture*, 221(10), 1543–1552.

Boucher, T. (1996) *Computer Automation in Manufacturing: An introduction*. Norwell: Kluwer.

Christopher, M. (2004) *Logistics and Supply Chain Management: Creating Value-Adding Networks*. Harlow: Prentice Hall.

Gronroos, C. (2000) *Service Management and Marketing: A Customer Relationship Management Approach*. West Sussex, UK: Wiley.

Johnston, C. (2008) *Service Operations Management*, 4th Ed. Harlow: Pearson Education.

Kalpakjian, S. (2001) *Manufacturing Engineering and Technology*, 4th Ed. Upper Saddle River, NJ: Prentice-Hall.

Ledolter, J. and Swersey, A. J. (2007) Testing 1 – 2 – 3: *Experimental Design with Applications in Marketing and Service Operations*. Palo Alto, CA: Stanford University Press.

Lovelock, C. (2007) *Services Marketing: People, Technology, Strategy,* 6th Ed. Upper Saddle River, NJ: Pearson Education.

Montgomery, D. (2009) *Introduction to Statistical Quality Control*, 6th Ed. Hoboken, NJ: Wiley.

Ng, et al. (2011) *Complex Engineering Service Systems*. Berlin: Springer, to appear.

Paulson, L. (2006) *Services Science: A New Field for Today's Economy*, IEEE Computer Society Magazine, 39, 18–21.

Rembold, U. (1994) *Computer Integrated Manufacturing and Engineering*. New Jersey: Prentice Hall.

Simchi-Levi, D. et al. (2010) *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*, 4th Ed. New York: McGraw Hill.

# Service Systems in Changing Paradigms: An Inquiry Through the Systems Sciences

**David Ing**

**Abstract** For professionals at the beginning of the twenty-first century, much of the conventional wisdom on business management and engineering is founded in the twentieth century industrial/manufacturing paradigm. In developed economies, however, the service sector now dominates the manufacturing sector, just as manufacturing prevailed over the agricultural sector after the industrial revolution. This chapter proposes the development of a body of knowledge on services systems, based on foundations in the systems sciences. The approach includes the design of the systems of inquiry, acknowledging that the body of knowledge on twenty-first century service systems is relatively nascent. A program of action science is proposed, with an emphasis on multiple realities and knowledge development through dialectic. The outcome pursued is an increased number of T-shaped people with depth and breadth in service systems, in communities of inquiry of researchers and practitioners.

**Keywords** Service systems · Service science · Inquiring system · Action science · Paradigms

D. Ing (✉)
IBM Canada Ltd., 3600 Steeles Avenue East,
Markham, ON L3R 9Z7, Canada
and
Department of Industrial Engineering and Management,
Aalto University, Espoo, Finland
e-mail: daviding@ca.ibm.com

H. Demirkan et al. (eds.), *The Science of Service Systems*,
Service Science: Research and Innovations in the Service Economy,
DOI 10.1007/978-1-4419-8270-4_16, 

# 1 Introduction: Structural Changes in the World Economy Call for an Inquiry into the Understanding of Service Systems Amongst Scientists, Managers, Engineers and Designers

Conceptually, *services* are not new. Concretely, an encounter with an instance of a *service system* is an everyday event. One can be recognized by its structure (e.g. resource configurations), function (e.g. creation and delivery of value) and process (e.g. party-to-party coordination):

> A service system can be defined as a dynamic configuration of resources (people, technology, organisations and shared information) that creates and delivers value between the provider and the customer through service. In many cases, a service system is a complex system in that configurations of resources interact in a non-linear way. Primary interactions take place at the interface between the provider and the customer. However, with the advent of ICT, customer-to-customer and supplier-to-supplier interactions have also become prevalent. These complex interactions create a system whose behaviour is difficult to explain and predict. (IfM and IBM 2008, p. 6)

Abstracting beyond instances of services to obtain a generalized understanding across a variety of types of service systems is a challenge. Changes in society, technology and economics have brought new voices to the prior conventional wisdom on services. Conceptual definitions, common features and principles from a systems foundation are yet to be fully worked out.

> . . . a theory of service systems should explain what service systems are and aren't, how they arise and evolve, the relation between internal and external service systems, and the role of people, technology, value propositions, and shared information in the system. (Spohrer et al. 2007, p. 73)

In the interest of developing a general theory, service systems should be acknowledged as subtypes of systems. It then follows than an emerging *science of service systems* is a specialization of the *science of systems*.

> Systems science (including cybernetics) is not a traditional discipline concerned with the study of a particular domain, but a meta-discipline, concerned with the domain-independent modelling of general systems (Van Gigch 1986). As such, it does not aim to find the one true representation for a given type of systems (e.g. physical, chemical or biological systems), but to formulate general principles about how different representations of different systems can be constructed so as to be effective in problem-solving. (Heylighen 1990; François 1997, p. 362)

Service systems are currently regarded as a multi-discipline within science, and may or may not mature into a meta-discipline.

Despite the rise of the services economy into the twenty-first century, "few researchers have studied service, and institutions have paid little attention to educating students in this area" (Spohrer et al. 2007). This chapter aims to contribute to coherency in the body of knowledge amongst scientists, managers, engineers and designers by inquiring into the underlying ways of knowing, i.e. inquiring systems. The next three subsections outline the challenge, an approach, and the desired future.

## *1.1 Challenge: Our Prior Understanding of Service Systems Is Inadequate for Societal Challenges that We Foresee in the Twenty-First Century*

The future is already here. It's just not very evenly distributed. (William Gibson)

A National Academy of Engineering report has been interpreted as a "failing grade for the innovation academy" for not meeting the needs of service businesses (Chesbrough 2004). The impact of ICT (Information and Communications Technologies) on growth and labour productivity was concentrated in the services sector and a few manufacturing sectors (OECD 2000), and significant in all 20 OECD countries in the period between 1995 and 2005 (OECD 2007). Yet, a business school professor exclaimed "Why is it that 80 percent of the economy in the United States is service yet 80 percent of the required operations management courses in business schools still focus primarily on manufacturing?" (Davis and Berdrow 2008).

Existing theories are clustered in schools of management, science and engineering, social sciences and humanities, and information. Advances in research into service systems are hampered by specialization along disciplinary lines, reinforced by expectations from institutions and funding bodies that work against an integrated approach. A skill gap has resulted as university graduates have insufficient training to work on innovating and interdisciplinary activities (IfM and IBM 2008).

Section 2 of this chapter will frame the development of a science of service systems as a paradigm shift. While meaning is occasionally shared across scientists, engineers, managers and designers, disciplinary thinking is a more common pattern. To see the boundaries on knowledge more clearly, five ways of knowing – inquiring systems – are outlined. Learning – both for researchers and practitioners – follows in a proposed program of action science.

## *1.2 Approach: Developing the Coherency and Validity of a Science of Service Systems Requires Engagement with Multiple Realities, and New Syntheses Produced Through Dialectic*

A large body of knowledge on services already exists. The challenge is how to integrate and/or bridge perspectives into a systemic whole. This presents an unbounded, unstructured problem, in which knowledge has already been structured within bounds.

> ... with few exceptions, professional schools largely teach their students how to solve bounded-structured problems. (....) The problem is "structured" in that it is phrased unambiguously in a language ... that states clearly what the problem is, and gives an equally clear procedure for finding the solution ... Just as strongly, there is a clear sense of what constitutes a "solution". The problem is "bounded" in that there is a finite set of appropriate "solutions" to the initial problem. (....)

> Unbounded problems, on the other hand, are generally on the cutting edge of knowledge. In the early stages of research, there may well be no single, accepted way of posing or structuring a problem to the satisfaction of all experts. (Mitroff and Linstone 1993, p. 14)

In particular, the compartmentalization of universities is criticized in three splits: (a) the theory-action split, (b) the peer-society split, and (c) the teacher-student split. In the theory-action split, scientists are cut off from learning possibilities involved with testing theories in praxis. In the peer-society split, the important research questions that cross professional boundaries are inhibited. In the teacher-student split, professors are discouraged from engaging in mutual learning activities with students and extra-academic stakeholders by distancing themselves (Levin and Greenwood 2001).

The development of new body of knowledge in service systems can be approached, in an alternative to a positivist science, as *action science*. Researchers and practitioners would advance *theories in practice*.

> Action science assumes that human beings are theory-builders who mentally 'construct' theories of reality, which they continually test through action (Argyris and Schön 1974; . . . Senge 1990). The difference between researchers and practitioners is that the former are 'explicit' theoreticians whereas the latter are 'tacit' theoreticians. The objective of action science is to make these tacit theories explicit so that they can be critically examined and changed. (Friedman 2001, p. 161)

Accordingly, this chapter is based largely on inductive and abductive reasoning, rather than deduction (Ing 2009).

Section 3 of this chapter introduces concepts from the systems sciences as a way to shape the multiple realities that emerge from a science of service systems crossing disciplinary boundaries.

Section 4 of this chapter opens the opportunity for dialectic by abducing a position through which knowledge might be generated through dialogue. Since this written content represents only one side of a dialectic, the written word is incomplete, and new knowledge will not be generated until multiple parties engage in joint sensemaking through rich conversations.

### *1.3 Desired Future: T-Shaped People Should Have Not Only a Depth in a Domain of Service Systems, But Also an Appreciation of the Breadth of Related Service Systems Designs*

Developing a science of service systems is not an end in itself. The function of a stronger understanding of service systems is a capacity to gain insights into a design or situation at hand, drawing on theories from general or related service systems. Redesigning a service system requires deeper knowledge than maintaining an existing one. The goal is typically to improve or transform from a current (functional or dysfunctional) state to some desired future state.

Section 5 of this chapter foreshadows an opportunity for a variety of professions – scientists, engineers, managers and designers – to cooperate in a shared body of knowledge. Progress on this cooperation relies much on a mutual understanding of concepts and language, as well as the recognition that errors and unknown knowns (as passive ignorance, ignoring) and taboos and denials (as active ignorance, the ignored) from industrial age thinking may be surfaced (Ing et al. 2003). Educational programs on service systems in the spirit of action science are exceptions rather than the rule.

## 2 As Paradigms on Service Systems Shift, Alternative Inquiring Systems Support Learning Through a Program of Action Science

> "It's like the fish in water. We don't know who discovered water but we know it wasn't a fish. A pervasive medium is always beyond perception." – Marshall McLuhan

Establishing doxa in engineering and management while a new science of service systems emerges draws attention to a legacy in science. Current practices, experience and education are anchored in disciplines with a long history of development over the past half century. The predispositions and assumptions from the last half century may or may not continue to be valid in the next half century. As a practical example, how should business performance of service system be measured? Many service businesses count hours of labour (e.g. billable utilization) as a key measure of productivity. When revenue and profitability are driven by the application of expertise and skills, the logic of tracking hours can encourage dysfunctional behaviours. Client satisfaction and the quality of customer deliverables are not always improved by more working hours. As a corollary, counting hours worked and not worked (e.g. vacation) induces an administrative overhead unnecessary for senior business professionals who are otherwise trusted to meet planned business commitments (Belson 2007). Counting hours in a service business may be as nonsensical as a standard 9-to-5 schedule to a farmer who tends to fields and livestock from sunrise to sunset.

In the subsection that follows, the challenge of clearly seeing services systems in the "new" economy with mindsets from the "old" economy are reviewed. Advances in technology are posed as a primary driver changing economics in businesses and society. Then, the systems sciences are proposed as common points of reference for both engineering and management education. Outlining the variety of inquiring systems surfaces closed and open ways of knowing. Action science is then described a method through which group learning can be conducted.

### *2.1 The Science of Service Systems Is Immature, Catching Up with Twenty-First Century Technological, Economic and Social Changes*

Does the development of a science of service systems represent a new paradigm? The science of service systems has yet to achieve the status of a normal science, from which features of scientific practice (e.g. law, theory, application and instrumentation) provide coherent models (Kuhn 1967). Some parts of the science of service systems could be described as immature or ineffective, in the resolution of practical problems.

> In such an uncontrolled and perhaps uncontrollable context, where facts are few and political passions many, the relevant immature field functions to a great extent as a 'folk-science'. (. . ..)
>
> The indubitable and public symptom of ineffectiveness of a field is the absence of facts. . .. (Unlike) in a matured field, the students do not encounter a collection of standardized materials, presented in a digestible form, and utterly reliable and incontrovertible in themselves . . .. By contrast, in the ineffective or immature field, the student is presented with one out of several sets of supposed basic materials, and can discover other sets by reading textbooks not on the recommended list. These materials themselves consist of intuitive generalized dressed up as empirical laws, and insecure theoretical speculations masquerading as fundamental explanations. (Ravetz 1971, pp. 366–367)

A paradigm is "a mode of viewing the world which underlies the theories and methodologies of science in a particular period of time" (New Shorter Oxford English Dictionary 1997). In a practical evolutionary view, three stages have been proposed as "a nation's economic evolution" – mechanical, electrical, and information (Tien and Berg 2003). This thinking can be extended to recognize advances in science with technology along a non-exhaustive list of disciplines, e.g.

- Mechanical
- Biological
- Material/chemical
- Electrical, and
- Information/communications

Within each of these fields of science, paradigms have shifted. In biology, the discovery of DNA led to the advent of molecular biology. In material science, nanotechnology reveals properties previously unseen at the molecular level. Simultaneously with changes within these sciences, boundaries between disciplines have naturally become redefined (e.g. biology and chemistry have led to biochemistry).

Business opportunities arise as paradigm shifts lead to technologies that change the possibility and feasibility of products and services.

> The effect of technology is – and always has been – to loosen constraints. As a result of technological development, what was not possible becomes possible. Or what was not economically feasible becomes so. (Normann 2001, p. 27)

In the late 1990s, the most significant paradigm shift for the sciences and the business world was in information, as digital content became networked, i.e. the Internet. These advances not only impacted computer science, but also other fields (e.g. bioinformatics in the life sciences). A new conventional wisdom on a science of service systems will take years to work through definitions and distinctions. This new science of service systems is largely being driven inductively from developments of society and business.

### *2.2 Intelligibility on Service Systems Amongst Scientists, Managers, Engineers and Designers Can Be Enabled Through Foundations in the Systems Sciences*

The motivation to view *service systems* through a lens of *systems science* is practical. In the services specialization of systems, definitions and theories are still evolving. At this time, *systemics* – as “an open set of concepts, models and practical tools useful for a better understanding and eventual management of complex situations or entities of any type” (François 1997, p. 362) – enable a rich vocabulary and set of concepts for discussion.

System science has a tradition of linkages with engineering, management and design. *Systems engineering* applies principles from systems science to improve performance and efficiency. In management, concepts and vocabulary from approaches such as the *socio-technical systems perspective* – rooted in human systems research at the Tavistock Institute (Trist et al. 1997) – is so deeply embedded in organization theory as to have become invisible. The pursuit of business and social innovation emphasizing creativity in *systems design* has been exhibited in formation of cross-disciplinary D-Schools (Atal and Wokye 2007).

The *engineering* of service systems conceptually would seem to be a small step from systems engineering. The IEEE defines systems engineering as “an interdisciplinary collaborative approach to derive, evolve, and verify a life-cycle balanced system solution which satisfies customer expectations and meets public acceptability”. An alternative concise definition sees systems engineering as “a multidiscipline that addresses a system from a life-cycle, cybernetic and customer perspective” (Tien and Berg 2003, pp. 22–23). Although some would perceive engineering as based primarily in hard science, the systems engineering literature includes natural and human sciences as part of the domain:

> (A) system (can be defined as) an assemblage of objects united by some form of regular interaction or interdependence ... A system can be natural (e.g., lake) or built (e.g., government), physical (e.g., space shuttle) or conceptual (e.g., plan), closed (e.g., chemicals in a stationary, closed bottle) or open (e.g., tree), static (e.g., bridge) or dynamic (e.g., human). In regard to its elements, a system can be detailed in terms of its components, composed of people, processes and products; its attributes, composed of the input, process and output characteristics of each component; and its relationships, composed of interactions between components and characteristics. (Tien and Berg 2003, pp. 23–24)

The lineage of engineering as an applied science following from theoretical knowledge is obvious.

The *management* of service businesses requires some reframing from the heritage of industrial businesses. Management – in itself, a multidiscipline – has hidden foundations from some leading thinkers who encourage a systems approach. While some see management as an art, others emphasize the science in management.

> (Amongst) Management Scientists . . . the systems approach to problems is fundamental and . . . organizations, a special type of system, are the principal subject of study.
>
> The systems approach to problems focuses on systems taken as a whole, not on their parts taken separately. Such an approach is concerned with total-system performance even when a change in only one or a few of its parts is contemplated because there are some properties of systems that can only be treated adequately from a holistic point of view. These properties derive from the relationship between parts of systems: how the parts interact and fit together. (Ackoff 1971)

There is not a single systems approach in management. Generic methodologies have been constructed for a functionalist systems approach (with 7 categories of theories), an interpretative systems approach (with 7 categories of theories), an emancipatory systems approach (with 2 categories of work) and a postmodern systems approach, leading to development of a pluralist approach of critical systems thinking (Jackson 2000).

The *design* of service systems integrates human systems with technical systems. In the industrial age, the pace at which machines were upgraded or replaced was measured in years, if not in decades. The advent of software has accelerated the pace of change with fixes, patches and upgrades into hours, if not minutes. The recognition of service systems with varying levels of information intensity has recently surfaced the consideration of alternative contexts for design (Glushko 2010).

While depth in at least one of the professions – science, engineering, management or design – provides a perspective on which knowledge on services systems could be advanced more generally, ambiguity in the breadth and bounds of the systems sciences themselves are considered to be a strength. Systemicists largely agree that systems science loses its value if it is seen as a discipline.

> Systems science is a meta- or trans-discipline (or possibly better, a meta-methodology) for everybody, and should not be simply reduced to a discipline status, even when and where it must be teached (sic). (François 1997, p. 362)

For the interests we have at hand – bridging the language and concepts of scientists, engineers, managers and designers, so that discussions of analysis and design can productively proceed – systems concepts and languages can aid in clarity. The undesirable alternative would have the quality of discourse fall to the common level of a Grade 6 education. When a twenty-first century paradigm on service systems has developed sufficiently with a normal science, the systems sciences will then likely recede into the background as a foundational body of knowledge.

### 2.3 The Validity of Analytic-Deductive Inquiry and Inductive-Consensual Inquiry Can Be Re-established by Sweeping in Knowledge Through Multiple Realities and Dialectic

> Inquiry is an activity which produces knowledge. (Churchman 1971, p. 8)

In periods of normal science, the world is known through commonsense understanding and coherent frameworks as published in textbooks. Emphasis is placed on dissemination of the known, over the pushing the frontiers of knowledge. In times of revolutionary change – as in scientific revolutions – commonsense understanding and textbooks are of suspect reliability. Knowledge generation rises in importance.

An inquiring system “is a system of interrelated components for producing knowledge on a problem or issue of importance” (Mitroff and Linstone 1993, p. 29). Five designs, based on philosophies developed over the seventeenth to twentieth centuries, have been identified. Although the designs have been described with a variety of labels – see Table 1 – we’ll refer to the five ways of knowing: (1) inductive-consensual, (2) analytic-deductive, (3) multiple realities, (4) conflict, and (5) unbounded systems thinking.

> The first and second ways of knowing are based in objective views of knowledge. The third way of knowing recognizes subjective views, where the model and data are inseparable in the minds of individuals. The fourth way of knowing generates knowledge through debates from polar positions. The fifth way of knowing incorporates aspects of the preceding four ways, with a guarantor of “progress” that ensures more perspectives and views are swept in. (Ing et al. 2003)

Many of the service systems in our everyday life are understood on the first two “ways of knowing”. In the first way of knowing – inductive-consensual – service systems can be often understood by simply observing social behaviour. Public service systems for citizens typically function by showing up in person and queuing (at least in orderly countries), with coordination self-enforced through social norms on taking turns. In the second way of knowing – analytic deductive – service systems can be understood by decoding the formula. Automated services typically ask requesters to choose from a menu, or respond to a series of questions, or invoke an exit option for exceptions.

In the third way of knowing – multiple realities – service systems produce a greater variety of outcomes with the introduction of subjective views. The same

**Table 1** Designs of inquiring systems

| Way of knowing | Mitroff and Linstone (1993) | Mitroff (1998) | Churchman (1971) |
|---|---|---|---|
| First | Inductive-consensual | Expert consensus | Locke: consensus |
| Second | Analytic-deductive | Expert modeling | Leibniz: fact nets |
| Third | Multiple realities | Multiple models | Kant: representations |
| Fourth | Conflict | Conflict | Hegel: dialectic |
| Fifth | Unbounded systems thinking | Systemic reasoning | Singer: progress |

service output delivered to two different customers in exactly the same way can be perceived by each as a different outcome. If the service involves aesthetic judgements – either on the part of the customer or of the provider – replicability and consistency can arise as issues. Resolving a customer satisfaction issue using an inductive-consensual or analytic-deductive design may only serve to further frustrate the client.

In the fourth way of knowing – conflict – service systems require multiple parties for resolution, potentially engaged in either adversarial or constructive positions. In adversarial circumstances, negotiations drawing out hidden assumptions and teasing out preferences and priorities for each stakeholder are often marked by extended deliberations. In constructive circumstances, productive friction can provide the spark for innovation (Hagel and Brown 2005).

The fifth way of knowing – unbounded systems thinking – integrates the other four designs to sweep in new knowledge. Metrology – the science of measurement – is central to this inquiring system. If a vector of progress can be established in advance of engagement, dialectic across multiple perspectives continues until advances cease to be obtained. An appropriate metric of performance in educational context could be learning. In a business context, the metric of customer value could be appropriate (Haeckel 1999).

With the science of service systems in its early development, the fifth way of knowing (unbounded systems thinking) is entirely appropriate. This inquiry can be an open system where features of inductive-consensual, analytic-deductive, multiple-reality and dialectical thinking are all included, and new ideas are continually swept in. In contrast to viewing disciplines having closed and fixed boundaries (e.g. this idea belongs to economics, that idea belongs to sociology, and the other idea belongs to political science), the friction of distinctions and meanings can lead to production of a distinct new (and unified) perspective on service systems. Establishing the guarantor – the vector of progress by which knowledge generation is to be measured – is the first step.

## 2.4 Action Science Is an Appropriate Approach for Knowledge Generation on Service Systems in Theory and in Practice

Service systems include both human systems and technical systems. Between and amongst the actions of recipients and providers of service, social practice (Bourdieu 1977; Dreyfus 1992) and communities of practice (Wenger 1999) introduce complications in descriptive models and normative models. Action science is helpful in untangling some of these distinctions.

> (Action science) is an inquiry into social practice, broadly defined, and is interested in producing knowledge in the service of such practice. Thus, what counts as a solution for action science both overlaps with and diverges from prevailing scientific criteria. Like the empirical-analytic tradition, action science requires that knowledge include empirically

> disconfirmable propositions that can be organized into generalizable theory. But at the same time, it also requires that these propositions be falsifiable in real-life contexts by the practitioners whom they are addressed. Like applied research, action science requires knowledge to be useful. Yet in so doing it emphasizes the designing and implementation of social action, and it rejects the current dichotomy between basic research and applied research. It instead asks that its knowledge illuminate basic issues in ways that are at once generalizable and applicable in particular cases. (Argyris et al. 1985, p. 232)

Action science is normally conducted by communities of inquiry (within communities of practice). In this early stage of developing a science of service systems, the emphasis should be less on problem solving, and more on problem setting.

> Problem solving can be understood as a matter of means-end deliberation. This is because the statement of a well-formed problem includes specification of the purposes to be achieved. But before a problem can be solved, it must be set. (....) Schön writes: "When we set the problem, we select what we will treat as the 'things' of the situation, we set the boundaries of our attention to it, and we impose upon it a coherence which allows us to say what is wrong and in what directions the situation needs to be changed. Problem setting is a process in which, interactively, we name the things to which we will attend and frame the context in which we will attend to them" (1983, p. 40). (Argyris et al. 1985, p. 47)

Section 3 of this chapter describes a series of learning frames, setting up contexts for *reflective experimentation*, where "participants act, fail, get stuck, and try to get unstuck, while simultaneously reflecting on these attempts with their peers" (Argyris et al. 1985, p. 319). Following *action science rules*, mutual learning would normally occur in face-to-face situations. Section 4 boldly presents a public inference of a personal inquiry in an interest of evoking responses.

> Action science rules ask individuals to retrieve and make public their inferences, while participants' rules lead them to jump to abstract conclusions and to lose sight of the steps that brought them there. Other rules require that participants design valid tests, when their own rules tell them to conduct private tests that create self-sealing processes. And still other rules ask that participants inquire into their errors. (Argyris et al. 1985, p. 320)

Strong responses to these inferences will lend credence to the assertion that the maturity of knowledge on service systems is low, and that opportunities for joint inquiry should continue to be sought.

## 3 The Coherency of Service Systems Can Be Examined As Multiple Realities Framed with a Variety of Systems Science Concepts

Towards a goal of learning amongst scientists, engineers, managers and designers, concepts from systems sciences are presented as frames by which assumptions on service systems can be probed. In this interest, ten topics are presented below to guide thinking and discussion about changes in society, economics and technology in the twenty-first century. The clustering of concepts into ten frames is somewhat arbitrary, and motivated with the practicality of organizing sessions in a series of meetings over a quarter or semester. The ten topics are:

1. Service systems, business models, and value creation
2. Ignorance and knowledge
3. Boundary
4. Order, purpose, self-organization
5. Living, being, becoming
6. Energy and complexity
7. Form, networks and power laws
8. Information, communication and meaning
9. Coevolution, competition and variety
10. Aesthetics, ethics and morals

If these frames were to be pursued as a study of systems science per se, each frame could become a course by itself. The content and references for each frame follows.

## *3.1 Service Systems, Business Models, Value Creation: Why Study Service Systems?*

The subtlety between *service science* and a *science of service systems* draws thinkers into the systems sciences. Why are service systems now so important, when, less than 10 years ago, service industries were considered to be the less desirable sectors of the economy?

While government statistics lag the world by at least a few years, OECD countries have seen services as economic engines towards which resources have recently shifted in a "new" service economy (Wölfl 2005). In the 1990s, information technologies became a major contributor towards increased productivity (OECD 2000). Deeper insight requires analysis of systems within these macroeconomic trends.

As technology has loosened constraints (Normann 2001), shifting opportunities for value creation has driven businesses – or more generally, institutions formed as purposive social systems – to transform their purposes, functions, structures and processes. Acknowledging a business model as a system design recognizes that individuals and organizations respond to changes in the environment, planned and unplanned.

> The business model defines the value-creation priorities of an actor in respect to the utilization of both internal and external resources. It defines how the actor relates with stakeholders, such as actual and potential customers, employees, unions, suppliers, competitors, and other internal groups. It takes account of situations where the actor's activities may
>
> (a) Affect the business environment and its own business in ways that create conflicting interests, or impose risks on the actor; or
> (b) Develop new, previously unpredicted ways of creating value
>
> The business model is in itself subject to continual review as a response to actual and possible changes in perceived business conditions. (Wallin 2006, p. 12)

Changes towards customer/client/citizen centricity and agility have led monolithic enterprises to transform into value constellations (Ramírez and Wallin 2000), operating in interorganizational networks. These transformations can be informed by recent advances in the study of systems of systems (Jamshidi 2009). In addition to appreciating quid pro quo monetary exchanges in the economy, broadening the perspective to include resources and ethos of social relations and institutions moves opens up the discipline of microeconomics to interactions in economic sociology (Swedberg 2003).

### *3.2 Ignorance and Knowledge: Which Aspects of Services Systems Are Known, Knowable and Unknowable?*

As we pursue a science of service systems, what can we know and what should we know? Are there things about the service systems that will (or should) remain unknowable?

A systemic approach to competence development and ignorance (Ing et al. 2003) draws on the training of physicians in the College of Medical Ignorance (Witte et al. 1998). The design of inquiring systems (Mitroff and Linstone 1993; Churchman 1971) sees knowledge generation – essential to development and innovation – as transformative in some situations more than others. While service engineers and service managers may be more comfortable with the knowable, service scientists and service designers may seek out creativity in the unknown and the sacred in an ecology of mind (Bateson 1972).

### *3.3 Boundary: Where Do We Draw Lines Delimiting Service Systems from Their Environments?*

Pure services businesses, manufacturing businesses and agricultural businesses don't really exist. What are the boundaries of a business when viewed as a system? What are the considerations for inclusion or exclusion? How do new informatic spaces (e.g. the Internet) impact social interaction in physical and social spaces?

Understanding service systems as open systems (Katz and Kahn 1978) is foundational. The lenses of physical, social and informatic perspectives are a response to the rise of ICT (information and communication technologies) that have altered the mediating spaces through which social interactions take place (Ing and Simmonds 2002). Principles for designing service systems may be informed by techniques of interactive planning (Ackoff 1994) and pattern languages (Alexander et al. 1977). The shift to value constellations (Normann and Ramírez 1994) requires adjustments of coordinating action outside of organizational boundaries. In drawing distinctions between parties to be included or served, critical systems theory (Jackson 2000) invokes reflections on boundary judgements.

### 3.4 *Order, Purpose and Self-Organization: Which Parts of Service Systems Should Be Actively Designed, and Which Parts Should Emerge?*

Investments in human systems – with individuals who exercise will – are more prominent in service businesses when compared to manufacturing businesses (with facilities and equipment) and agricultural businesses (with land and cultivation). On which organizational dimensions should leaders of service businesses set direction and/or bounds, and on which should they let direction emerge from the experiences of front-line representatives? Which styles of coordination work in global businesses? What processes enable self-organization?

Unlike machines that operate only on legal (rule-based) order, human systems additionally operate in negotiated order (Strauss 1978) with increasingly distributed network form organizations (Parhankangas et al. 2005). Organizational systems require different strategies in placid and turbulent environments (Emery and Trist 1965). The horizon for planning goals, objectives and ideals (Ackoff 1981) enables coherency in direction, with context and coordination (Haeckel 1999) additionally maintaining consistency. As an alternative to coordinating a service business as did master builders of a cathedral, open source has been compared to a bazaar (Raymond 2000). The scaling of service systems up to global levels can be informed by research into heterarchy (Hedlund 1986), and polycentric and geocentric forms (Perlmutter and Heenan 1979).

### 3.5 *Living, Being, Becoming: Can Service Systems Effectively Evolve?*

As service systems mature, they may continue to prosper as living systems, or decline in relevance to dysfunction and death. Comparing service systems metaphorically to machines or organisms evokes non-rational understandings of change, at the risk of misguidance. Appreciating service systems formally as a subtype of systems in general draws in knowledge on evolution, transformation and pathologies.

The purposes of systems, as a whole and in their parts, can be distinctly categorized as deterministic (mechanistic), animate (organismic), social and ecological models (Ackoff and Gharajedaghi 1996). The essential function of service systems can mapped against the 20 subsystems identified in living systems theory (Miller 1978). Diagnosing dysfunctions through the viable system model (Beer 1972, 1979) sheds light on system dysfunctions through coordination of abstract (e.g. strategic vs. operational) subsystems. Modeling the functional capability for service systems to encode and decode information for metabolism and repair functions itself enables anticipatory behaviour in living systems (Rosen 1985).

## 3.6 Energy and Complexity: How Can Service Systems Be Sustainable?

Natural science sees the world as material, energy and information. Industrial systems typically improve efficiency by embodying repetitive activities into machines. Service systems generally operate with less tangibility and greater agility, often without similar economies of scale. Do service systems have to emulate industrial systems to attain sustainability, or are alternative designs feasible?

In ecosystem ecology, energy and complexity are related through hierarchy theory. Service systems can invest in natural and man-made species of capital as potential energy available to be released on demand.

In economics, the parallelism between energy and capital is related to information (e.g. property rights) in underdeveloped countries (de Soto 2000). The choice between complicated and complexified designs trades off between sustainability and efficiency (Allen et al. 1999). Supply side sustainability explores the advantages and disadvantages of systems operating on high gain resources and low gain resources (Allen et al. 2003). Systems accustomed to high gain resources require a great amount of discipline to transform in a "prosperous way down" to low gain resources (Odum 2007).

A universal property of systems – entropy, the second law of thermodynamics – finds that models of economics based on presumptions of equilibrium are misguided (Georgescu-Roegen 1971). As an alternative to bureaucracies of oversight and punitive enforcement, innovations in governance can be introduced through self-regulating designs that dissolve undesired behaviours (Hawk 1999). Mid-level systems can be designed as self-refueling to ensure essential functions are maintain as sustainable in nature (Jacobs 2001).

## 3.7 Form, Networks and Power Laws: Over Which Scales, Scopes and Speeds Can Service Systems Effectively Function?

Service systems in the twenty-first century increasingly operate with parts loosely coupled. Simultaneously, social ties can be developed as long term interorganizational relationships, joint capabilities can be coordinated towards target markets and/or cascaded projects, and each service request can be handled seamlessly with the specific customer, client or citizens at the centre.

Systems theory provides common language and concepts, with structure as an arrangement in space, and process as an arrangement in time. Cellular form organizations (Miles, Snow et al. 1997) are structures well-suited to managing and growing knowledge-intensive service businesses. With research into organization learning only beginning the 1990s, observing "how buildings learn" (Brand 1994) has provided insight into the varying paces of change, with rapidly changing layers shearing against more durable layers. The risk of tightly-coupled systems can lead to “normal accidents” (Perrow 1984).

Service systems designed as networks should not only obey, but also learn to take advantage of power laws (Barabási 2002). The advent of Internet technologies has enabled the structure of production to be shifted to open source (Benkler 2006). Digitalization also has enabled the potential for products and services to be shifted from the mass market to the long tail (Anderson 2006).

## *3.8 Information, Communication and Meaning: How Can Service Systems Be Coordinated?*

Small service systems can rely on knowledge embodied in individuals. Larger service systems improve their knowledge and skills by learning, sharing meaning and identity through communities of practice (Wenger 1999).

In these types of social interaction, information serves a variety of functions (e.g. directing, requesting). Information may be interpreted with different meanings according to the context of the parties to the conversation.

Drawing from computer science, approaching service systems from a language action perspective (Ing 2008), offerings (Ramírez and Wallin 2000) can be coordinated through commitments (Flores and Ludlow 1980). Since service systems include both human systems and technology systems, what computers can and cannot do (Dreyfus 1992) should be appreciated, in the ways that computers affect cognition (Winograd and Flores 1986).

In less directive interactions within service systems, generative dialogues (e.g in the style of Béla H. Bánáthy) can dissolve criticisms of overt control. In circumstances of transformation, a context with homeopoetic ethic for organizational change (Rowland 2004) and self-organization of public discourse (Walton 2004) may be appropriate.

## *3.9 Coevolution, Competition and Variety: How Can a Service System Operate in the Context of Others?*

Leaders of service systems can choose to cooperate, compete or not engage with others. The dimensions of coevolving relationships are complex, each with merits and demerits. Competition may or may not result in conflict. Cooperation can be different from coordination, if increased variety is desired. The rise of open source as sharing in communities contrasts to views of private source and ownership.

Definitions of types of interactions between species (e.g. parasitism, mutualism) are categorized in basic ecology (Odum 1983). The benefits of cooperation may show up with positive feedback as increasing returns (Arthur 1996). Within or outside the relationship, coordination may follow the law of requisite variety (Ashby 1956). Benefits may accrue from a design of diversity (Page 2008). If the relationship is not going well, partners may have to choose to express themselves through exit, voice and loyalty (Hirschman 1970). For large scale issues, however, there may be no exit, and action only in the face as catastrophe looms large (Homer-Dixon 2006). Reacting, rather than proactively or interactively dealing with these issues leads only to a post-normal science of precaution (Ravetz 2004).

## 3.10 Aesthetic, Ethics and Morals: What Impacts Can Service Systems Have on the Human Condition?

Service engineers and managers of service businesses may be most explicitly focused in design and economics. From a larger philosophical perspective, there has been a long tradition in the systems movement with the classical ideals of aesthetics, ethics and morals.

The leading view in the systems approach recognizes enemies – politics, morality, religion and aesthetics – with the prescription that they should be embraced (Churchman 1979). In a complementary but different approach, goal setting can be instead considered as values and norms in the appreciative systems of Sir Geoffrey Vickers (Checkland 2005). Both of these approaches have influenced more recent work on systemic governance and creative problem solving through critical systemic praxis (McIntyre 2004). Commercial and guardian syndromes are both recognized as valid systems of survival, with risks of corruption when features are intermixed (Jacobs 1992).

## 3.11 Acknowledging Systemic Frames Opens Up Additional Realities on Which the Coherency of Service Systems Can Be Examined

The systems sciences do not provide “right” or “wrong” answers on service systems. They can only provide concepts, language and some principles that can be shared across scientists, engineers, managers and designers.

The science of service systems is not sufficiently mature to provide a standard textbook, based on context that follows deductively. Until the point at which that science has matured, action science suggests learning in communities of inquiry. Each participant in the inquiry will bring his or her own perspective on service systems of interest, surfacing and challenging the assumption of others in engagement. As a foundation, the systems sciences can provide some neutral territory on which sensemaking on service systems can occur.

# 4 The Validity of Understanding on Service Systems Can Be Improved Through the Dialectic of Multiple Perspectives

This chapter represents a single perspective on service systems, and is thus inadequate to the task of productively generating new knowledge. The written word does, however, provide an efficient means to potentially provoke a reader to reflect on his or her own frames and assumptions.

The subsection that follows explores the opportunity and challenge of multiple perspectives in developing knowledge in the style of action science. As an exercise for the reader, a single perspective is presented – not as end product, but as a position seeking an opponent to develop even greater knowledge. The reader is invited to challenge, extend or repudiate this position in the interest of advancing a science of service systems.

## *4.1 Conversations from Multiple Perspectives Can Induce a Variety of Service System Designs*

> . . . to conceive of knowledge as a collection of information seems to rob the concept of all of its life. (. . ..) In other words, knowledge resides in the collection. It is how the user reacts to the collection of information that matters. (Churchman 1971, p. 10)

Only people know. Across the wide variety of types of service systems, each person brings his or her own perspectives, based on personal internal models and experiences. Advancing a science of service systems involves transforming a community of interest – with services at its centre – into a community of inquiry. Crossing prior disciplinary boundaries, that community of inquiry convenes diverse roles to find generalities across – and distinctions between – a range of service systems types. Since the science emerges through social interactions, setting a collegial context is a prerequisite to knowledge development. An ultimate result from the community of inquiry could be new conventional wisdoms about service systems. In a domain where theoretical and practical orientations coincide, however, bridging the variety in communities of practice may be a more practical goal than striving to unify predispositions and perspectives.

As an exercise, the next subsection proposes a position that is theory-building (Eisenhardt and Graeber 2007), with an inductive style that surfaces patterns across a broad range of service systems. This position dissolves the distinctions between the agricultural, manufacturing and service sectors as categorized by economists from an industrial paradigm, in the interest of a more general understanding from a systems perspective. In a dialectic, a practically-oriented position could find parts or the whole of this theory-building perspective irrelevant to an immediate context, or potentially edifying as features from adjacent contexts may be cross-appropriated to improve or transform an existing design.

## 4.2 A Theory-Building Position on System Models in a Service Economy Frames a Matrix with Types of Resources and Ethos

Since the nineteenth century, economists have developed a sense of services as a third sector, the residual after agriculture and industrial production have been taken into account. Principles of systems theory lead us to ask about the input, process and outputs associated with human beings working together collectively. A mechanistic worldview sees resources primarily as land, labour and capital – where capital in the industrial age has generally been regarded as machinery driven by internal combustion or electrical motors – and outputs as mostly tangible products.

As *system inputs*, research into services in the late twentieth century has recognized the contribution of knowledge and human skills, e.g. the emergence of a creative class (Florida 2000, 2005). As *system outputs*, research into services recognizes *outcomes*, e.g. customer satisfaction, as distinct from *outputs*, e.g. the delivery of the service only from the provider's perspective. As *system processes*, the model of *producer-product* in well-established and replicable formulas has been contrasted with *coproduction* where outcomes and outputs emerge through synergy (Ackoff and Emery 1972; Normann and Ramirez 1994; Parhankangas et al. 2005).

In a human-oriented view of service systems, the contribution and involvement of individual and groups particularly impacts mental models. As a position – a starting point into a conversation, and not the end point after deliberation – three categories of resources with three categories of ethos are proposed. When the three categories of resources are mapped against the three categories of ethos, a matrix of nine types of system models is formed.

### 4.2.1 System Inputs Acknowledging Services Include Natural and Social Features of Resources

Following the shifts towards a service economy, let's consider three major types of resources:

(1) Renewable resources
(2) Appropriable resources, and
(3) Cultural resources

*Renewable resources* are replenished by nature. Human beings can offset the depletion of renewable resources consumed through programs of replenishment or conservation. Businesses based in renewable resources include farming and fishing. Major activities within such businesses include cultivation and harvesting.

*Appropriable resources* are generally non-renewable. Manufacturing processes transform the appropriable resources with energy, resulting in man-made products. Businesses based in appropriable resources include extractive activities such as mining and petrochemical refining, and manufacturing activities such as building automobiles. Major activities within these businesses include acquisition and processing.

*Cultural resources* originate from human interaction. They are embodied in human beings and shared in practices of everyday life. Cultures include language, artistic expressions, rituals and behavioural norms. Cultural practices are reproduced with shared experiences and predispositions through family ties, social networks, history and institutions. In today's world, human beings may adopt aspects of culture from regional domiciles, workplaces, generational cohorts and/or shared interests. Participating in these businesses includes affiliating with the culture (e.g. being accepted as legitimate by the community) and practicing the skills (e.g. being a player rather than an observer).

Describing a business by its essential resources is only a partial analysis. As a renewal resource, growing vegetables on a farm is different from growing vegetables in a hydroponic skyscraper. The mass production of automobiles is different from a restoration of an antique car. Shooting a major motion picture is different from capturing home videos. This leads to another dimension: ethos.

### 4.2.2 System Processes and Outputs Acknowledging Services Include Human Engagement in Practices

An ethos is "the characteristic spirit of a culture, era, community, institution, etc., as manifested in its attitudes, aspirations, customs, etc." (New Shorter Oxford English Dictionary 1997). A business is a social system, so there are varied and alternative structures of actions to produce similar types of outputs. From a systems perspective, ethos is part of the operation of the system. Let's consider three types of ethos:

(a) An organic ethos
(b) An industrial ethos, and
(c) A service ethos

The feeling from each ethos comes through from the engagement of an individual associated with a profession or community.

An *organic ethos* may be described as one that appreciates and nurtures the local bounty. An Amish farm may be the ultimate reflection of an organic ethos in agriculture.

> What is underway on an Amish farm does not involve single purpose. The farms are not regarded as economic units, although the Amish make sound economic decisions. What we observe on the Amish farms is similar to what we observe on a natural ecosystem – homeostasis. Purpose and mechanism are transcended.
>
> . . .. (The Amish) are interested in profit and high yield, but neither concern drives them as a single purpose. Had the Land Institute's newly acquired 160 acres been an Amish farm, it would have been highly diversified . . . The living riparian community on each side of the two streams would have been a habitat for an abundance of wild species, including quail, pheasant and deer. It would have been a source of fuel, a boundary dividing the farm into

> smaller fields. It would host some predatory birds and insects. The smaller fields would have suited a horse- or mule-powered agriculture. The larger cottonwoods would have provided shade for grazing animals or for a resting team and driver. The fallen hackberry limb would have been converted into firewood. The straw that we plow under or burn would have become bedding for livestock and thus become a way of holding urine and manure, and all three would have returned to the fields from which they came. Some of the grain would be fed on the farm, some would be sold, depending on need.
>
> Because the emphasis for the Amish is not exclusively on production, mass production of food on the farm is incompatible with their sense of how to live in the world. (Jackson 1987, pp. 128–129)

The description of an organic ethos in the context of business isn't necessarily meant as an anti-technology bias; it is meant as a way seems more natural to the community. Similarly, photography on film holds an organic ethos for those from an age of chemistry in a way that digital photography does not.

An *industrial ethos* is associated with efficient machinery, and describes much of the modern world. Machines extend the capabilities of human beings, replacing social functions with automated mechanisms – either as improvements or degradations, depending on the point of view. Much of the business world implicitly takes the industrial ethos, from the days of Henry Ford's Model T, to the current day.

> Competitive advantage cannot be understood by looking at a firm as a whole. It stems from the many discrete activities a firm performs in designing, producing, marketing, delivering, and supports its products. Each of these activities can contribute to a firm's relative cost position and a basis for differentiation. A cost advantage, for example, may stem from such disparate sources as a low-cost physical distribution system, a highly efficient assembly process, or superior sales force utilization. Differentiation can stem from similarly diverse factors, including the procurement of high quality raw materials, a responsive order entry system or a superior product design (Porter 1985, p. 13)

The industrial ethos has a predisposition for finding more efficient ways of getting work done. It can be dispassionate about tradition, and thus surfaces advocates and resisters. The industrial ethos occurs not just in manufacturing businesses, but also in public enterprises. It is closely related to Weber's idea of a machine bureaucracy, which served to eliminate nepotism in German civil service of the early twentieth century.

A *service ethos* is associated with humility. Humility is the quality of having or showing a low estimate of one's own importance. It is reflected in the person providing the service recognizing the wants and needs of the customer / client / citizen above his or her own position. A service ethos does not mean a lower societal rank, as can be demonstrated in the spirit of servant leadership.

> The servant-leader *is* servant first.… It begins with the natural feeling that one wants to serve, to serve *first*. Then conscious choice brings one to aspire to lead. That person is sharply different from one who is *leader* first, perhaps because of the need to assuage an unusual power drive or to acquire material possessions.… The leader-first and the servant-first are two extreme types. Between them there are shadings and blends that are part of the infinite variety of human nature.
>
> The difference manifests itself in the care taken by the servant-first to make sure that other people's highest priority needs are being served. The best test, and difficult to administer, is: Do those served grow as persons? Do they, *while being served*, become

> healthier, wiser, freer, more autonomous, more likely themselves to become servants? *And*, what is the effect on the least privileged in society? Will they benefit or at least not be further deprived? (Greenleaf 1977, p. 13)

The service ethos is commonly associated with service professions such as the clergy and nursing. This does not preclude for-profit businesses placing value on serving customer and other constituents.

A service ethos in a business often espouses social and ethical features as paramount, and thus attracts individuals who share those values. The individuals choose the organization as much as the organization chooses the individuals. An individual who doesn't fit in with the character of an ethos-driven organization generally disassociates himself or herself within a short period of time.

### 4.2.3 A Matrix of Nine Types of System Models Result from Crossing Types of Resources and Ethos

As a way of building systems models, the three types of resources can be matrixed with three types of ethos to produce nine system models.

Each of these nine system models described in Table 2 has unique features.

The (1a) *agroecological* system model, as illustrated by family farms but exemplified by the Amish, is designed around renewal resources, operating with an organic ethos. Diversity of crops, livestock and byproducts enables near self-sufficiency, with local trade supplementing family efforts.

The (1b) *materials refining* system model begins with similar resources to the agroecological, but takes an industrial ethos with the use of machines. Examples include food processed at superhuman speeds, or pharmaceutical development of plant and animal extracts. Corporate agribusiness also conforms to this type of system.

**Table 2** Nine system models

| | (a) *Organic ethos:* local bounty | (b) *Industrial ethos:* machine efficiency | (c) *Service ethos:* humility |
|---|---|---|---|
| (1) *Renewable resources:* Cultivate and harvest | (1a) Agroecological system model<br>• (Amish) family farms | (1b) Materials refining system model<br>• Food processing Pharmaceuticals | (1c) Physical wellness system model<br>• Health care |
| (2) *Appropriable resources:* Acquire and process | (2a) Handcrafting system model<br>• Fashion apparel | (2b) Lean production system model<br>• Petrochemicals<br>• Automobile | (2c) Security system model<br>• Insurance<br>• Banking |
| (3) *Cultural resources:* Affiliate and practice | (3a) Performative experience system model<br>• Concerts<br>• Live theatre | (3b) Media publishing system model<br>• News<br>• Television and movies | (3c) Intellectual development system model<br>• Education |

The (1c) *physical wellness* system model takes natural living beings (i.e. human beings and animals), and applies a service ethos. Health care services in the spirit of nursing are of this type.

The (2a) *handcrafting* system model starts with appropriable resources but applies an organic ethos. Fashion apparel, where uniqueness and custom fit are important, places a high value on craftsmanship.

The (2b) *lean production* system model is based on appropriable resources, and the industrial ethos is a direct descendant of the mass production style of Henry Ford. Petrochemical and automobile production clearly follow this type of business model.

The (2c) *security* system model takes appropriate resources – potentially abstract, as in property rights – and applies a service ethos. Insurance means that if an insured item is lost, it can't be lost again. Banking enables funds to be channeled from those who have plenty to those who have short-term obligations to meet.

The (3a) *performative experience* system model is founded on cultural resources (e.g. musical scores, actors) working in an organic ethos. Concerts and live theatres are valued for their immediacy, and the immersive experience has provides benefits to "being there".

The (3b) *media publishing* system model takes cultural resources (e.g. concert performances), and applies an industrial ethos. Live events (e.g. news as it happens) can be reproduced at lower fidelity and bandwidth for viewers with a lesser interest in the content.

The (3c) *intellectual development* system model starts with cultural resources (e.g. high school graduates) and applies a service ethos. Education is delivered through pedagogy.

In contrast to the traditional three-sector categorization of agriculture, manufacturing and services, the above nine system models provide a framework through which the validity of perspectives on service systems – as well as agricultural systems and industrial systems – can be discussed. Other dimensions and categorizations could have equal validity, and friction between varied perspectives could be constructive.

### *4.3 In an Action Science Approach, this Position Seeks a Dialectic Through Which Mutual Learning Can Occur*

In an appreciation of the new learning to be done on service systems, alternative positions should be considered, presented and discussed. The context for alternative positions could be driven by inquiry in various modes:

- Why? For which purposes should we develop models of service systems? Will the commonalities and distinctions between types of service systems enable cross-appropriate of features as innovations?

- Where? In which circumstances and situations are more explicit or more formal models of service systems helpful? Are prior models developed in an industrial paradigm good first-order approximations?
- Who? For which professionals or domains are models of service systems useful? Will deeper inquiry introduce unnecessary confusion?
- When? How patient can we be on formalizing theoretical specifications of service systems? Will a commonsense understanding of service systems evolve naturally, or will a revolution take place?
- How? Which institutions and fields can rise to lead development of knowledge on service systems? How can questions of greater immediacy be handled, while the depth of scientific knowledge accumulates?

Each reader of the above nine system models will have already formed an initial impression of the value of that position, and potential gaps and/or weaknesses. Dialogue within a community of inquiry on service systems can take this position as one of many starting points, in an engagement to further develop the science.

## 5 Maturity in Service Systems Will Be Marked with T-Shaped People Having Deep Knowledge in a Type and/or a Feature, and General Knowledge Across the Varieties

While a theory of service systems is under development, practitioners who deal with service systems every day will draw on conventional wisdom immediately at hand. Until a state of normal science has been established, concise textbooks that properly lay out the breadth of service systems will be incomplete.

To conclude this chapter, roles interested in service systems – scientists, engineers, managers and designers – are recognized. The challenge of prior knowledge from the industrial paradigm is reiterated. Finally, the maturity of the science of service systems is expressed in the development of T-shaped people with both breadth and depth in the domain.

### *5.1 Scientists, Engineers, Managers and Designers Should Clearly See Domains of Knowledge As Generic, or for a Type or Part of a Service System*

No individual is omniscient. Specialization of knowledge occurs because human beings are mortal. Development of the domain of service systems amongst scientists, engineers, managers and designers is closer to infancy than to maturity. To overcome incommensurability, a common language and set of concepts is necessary.

In the mid-twentieth century, the systems sciences emerged as a way to bridge the natural sciences, social sciences, and humanities. Systems ideas have foundations dating back to the ancient Greeks, with a universal understanding across national boundaries, cultures and languages. Systems concepts such as function, structure and process are well understood across all sciences. These foundations can be applied in development of knowledge about services in the twenty-first century.

Amongst scientist, engineers, managers and designers, one of the early questions to be asked is: within what boundaries is your understanding of service systems delimited? The response could be:

- a part of the service system, e.g. the function of marketing (which may or may not coincide with a marketing department in an organizational structure)
- a type of service system, e.g. a transportation service or a professional service, or
- service systems in general, e.g. interactions between providers and clients in a variety of contexts

Explicit specification of the domain of knowledge – as well as the domain of ignorance – can help communications and accelerate the learning on service systems.

In the domain of information systems, much research has been conducted on capability maturity models. A similar framework – appropriate not just to practitioners but also researchers – might be helpful in the domain of service systems.

## 5.2 The Legacy of Industrial Age Thinking Still Looms Large on Service Systems

Industrialization – specifically as the introduction of technology to society – has advanced well-being in human civilization. Economies of scale improve efficiency in the production of goods, and mass distribution spreads the benefits of modern conveniences to a wider population. The improvements in productivity in industrial production have not been paralleled by improvements in productivity in services. How much of our learning in the industrial paradigm is applicable to service systems?

Developing a science of service systems may require redefinition of the types of improvement that are being sought. A service system includes both service providers and service recipients in mutual engagement. Reducing the perspective to parts of a service system – in a divide and conquer approach – won't advance our understanding in the early days of this science. Maintaining the holism in system models – requires embracing "enemies" in dialectic in the pursuit of further development (Churchman 1979).

The rise of the service sector (Wölfl 2005) – and specifically the rise of Information and Communication Technology (ICT) capital (OECD 2000) – signals that labour trained for the industrial era is being challenged to keep up with changes. Presuming that students in graduate engineering and management programs will eventually become leaders in society, they should recognize that the drivers of value creation in the next 25 years will likely to differ from those in the past 25 years. As these emerging leaders accumulate experience in business organizations – either in for-profit or not-for-profit designations – they will shape and be shaped by the economic and technological context in their work.

## 5.3 When a "Conventional Wisdom" on Service Systems Has Been Established, the Breadth of Depth of Knowledge for T-Shaped People Can Be Filled Out

How will we know when the science of service systems has been sufficiently developed into a normal science? One signal will be the presence of T-shaped people.

> The need for T-shaped skills surfaces anywhere problem solving is required across different deep functional knowledge bases or at the juncture of such deep knowledge with an application area.... People possessing these skills are able to shape their knowledge to fit the problem at hand rather than insist that their problems appear in a particular, recognizable form. Given their wide experience in applying functional knowledge, they are capable of convergent, synergistic thinking. (Leonard-Barton 1995, p. 75)

Initial approaches to the engineering and management of service systems have built incrementally on existing disciplines. The disciplines include economics and law, operations research, industrial engineering, computer science, information systems, MBA and management consulting, management information systems and knowledge management, organizational studies and organizational learning (Spohrer et al. 2008, pp. 6–7). Curriculum has been developed as courses inserted into existing programs (IBM 2006) and as the premise for a new program (Tukiainen et al. 2006). While a new science of service systems is under development, a bottom-up approach to curriculum development has been practical.

As a complementary contribution to an educational curriculum, this chapter has proposed knowledge development in a way embraces uncertainties as the science of service systems evolves. The challenge of multi-disciplinary thinking can be dissolved through a foundation in systems science.

**Acknowledgements** The author appreciates ideas and feedback on the earliest drafts of this chapter from the team on "The trajectory of systems research and practice" – Allenna Leonard, Gary Metcalf, Leonie Solomons and Jennifer Wilby – and other participants in the 2008 Fuschl Conversation hosted by the International Federation for Systems Research.

## References


Ackoff, R.L. and Gharajedaghi, J. (1996). Reflections on systems and their models. *Systems Research*, 13(1), 13–23.

Ackoff, R.L. (1971). Towards a system of systems concepts. Management Science 17, no. 11: 661–671. http://www.jstor.org/stable/2629308.

Ackoff, R.L. and Emery, F.E. (1972). *On purposeful systems*. Aldine–Atherton.

Ackoff, R.L. (1981). *Creating the corporate future: Plan or be planned for*, New York: John Wiley and Sons.

Ackoff, R.L. (1994). *The democratic corporation*, New York: Oxford University Press.

Alexander, C., Ishikawa, S. and Silverstein, M. (1977). *A pattern language*, New York: Oxford University Press.

Allen, T.F.H., Tainter, J.A. and Hoekstra, T.W. (1999). Supply-side sustainability. *Systems Research and Behavioral Science*, 16(5), 403–427.

Allen, T.F.H., Tainter, J.A. and Hoekstra, T.W. (2003). *Supply-side sustainability*, New York: Columbia Univ Press.

Anderson, C. (2006). *The long tail*, New York: Hyperion.

Argyris, C. and Schön, D.A. (1974). *Theory in practice: Increasing professional effectiveness*, San Francisco: Jossey-Bass.

Argyris, C., Putnam, R. and Smith, D.M. (1985). *Action science*, San Francisco: Jossey-Bass.

Arthur, W.B. (1996). Increasing returns and the new world of business. *Harvard Business Review*, 74(4), 100–111.

Ashby, W.R. (1956). *An introduction to cybernetics*, London: Chapman & Hall.

Atal, M. and Wokye, E. (2007). Talent Hunt: The Methodology. *BusinessWeek*, (D-Schools Special Report). Available at: http://www.businessweek.com/innovate/content/oct2007/id2007101_960501.htm?chan=innovation_special+report+--+d-schools_special+report+--+d-schools (Accessed November 1, 2009).

Barabási, A. (2002). *Linked*, Cambridge, MA: Basic Books.

Bateson, G. (1972). *Steps to an ecology of mind*, Northvale, NJ: Jason Aronson.

Beer, S. (1972). *Brain of the firm: The managerial cybernetics of organization*, New York: Wiley.

Beer, S. (1979). *The heart of enterprise*, New York: Wiley.

Belson, K. (2007). At IBM, a vacation anytime, or maybe none.(Electronic version). *New York Times*. Available at: http://www.nytimes.com/2007/08/31/nyregion/31vacation.html.

Benkler, Y. (2006). *The wealth of networks: How social production transforms markets and freedom*, New Haven, CT: Yale University Press.

Bourdieu, P. (1977). *Outline of a theory of practice*, Cambridge, UK: Cambridge University Press.

Brand, S. (1994). *How buildings learn*, New York: Viking.

Checkland, P. (2005). Webs of significance: the work of Geoffrey Vickers. *Systems Research and Behavioral Science*, 22(4), 285–290.

Chesbrough, H. (2004). A failing grade for the innovation academy. *Financial Times*, 24, 43–44.

Churchman, C.W. (1971). *The design of inquiring systems: Basic concepts of systems and organization*, New York: Basic Books.

Churchman, C.W. (1979). *The systems approach and its enemies*, New York: Basic Books.

Davis, M.M. and Berdrow, I. (2008). Service science: Catalyst for change in business school curricula *IBM Systems Journal*, 47(1), 29–39.

de Soto, H. (2000). *The mystery of capital: Why capitalism triumphs in the west and fails everywhere else*, New York: Basic Books.

Dreyfus, H.L. (1992). *What computers still can't do: A critique of artificial reason*, Cambridge, MA: MIT Press.

Eisenhardt, K.M. and Graeber, M.E. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, 50(1), 25–32.

Emery, F.E. and Trist, E.L. (1965). The causal texture of organizational environments. *Human Relations*, 18(1), 21–32.

Flores, F. and Ludlow, J.J. (1980). Doing and Speaking in the Office. In *Decision Support Systems: Issues and Challenges, Proceedings of an International Task Force Meeting, June 23–25, 1980*. pp. 95–118.

Florida, R.L. (2002). *The rise of the creative class: And how it's transforming work, leisure, community and everyday life*, New York: Basic Books.

Florida, R.L. (2005). *The flight of the creative class*, New York: HarperBusiness.

François, C. (1997). *International encyclopedia of systems and cybernetics*, Munich: K. G. Saur.

Friedman, V.J. (2001). Action science: Creating communities of inquiry in communities of practice. In *Handbook of action research: Participative inquiry and practice*. London: Sage, pp. 159–170.

Georgescu-Roegen, N. (1971). *The entropy law and the economic process*, Cambridge, MA: Harvard University Press.

Glushko, R.J. (2010). Seven Contexts for Service System Design. In P. P. Maglio, C. A. Kieliszewski, & J. C. Spohrer, eds. *Handbook of Service Science*. Service Science: Research and Innovations in the Service Economy. Springer. Available at: http://www.springer.com/business/operations+research/book/978-1-4419-1627-3.

Greenleaf, R.K. (1977). *Servant leadership*, New York: Paulist Press.

Haeckel, S.H. (1999). *Adaptive enterprise: Creating and leading sense-and-respond organizations*, Boston, MA: Harvard Business School Press.

Hagel, J. and Brown, J.S. (2005). *The only sustainable edge*, Cambridge, MA: Harvard Business Press.

Hawk, D.L. (1999). Innovation versus environmental protection presumptions. *Systemic Practice and Action Research*, 12(4), 355–366.

Hedlund, G. (1986). The hypermodern MNC – A heterarchy? *Human Resource Management*, 25(1), 9–35.

Heylighen, F. (1990). Classical and non-classical representations in physics I. *Cybernetics and Systems*, 21(4), 423–444.

Hirschman, A.O. (1970). *Exit, voice, and loyalty*, Cambridge, MA: Harvard University Press.

Homer-Dixon, T. (2006). *The upside of down*, Toronto: Knopf.

IBM (2006). Service science, management & engineering conference: Education for the 21st century. Available at: http://www.almaden.ibm.com/asr/summit/agenda.shtml (Accessed November 1, 2009).

IfM and IBM (2008). *Succeeding through Service Innovation: A Service Perspective for Education, Research, Business and Government*, Cambridge, UK: University of Cambridge Institute for Manufacturing. Available at: http://www.ifm.eng.cam.ac.uk/ssme/.

Ing, D. and Simmonds, I. (2002). Enabling collective knowledge work through the design of mediating spaces: A framework for systemic socio-informatic change. In *Proceedings of the 46th Annual Meeting of the International Society for the Systems Sciences*. Shanghai.

Ing, D., Takala, M. and Simmonds, I. (2003). Anticipating organizational competences for development through the disclosing of ignorance. In *Proceedings of the 47th Annual Meeting of the International Society for the System Sciences*. Hersonissos, Crete.

Ing, D. (2008). Offerings as commitments and context: Service systems from a language action perspective. In *Proceedings of the 12th International Conference of the UK System Society*. Oxford, UK.

Ing, D. (2009). Envisioning Innovation In Service Systems: Induction, Abduction and Deduction. In *Proceedings of the 53rd Annual Meeting of the International Society for the Systems Sciences*. Brisbane, Australia.

Jackson, M.C. (2000). *Systems approaches to management*, New York: Kluwer.

Jackson, W. (1987). *Altars of unhewn stone: Science and the earth*, San Francisco: North Point Press.

Jacobs, J. (1992). *Systems of survival: A dialogue on the moral foundations of commerce and politics*, New York: Random House.

Jacobs, J. (2001). *The nature of economies*, Toronto: Vintage.

Jamshidi, M. (2009). System of systems engineering: innovations for the 21st century. In *System of systems engineering: innovations for the 21st century*. Hoboken, NJ: Wiley.
Katz, D. and Kahn, R.L. (1978). *The social psychology of organizations* 2nd ed., New York: Wiley.
Kuhn, T.S. (1967). *The structure of scientific revolutions*, Chicago: University of Chicago Press.
Leonard-Barton, D. (1995). *Wellsprings of knowledge: Building and sustaining the sources of innovation*, Cambridge, MA: Harvard Business Press.
Levin, M. and Greenwood, D. (2001). Pragmatic Action Research and the Struggle to Transform Universities into Learning Communities. In *Handbook of action research: Participative inquiry and practice*. London: Sage.
McIntyre, J. (2004). Facilitating critical systemic praxis (CSP) by means of experiential learning and conceptual tools. *Systems Research and Behavioral Science*, 21(1), 37–61.
Miles, R.E., Snow et al. (1997). Organizing in the knowledge age: Anticipating the cellular form. *The Academy of Management Executive (1993)*, 11(4), 7–24.
Miller, J.G. (1978). *Living systems*, New York: McGraw-Hill.
Mitroff, I.I. and Linstone, H.A. (1993). *The unbounded mind: Breaking the chains of traditional business thinking*, New York: Oxford University Press.
Mitroff, I.I. (1998). *Smart thinking for crazy times: The art of solving the right problems.* San Francisco: Berrett-Koehler.
Normann, R. and Ramírez, R. (1994). *From value chain to value constellation: designing interactive strategy*, Chichester, England: Wiley.
Normann, R. (2001). *Reframing business*, New York: Wiley.
Odum, E.P. (1983). *Basic ecology*, Philadelphia: Saunders College Publishing.
Odum, H.T. (2007). *Environment, power, and society for the twenty-first century*, New York: Columbia University Press.
OECD (2000). A New Economy? The Changing Role of Innovation and Information Technology in Growth. Available at: http://www.oecd.org/document/62/0,3343,en_2649_34273_2675198_1_1_1_1,00.html.
OECD (2007). OECD Science, Technology and Industry Scoreboard 2007: Innovation and Performance in the Global Economy. Available at: http://www.oecd.org/document/59/0,3746,en_2649_33703_44198843_1_1_1_1,00.html.
Page, S.E. (2008). *The difference: How the power of diversity creates better groups, firms, schools, and societies.*, Princeton, NJ: Princeton University Press.
Parhankangas, A. et al. (2005). Negotiated order and network form organizations. *Systems Research and Behavioral Science*, 22(5), 431–452.
Perlmutter, H.V. and Heenan, D.A. (1979). *Multinational organization development*, Reading, MA: Addison-Wesley.
Perrow, C. (1984). *Normal accidents*, New York: Basic Books.
Porter, M.E. (1985). *Competitive advantage: Creating and sustaining superior performance*, New York: Free Press.
Ramírez, R. and Wallin, J. (2000). *Prime movers: Define your business or have someone define it against you*, Chichester, England: Wiley.
Ravetz, J.R. (1971). *Scientific knowledge and its social problems*, London: Oxford University Press.
Ravetz, J.R. (2004). The post-normal science of precaution. *Futures*, 36(3), 347–357.
Raymond, E.S. (2000). The Cathedral and the Bazaar. Available at: http://www.catb.org/~esr/writings/cathedral-bazaar/cathedral-bazaar/ (Accessed November 1, 2009).
Rosen, R. (1985). *Anticipatory systems: Philosophical, mathematical & methodological foundations*, Elmsford, NY: Pergamon Press.
Rowland, G. (2004). Designing with a homeopoietic ethic for organizational change. *Systems Research and Behavioral Science*, 21(3), 219–226.
Schön, D.A. (1983). *The reflective practitioner*, New York: Basic Books.
Senge, P.M. (1990). *The fifth discipline*, New York: Doubleday/Currency.

Spohrer, J. et al. (2007). Steps toward a science of service systems. *Computer*, 40(1), 71–77.

Spohrer, J. et al. (2008). The service system is the basic abstraction of service science. In *Proceedings of the 41st Annual Hawaii International Conference on System Sciences. HICSS*. p. 104.

Strauss, A.L. (1978). *Negotiations: Varieties, contexts, processes, and social order*, San Francisco: Jossey-Bass.

Swedberg, R. (2003). *Principles of economic sociology*, Princeton, NJ: Princeton University Press.

Tien, J.M. and Berg, D. (2003). A case for service systems engineering. *Journal of Systems Science and Systems Engineering* 12(1), 13–38.

Trist, Eric L., and Hugh Murray. (1997). Historical Overview: The Foundation and Development of the Tavistock Institute to 1989. In The Social Engagement of Social Science: The socio-ecological perspective, ed. Eric L. Trist, Frederick Edmund Emery, and Hugh Murray, 3:1–35. Philadelphia: University of Pennsylvania Press.

Tukiainen, T., Takala, M. and Ing, D. (2006). Master's program for service management at Helsinki Polytechnic Stadia. In *Service Science, Management and Education Conference: Education for the 21st Century*. Palisades, NY.

Van Gigch, J.P. (ed.) (1986). *Decision-making about Decision-making: metamodels and metasystems*, Cambridge: Abacus Press.

Wallin, J. (2006). *Business orchestration: Strategic leadership in the era of digital convergence*, Chichester, England: Wiley.

Walton, D.C. (2004). Designing within: Dr Bela H. Banathy's contributions to the self-organization of public discourse. *Systems Research and Behavioral Science*, 21(3), 281–293.

Wenger, E. (1999). *Communities of practice*, Cambridge, UK: Cambridge University Press.

Winograd, T. and Flores, F. (1986). *Understanding computers and cognition: A new foundation for design*, Norwood, NJ: Ablex.

Witte, M.H., Kerwin, A. and Witte, C.L. (1998). Curriculum on medical and other ignorance: shifting paradigms on learning and discovery. *Memory distortions and their prevention*, 125–156.

Wölfl, A. (2005). *The Service Economy in OECD Countries*, Organization for Economic Co-operation and Development. Available at: http://www.oecd.org/LongAbstract/0,3425,en_2649_34409_34428002_1_1_1_1,00.html.

# Service Customization Research: A Review and Future Directions

**P.K. Kannan and John Healey**

**Abstract** Service customization is an important new opportunity for firms in their pursuit of better outcomes in their service provision process. Much like the recent expansion of product customization in goods markets, service customization has been expanding recently due to a variety of factors, such as technological development allowing for improved service delivery and better communication with customers as well as a growing acceptance amongst customers of the customization process. Much of the previous research on services in this area has viewed service variability as a negative that should be limited. However, customer variability in product needs provides a similar opportunity to deliver more value for consumers through specialization of services. In fact, the co-creation of value in services makes the development of effective mass customization systems in the area of services exceptionally important. This chapter will examine service mass customization and the design of systems for service customization. Starting with a review of extant work, the chapter will develop a framework for service customization and service design, specifically, focusing on the concept of customer variability and how this concept can be used to extract greater value from the transaction between the customer and the firm. Based on the framework, the chapter will then identify important directions for further research from both practice and academic viewpoints.

**Keywords** Service science · Service customization · Service systems · Value co-creation · Customer variability

P.K. Kannan (✉)
R. H. Smith College of Business, University of Maryland, 3461 Van Munching Hall,
College Park, MD 20742, USA
e-mail: pkannan@rhsmith.umd.edu

H. Demirkan et al. (eds.), *The Science of Service Systems*,
Service Science: Research and Innovations in the Service Economy,
DOI 10.1007/978-1-4419-8270-4_17, 

# 1 Introduction

Service customization offers a new opportunity for firms to develop better service systems, offerings, and solutions to customers with the goal of better outcomes. New advances in technology have resulted in the capability of service firms to deliver high-quality, individually-tailored solutions to their customers, helping to create more value along with the customer (Spohrer et al. 2007; Demirkan et al. 2008). Customization strategy has a variety of implications for service providers, specifically within the context of service design. However, in addition to the benefits of service customization, there are some costs and drawbacks that need to be considered. Therefore, the effective design and implementation of service customization is a crucial area of research that will allow us to better understand how to develop service customization systems, with the goal of creating more value with customers. This is specifically important development of service customization systems calls for close integration of issues researched across different disciplines from service operations, information technology, service marketing, and consumer psychology among others.

While customization research in the production domain has been fairly extensive, the research in service customization is still largely being developed as it falls in the interface of many disciplines. While it is important to take lessons from the product-based customization research, it is also crucial to recognize the differences between production and service provision, and how those differences can cause differences specifically within the process of customization. Therefore, the goal of this chapter is to explore the issue of customization, specifically within a service context, and to examine how the traditional product-based models can inform our thoughts on service customization, as well as how differences between production and service provision can result in important differences. Based on the above understanding, this chapter will propose a framework for service customization that not only provides a foundation for examining various issues related to customization, but also highlight the managerial implications of the related research issues.

Customization, in both the service and production firms, has recently expanded due to many factors. The first factor is the expansion of a variety of new technologies. These new technologies have resulted in more flexible manufacturing and better information transmission. Second, consumers are demanding more customized product and service offerings. This has created an environment in which even traditional segmented product and service offerings may be too broadly targeted to develop appropriate niche strategies. Third, product life cycles are shortening, which along with increased competition, has caused the breakdown of more traditional strategies, which often rely on longer life cycles. Finally, firms can better avoid the commoditization of their products through the use of mass customization, allowing for higher profits for the firm. In the future, more companies are likely to develop customization strategies as consumers become more accustomed to the process of customization.

One major gap in the literature on customization is the lack of research on service customization. Strategies for service firms are considerably different than strategies for manufacturing firms, and thus, customization strategies for service firms need to be considered in a separate manner. Customization research has typically been performed in product contexts. One of the reasons for the focus on products and manufacturing is that customization has traditionally been a focus of operations management research. In this research, the focus has been on how to hold manufacturing costs down for customized products. Recently, however, the marketing, strategy, and management literature has relatively recently begun to address customization issues. The cross-discipline nature of research in mass customization has created a rich understanding of the process, while allowing for considerable new research in a variety of disciplines. Much of the early research on mass customization has viewed mass customization as the eventual successor to mass production (Ahlstrom and Westbrook 1999). However, another viewpoint has developed that views mass customization and mass production as coexisting and developing synergy through this coexistence (Kotha 1995). The different perspectives on mass customization and its relationship to traditional mass production strategies will be crucial in the discussion of frameworks for considering service customization. We will first start with key definitions

## *1.1 Definitions*

Partly due to the somewhat contradictory nature of the two terms, mass customization has a variety of definitions. Davis (1987) states that mass customization is the process of providing a one-of-a-kind product without sacrificing the benefits of scale economies. In a later work, Davis (1989) refines this definition as the ability to provide individually designed products and service offerings to customers through high process agility, flexibility, and integration. Another pair of definitions of mass customization was provided by Hart (1994). The first, which he termed the "visionary definition", is "the ability to provide your customers with anything they want profitably, any time they want it, anywhere they want it, any way they want it." This definition, while useful from a general perspective, is not particularly specific or practical. Hart (1994) then provides a second, more practical definition, which is "the use of flexible processes and organizational structures to produce varied and often individually customized products and services at the low-cost of a standardized, mass-production product." Another definition, based more on the practical rather than theoretical issues of mass customization, was provided by Teresko (1994). He states that mass customization is the ability of today's manufacturing technology to bring down the cost of variety. This definition illustrates an operations viewpoint of mass customization. Pine (1993) defines mass customization as the process with a goal of providing enough variety in products and services that the firm can provide nearly everyone what they want at a reasonable cost. These definitions are a good starting point to look at the conceptual and theoretical issues of mass customization and how those issues specifically apply to service customization. They also show the many different viewpoints of mass customization and what it means for businesses attempting a mass customization strategy.

## 1.2 Service Customization

As stated before, the research on mass customization, including many of the definitions previously given, was mostly focused on production firms. While this literature can inform us in our discussion of service customization, it is important to consider the potential differences between the mass customization of product offerings and the customization of service offerings.

The first step to examine the differences between product and service customization is to look at how the process of manufacturing and service provision differ generally. One framework for the examination of service provision was provided by Rust and Kannan (2002). The authors describe a traditional service model, in which a physical product is encased in a combination of service delivery, a service product, and a service environment. Many companies are now changing their focus to the service aspects of their businesses rather than the product-centric aspects of their businesses. Service customization can occur in any part of the process of service provision. Therefore, one of the primary differences between product and service customization is the interaction between different elements of service provision and how customization can alter those interactions.

Another key difference between production and service provision is the importance of touch points in the service offering. Touch points are the points at which the firm and the consumer interact in the provision of the service. The process of service customization, therefore, must start from the touch points. New technologies have changed the nature of touch points. For example, in many service businesses, touch points are traditionally firm employees. However, new technologies have resulted in a variety of new potential touch points, such as self-service kiosks. One example of this shift is retail banking, in which ATMs have partially replaced tellers. The implementation of automated touch points allow for additional options for the firm when considering customization strategies. However, unlike production systems where the quality of the customized offering is not dependent on customer skills, in service systems the impact of technology is dependent on variation in customers' skills.

The next step in the process of examining service and product customization is to look at the process and design of service customization system. Service customization has existed in less formalized forms in many service businesses for years. For example, most restaurants offer the capability to make special orders based on customer feedback. However, the development of new technologies has resulted in the opportunity for a more formalized and larger-scale strategy of service customization. The advance of information technology has been a particularly important factor allowing for a variety of service firms to begin more formalized customization programs. This new technology has allowed firms to collect more information on consumer preferences, and specifically, for the purposes of service customization, the heterogeneity of those preferences. This offers an exciting new opportunity for service providers to better serve their customers and potentially make higher profits.

Service customization is important because it offers service providers the opportunity to offer a more individualized service, based on the needs of the customer. As firms become more focused on service provision, it is important to develop customization processes for these offerings. Service customization offers service firms many of the same opportunities that product customization offers to production firms. Specifically, service customization will allow firms the ability to provide service offerings in such a way as to result in better profit maximization as well as provide better outcomes for customers. One of the most important reasons for the expansion of mass customization is that firms feel customers have begun to demand increased variety (Ahlstrom and Westbrook 1999). In addition, firms feel that customer needs are changing faster and that product lifetime is decreasing. This has led to an increase in the desire of firms to engage in customization efforts in order to better provide value for customers.

In what follows, we will first look into the extensive literature on product customization. This will provide insights for future frameworks and potential research for service customization. Next, we will examine the nature of services and customization. In this section, we will look at how service offerings differ from product offerings and how those differences can be manifested in service customization, in the context of extant work. Third, we will develop a framework for service customization and the design of service customization systems. Finally, we will look at some future research areas in service customization.

## 2 Product Mass Customization

The first step in the study of service customization is to look at the more extensive literature on product mass customization. Many authors have developed frameworks for examining the process of customization within the product contexts. These models, as well as specific research on methodologies, implementation, and customization system design, will serve to provide a basis for the study of customization in service context.

### *2.1 Frameworks*

One framework for considering the issues of mass customization was presented by Duray et al. (2000). The authors examine four stages of the production cycle:

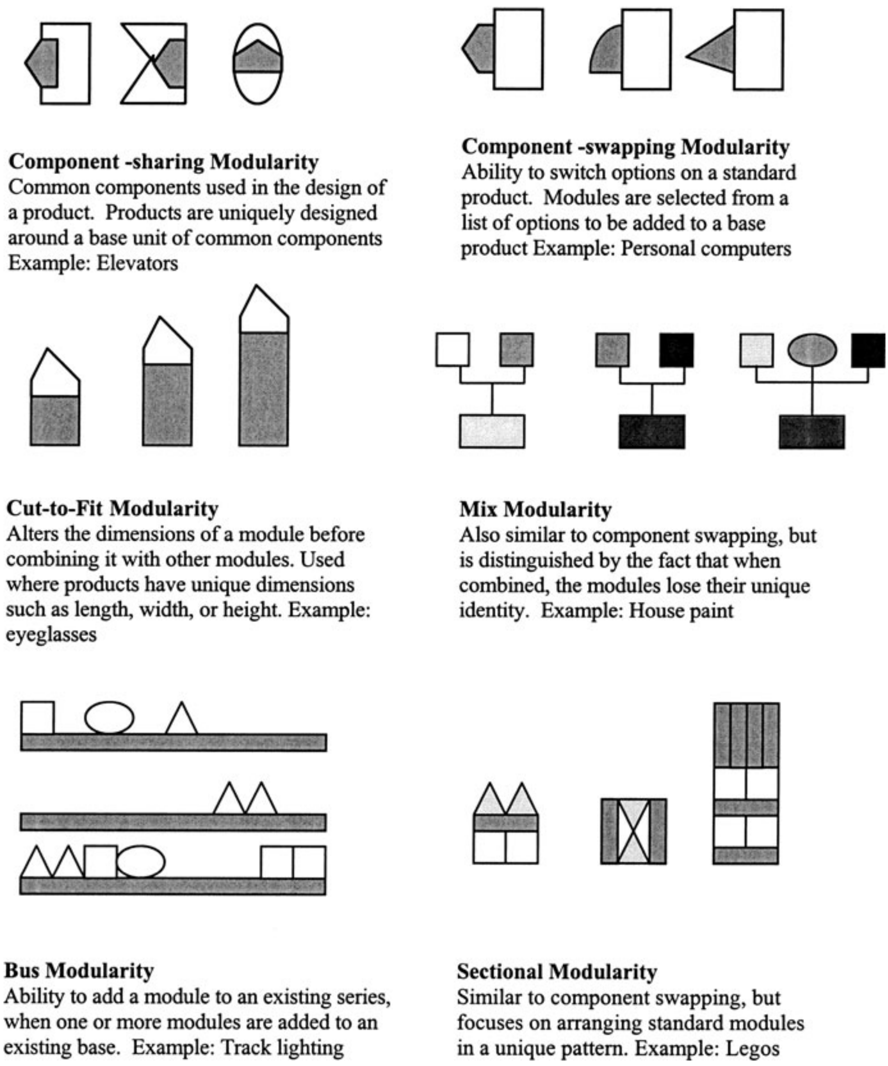



**Fig. 1** Modularity types

design, fabrication, assembly, and use. The authors also present different modes of modularity. The six types of modularity are component-sharing modularity, component swapping modularity, cut-to-fit-modularity, mix modularity, bus modularity, and sectional modularity. These are illustrated in the Fig. 1.

The authors then combine the concepts of point of customer involvement, modularity type, and the production cycle (Fig. 2).

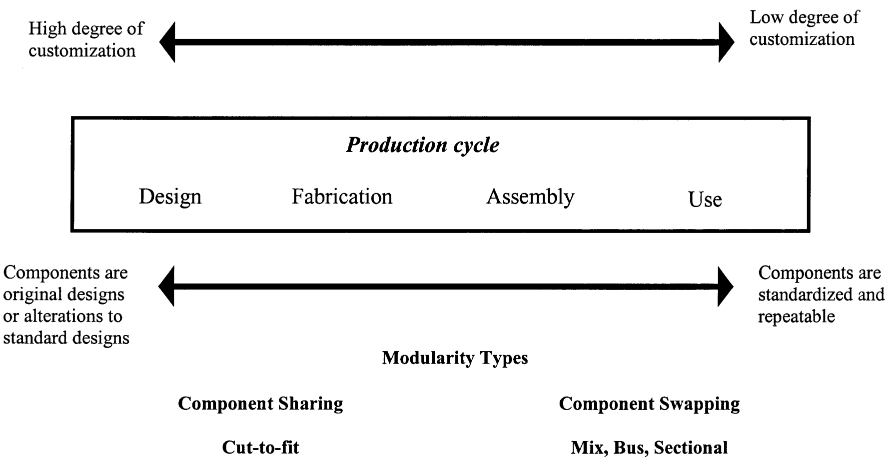



**Fig. 2** Point of customer involvement

Finally, the authors present four groupings of different types of customizers based on the point of customer involvement and type of modularity: fabricators, involvers, modularizers, and assemblers (Fig. 3).

Fabricators are firms that involve the customer early in the process in order to develop unique designs, but still use modular components. Involvers also allow the customer into the customization process early, but only by allowing consumers to choose from combined standard models. Modularizers develop modules in the early stages of the production, but do not involve the customer until later. Finally, assemblers develop modules and involve the customer late in the process.

Another framework for considering mass customization was developed by Gilmore and Pine (1997). The authors define four approaches to customization: collaborative, adaptive, cosmetic, and transparent. The four types of customization vary on two main attributes: the product itself and the representation of the product. Collaborative customization occurs when the customizer engages the customer in a conversation to help them identify their needs in order to more accurately fulfill those needs. This is fairly common in customized consumer goods, such as customized personal computers. Adaptive customization is when the firm offers a standardized product, which the user can customize themselves. Cosmetic customizers present a standardized product differently to different customers. Finally, transparent customizers provide customers with customized goods without letting them know that the good is customized. This often occurs in environments when customer needs are fairly easily deduced but in which customers do not want to continually spend time customizing a good.

These four approaches to customization all have potential extensions into service customization. In fact, many of the forms of customization have been practiced in service firms for many years. The application of these frameworks and how they might affect customization systems is an interesting area for future research.

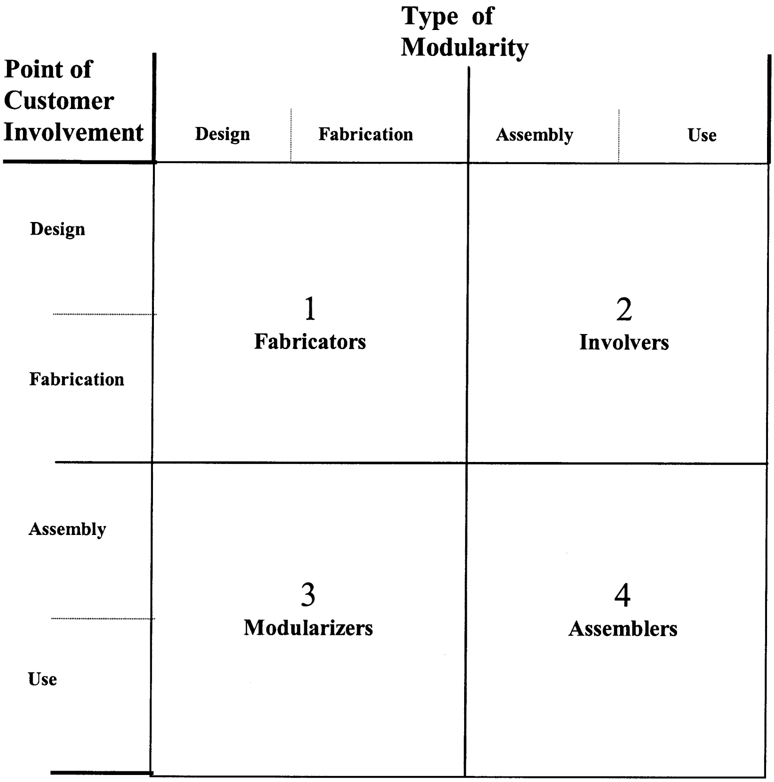



**Fig. 3** Matrix grouping of mass customization configurations

Another framework for analysis of customization was developed by Murthi and Sarkar (2003), who develop a three-step framework. The steps are to first learn about consumer preferences, then matching product offerings to customer preferences, and, finally, an evaluation of the learning and matching processes. The authors develop a framework, which they call the Enhanced Value Net. This model looks at how personalization occurs in a competitive framework (Fig. 4).

A fourth framework for considering mass customization was presented by Lampel and Mintzberg (1996). The authors present customization and standardization as a continuum rather than as two separate concepts. They identify five different stages of this continuum, which vary on four different aspects of the manufacturing and distribution process. The four aspects are design, fabrication, assembly, and distribution. The first stage is pure standardization, in which each of the aspects of the process is standardized. This stage has no differences between products, with products targeted at the broadest possible group of consumers. The next level is segmented standardization. In this stage, distribution is customized. There are small differences provided in the product to target it to a specific aggregated segment. The third step on the continuum is customized

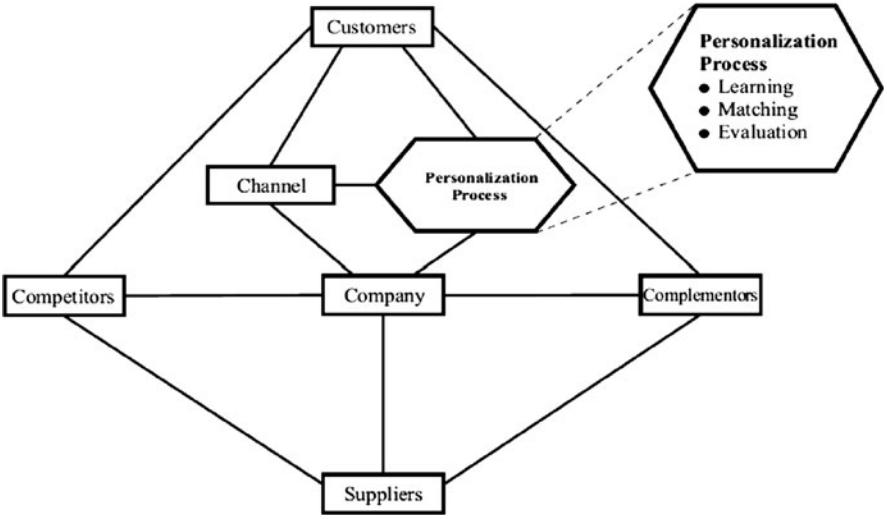



**Fig. 4** The enhanced value net

standardization, which has customized distribution and assembly. In this stage, there is a standardized product in which the assembly is customized by the consumer, such as at fast food restaurants where consumers can choose what they want on their hamburgers. The fourth step is tailored customization. In this step, everything but design is customized. A prototype of the product is presented to the customer, who gets to customize that product. The final step is pure customization, in which every aspect of the process is customized.

This is an important framework for considering service customization because it offers service providers the ability to decide on a level of standardization to maintain in order to keep costs low, while at the same time allowing some customization in order to better serve their customers and better extract value from those customers. Different service firms in different businesses will have different optimal levels for customization of service provision.

A final, and slightly broader, framework for the idea of customization is the idea of customerization presented by Wind and Rangaswamy (2001). The authors define customerization as a move from a seller-centric firm to a buyer-centric firm. The authors for this paper offer a framework in which they separate the concepts of personalization, mass customization, 1-to-1 marketing, customerization and standardization. The authors present two attributes on which these concepts differ, operational customization and marketing customization (Fig. 5).

Building on earlier work, in a survey paper on mass customization, Da Silveira et al. (2001) present eight generic levels of mass customization: standardization, usage, package and distribution, additional services, additional custom work, assembly, fabrication, and design. These strategies were taken from earlier research and integrated into one framework, in which many different but similar concepts

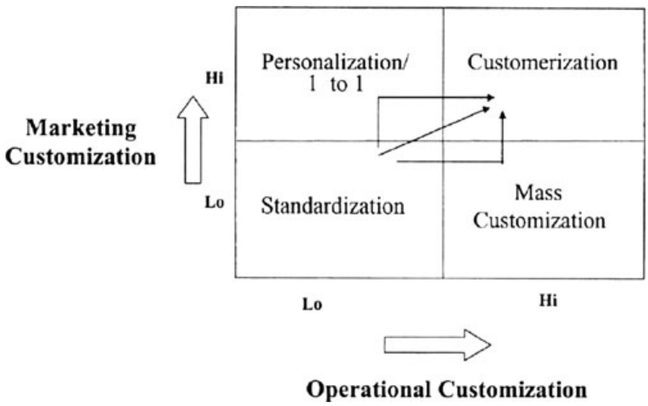



**Fig. 5** Pathways to customerization

were combined into over-arching ideas. For example, the idea of package and distribution customization comes from the cosmetic approach (Gilmore and Pine 1997), segmented standardization (Lampel and Mintzberg 1996), and customizing packaging (Spira 1996).

One form of customization that is slightly different from those listed above is bundling. This is when products (often in the form of content or information) are put together based on either firm design or customer preferences. Hitt and Chen (2001) show that in a monopolistic setting, bundling chosen by consumers outperforms either individual selling or firm selected pure bundling when marginal costs are positive and customers have heterogeneous preferences. Bundling is an especially important form of customization when considering service customization because most service offerings are bundled.

## 2.2 *Implementing Successful Mass Customization*

The Da Silveira et al. (2001) paper presents six factors that the literature often present as success factors for mass customization strategies. They divide these six factors into two large groupings. The first two factors are market-driven success factors, while the other four are organizational success factors.

The first market driven success factor is that demand for variety and customization must exist. This deals with the issue that in addition to the advantages of customized products (such as improved targetability), there are also costs to customization (such as time costs). Therefore, customers must demand customization enough to cover this cost. The other market success factor is that market conditions must be appropriate for mass customization. This issue primarily deals with the competitive environment of the firm and its effects on the firm's mass customization strategy. For example, the ability to be the first-mover into mass customization in a market may result in better market conditions for the customizer. Therefore, the market conditions are a major success factor for a firm considering mass customization strategies.

The first organizational success factor is that the value chain should be ready for mass customization. The entire supply network, from suppliers to distributors to retailers needs to be prepared and willing to help ensure success of a mass customization strategy. Often, all parts of the supply network need to be willing to share information to ensure efficiency in customization in order to ensure that mass customization does not prohibitively increase the price of production, sales, and distribution by too much to make it an effective strategy. The second organizational factor for success is that technology, specifically information technology and process flexibility technology, must be available for the customizing firm. Third, products should be customizable. This is on its face a somewhat obvious observation. However, in order to make products customizable, for many products, they must have potentially modular components. In addition, organizations need to be designed to ensure fairly rapid product development and R&D programs, due to the fairly short product life-cycle for customized products. Finally, organizations must be set-up to encourage knowledge sharing. Different units of an organization must be capable and willing to share information on a variety of issues in order to ensure effective mass customization.

While the previous list of success factors outlines many of the theorized issues that separate success and failure of mass customization strategies, it is not an exhaustive list. For example, in a case study of Hewlett-Packard, Feitzinger and Lee (1997) argue that the most effective way to mass customize products is to wait as long as possible in the supply chain before allowing the customer to customize the product. The authors state that this allows the company to mass customize while still holding down production costs, a major concern for product customization.

Da Silveira et al. (2001) examine a number of methodologies and technologies that enable the success factors to develop within an organization. They focus specifically on the organizational factors. Methodologies must develop in the correct way to ensure the organization can effectively develop a mass customization strategy. Agile and lean manufacturing are required for the development of effective mass customization. Agile manufacturing is the ability to change manufacturing processes quickly due to market changes. Agile manufacturing is different than flexible manufacturing in that agile manufacturing is more proactive than flexible manufacturing (Gutman and Graves 1995). Agile manufacturing has been divided into internal agility and external agility (Owen and Kruse 1997). Internal agility is the ability of the organization to respond to market changes quickly with new products and product features. This requires the ability to change manufacturing very quickly due to small lot sizes. External agility refers to the ability to use relationships with other businesses in order to produce high-quality customized products. Lean manufacturing is when the producer develops an efficient manufacturing process for the production of the product. Supply chain management in this context refers to effective practices in optimizing the different elements of the value chain to gain competitive advantages (Boyton et al. 1993).

A variety of factors contribute to successful supply chain management, such as interconnected information networks with suppliers, the ability to maintain small inventories while still delivering products effectively, suppliers who are actively collaborating with suppliers, and the ability to deliver the right-product to the right-customer. The final methodology is the development of customer-driven design and manufacturing capabilities. This is developing organizationally in order allowing customers to provide information on the design of products and developing manufacturing to produce those new products.

Next, Da Silveira et al. (2001) present a variety of mass customization enabling technologies. The first group is advanced manufacturing technologies, which include computer numeric control, flexible manufacturing systems, computer-aided design, computer-aided manufacturing, computer integrated technology, and electronic data interchange. These technologies are specifically designed to make manufacturing processes more agile and flexible. Many of these technologies will not directly apply to service customization, which is another major difference between product and service customization. The second group of technologies is communication and network technologies. These technologies can provide direct links between different groups in an organization and improve the response time to customer requirements.

Another group of technologies that is important for the development of mass customization systems is the technology that links customers with the producers. Mass customization is a process that requires far more communication between the firm and the consumer, at some point in the process, than mass production or traditional service provision. Therefore, one of the primary drivers for mass customization success is the development of an effective communications system between the customers and the producers, which often involve the extensive use of information technology. Da Silveira et al. (2001) present four steps for developing an effective communication link between customers and producers. The first step is to define a catalogue of options available to the consumer. In this step, the firm provides information to the consumers about potential customization opportunities for the product, often based on past analysis of consumer demand. In many firms, this takes the form of an online catalog of options, on which customers directly specify their selections. The second step is to collect and store information on the consumers. This can make the customization process easier for the consumer, by providing them with better options. In addition, it allows for analysis of the data with the goal of improving manufacturing performance. The implementation of mass customization systems only makes it more important to maintain customer information. The third step is to link the retailer with the manufacturer (which can either be separate firms acting in a channel or the same vertically integrated firm in a channel). This allows the manufacturer to gather more information to help make manufacturing decisions. Finally, the manufacturer uses the data collected in previous steps to design product features and manufacturing techniques. Through these steps, a firm can use technology to cheaply and quickly obtain information on consumer preferences, allowing for better mass customization strategies. Many of these steps would also be applicable to service customization. For example, it is crucial for service customizing firms to effectively provide the customer with a set of options and to gather and maintain customer information. However, the nature of many service firms, in which they directly interact with customers, make some of the channel issues less important.

A word of caution in switching a firm to a mass customization strategy was provided by Zipkin (2001). The author identifies three capabilities for mass customization. The first is elicitation, which is “a mechanism for interacting with the customer and obtaining specific information. Next, process flexibility is the production technology that is used to create the product as specified in the first stage. Finally, logistics need to be able to ensure that the identity of each item is maintained and delivered to the correct customer. The author presents an argument that not all companies have the appropriate capabilities in these areas in order to effectively implement a mass customization strategy.

Zipkin (2001) describes four kinds of elicited information in mass-customization systems: name and address, customers’ selections from menus of alternatives, physical measurements, and reactions to prototypes. Obviously, some of this data is more difficult to obtain. For example, while it is fairly easy to obtain basic information, such as name and address, it can be far more difficult to collect data on reactions to prototypes.

Therefore, a variety of factors can lead to success in developing a mass customization strategy. These factors are crucial to consider when making a decision about whether to engage in a mass customization strategy. After deciding to engage in a mass customization strategy, these factors are also important in designing customization system designs.

### *2.3 Customization System Design*

Previous research has examined the idea of elicitation of customer information and how it can be effectively implemented by companies in markets with varying degrees of customer knowledge. For example, recent research has looked into the design of customization systems for goods (Randall et al. 2007). The authors examine user design, which is a form of customization that involves a system that allows the user to specify certain characteristics of the customizable product. In this research the authors study the use of parameter-based customization systems versus the use of needs-based systems. In parameter-designed systems, the users directly enter design components for the customized product. In a needs-based system, the system uses an optimization algorithm to determine the best components based on consumer needs. The authors find that expertise is a major factor in the success of parameter-based systems compared to need-based systems. All outcomes, including comfort and fit measures increase with user expertise in the parameter-based systems. For novices, which are defined as those without expertise, the need-based system results in superior outcomes. This has important implications for business managers in many industries. If most customers are fairly knowledgeable about the product, a parameter-based system alone may be the best option for the company.

If a firm produces in an industry without much detailed knowledge, a needs-based system might be the best system design. Finally if a firm is in an industry with very high heterogeneity of knowledge, the best option may be to develop a system to discern consumer knowledge and direct the users to the appropriately designed system to ensure the best results of the customization process.

Von Hippel (1998) also deals extensively with knowledge and experience and how those factors can affect system design. He deals with how mass customization can develop even though consumers do not have the same level of expertise as companies who specialize in specific product categories. The author argues that one of the drivers for mass customization strategy is that an agency-related problem exists in product design and is one of the primary drivers of firm's strategies for problem-solving and product design towards customers, who are typically closer to novices than production firms. Specifically, consumers have more motivation to create an outcome that is exactly correct for their needs than a firm, which might be satisfied with creating a "good enough" solution in order to prevent the development of different solutions for each consumer. Therefore, even though consumers do not have the same level of knowledge about the product, their motivation to obtain a product perfectly positioned for themselves results in the desirability of mass customization. This theory has important implications for service customization. The most important implication is that it demonstrates the importance of viewing customization from a service perspective due to the similarity between this concept and the concept of value co-creation. If firms and customers view themselves as partners in creating value, the agency issues of creating less than optimal solutions diminishes and the motivation for unique solutions and outcomes increases. The author also presents a concept he terms "sticky" local information. This refers to the cost of transferring information about the optimal product design from one location to another, or, specifically, from a consumer to a producer. Therefore, customization systems are a method for overcoming the agency-based problem. The primary strategic objective is to lower the cost of "sticky" local information.

In addition, experimental evidence has been collected to determine the effectiveness of certain system design elements for customization systems. For example, Brown and Krishna (2004) develop an experiment to test the effects of default options on marketplace metacognition. Marketplace metacognition is a consumer's social intelligence about marketplace behavior. In this experimental study, the authors found that customers treat default options as though they contain some information about the marketplace. The authors term this "carriers of meaning." Therefore, defaults are a very important part of any service customization system design. Another experimental study of customization involved the framing of options as either additive or subtractive (Park et al. 2000). This paper found that consumers select more options when the choice is framed as a subtractive choice (one in which the customer starts with a higher default and takes away options) versus an additive choice (one in which a customer selects an increase in options compared to the default).

Another area of potential future research with major implications for system design is to look at customer demand for mass customized products. One such study involved modeling the use of experimental choice-menus for determining customer preferences and price sensitivities (Liechty et al. 2001). The authors then develop a Bayesian model, specifically a constrained random-effects multivariate probit model, to describe the data from the experimental menus. In this model, the authors account for customer heterogeneity for the utilities for components and characteristics. This model offers an interesting research opportunity to further explore mass customization from the demand-side of the transaction rather than the supply-side, which is where most research has occurred in this area.

### *2.4 The Effect of Customization on Channel Members*

Another issue in the analysis of customization is the effect that customization strategies can have on partners, such as suppliers (Murthi and Sarkar 2003). A firm could move from a single to multiple-supplier strategy, in an attempt to increase potential customization options. For example, Dell uses several suppliers for video cards in order to better serve heterogeneous customers. Mass customization can, therefore, result in a far more complicated set of suppliers. Mass customizing firms must balance the needs of heterogeneous consumers with the potential additional production costs found by increasing the number of suppliers.

Another strategic concern for firms performing mass customization is the amount of information to share with suppliers. This is also a concern for companies performing more traditional manufacturing. However, this problem is extended in the case of mass customization because of the importance of sharing information in order to hold down production costs. Information can change bargaining power between firms, since more information on higher value customers could change bargaining positions for the supplier.

Another major issue in customization strategy is whether to engage in the customization or to have an intermediary perform the customization. Often an intermediary can be a better customizer since it possesses more knowledge of individual consumers than many manufacturers (Murthi and Sarkar 2003). This advantage has been diminishing due to the increased use and effectiveness of information technology. However, in certain markets, firms should consider allowing an intermediary to offer the customization, while focusing on other aspects of the business such as production.

## 3 Nature of Service and Customization: The Extant Perspective

The previous research in product customization provides a useful basis for the study of service customization. However, the differences between service and product offerings will create important differences in all stages of the process of customization. This section will look at how these differences can manifest themselves into new opportunities and new challenges for customizing service offerings instead of product offerings, following the current thinking in the service literature (Fisk and Brown 1993; Maglio et al. 2006; Chase and Apte 2007).

### 3.1 Background of Services

While the background on customization in production firms is important, service firms have many differences with traditional production firms, and thus have to be considered with different frameworks (see, for example, Heskett et al. 1994) . Frei (2008) provides a framework for service business consisting of four elements for successful service firms. The first, the offering, involves a necessary tradeoff. When developing an effective service offering, the firm must decide which attributes of the service are going to be the focus of the firm and which attributes are going to be comparatively weak. Very few firms can specialize in providing great service in all aspects due to the cost that would be required to provide this great service. It is important in this stage to decide who the targeted customers are and what attributes will allow the firm to best target these customers.

The second element is the funding mechanism. This is a major difference between service firms and manufacturing firms. Manufacturing firms, generally, collect revenue from the sale of a product. Service firms often cannot collect revenue on a purely transactional basis. For example, if a salesperson offers service to a customer in a retailing environment, that salesperson is providing service, but generally does not request compensation directly for performing this service. It is important, therefore, for service firms to design a system that allows for the collection of revenue in a manner that is both acceptable to the customer and the firm.

The third element of the successful service firm is an effective employee management system. The firm must be able to attract service personnel, and develop the talents of the personnel in an appropriate manner, to ensure that the employees can deliver the service offerings in the desired manner. The elements of the employee management system, which include training, job design, and performance management (Frei 2008), must be focused on developing personnel in a way to ensure effective performance in the areas in which the firm is focused.

The final element of the successful service firm as presented by Frei (2008) is the customer management system. This step is especially crucial in a service customization setting, since customers are being asked to participate even more directly in the service process. One important aspect of this element is the training of customers. Customers are integral members of the value creation in a service setting and, therefore, much like customers, need to be trained to deliver service offerings effectively. However, training is far more difficult since formalized training programs are often not an option with customer training. In addition, the firm only has limited ability to choose their customers. An effective system for managing customers trains the consumer to participate in the service process more effectively and can also serve to choose consumers that are the focus of the firm, and thus may be better at participating in the process.

### 3.2 Implications for Service Customization

Customization of services will affect services in all four of the elements presented by Frei (2008). The process of customization will require the firm to modify their strategy at every step of the design of their service.

The most obvious change in strategy will occur with the offering. In service customization, the firm is directly altering the offering by allowing the customer to decide on their preferred offering. Firms need to be careful to allow for the consumers to have enough options at this stage, while also ensuring that costs do not excessively increase due to potential additional costs. For example, if consumers are allowed to receive service at additional times, the firm will have to maintain some service infrastructure for additional hours than they might under a single-offering strategy. While technology may help to make such provision posssible and efficient, the effectiveness will depend on the customers' – their preferences and skill levels in using the technology.

The second aspect is the funding mechanism, which will be particularly crucial in a framework for service customization. Typically, customers compensate the firm for service offerings as part of a bundle. This may have to change in a service customization context due to the ability of the consumer to directly choose the elements of their bundle. In addition, the firm will have to design a system in which the customer will find payment to be palatable. This might require the use of extensive record keeping system, to move the pricing temporally further from the touch point.

The primary goal of the firm for employee management systems while implementing a service customization strategy is to maintain lower costs while still effectively preparing employees for the challenges of customization. Effective employee training must be provided by the firm to ensure that the employees are capable and prepared to deliver customized service offerings. This training should also contain information on how to maintain lower costs while still delivering effective customized offerings.

The final element, the customer management system is especially important within a service customization context. Customers must be effectively managed since they play an even greater role in the service process under a customization system than under a traditional service design system. Customers often need to be more trained in the system to be effective at creating effective service offerings. This is similar to the results found by Randall et al. (2007) in the product domain, who find that better outcomes are produced by needs-based systems instead of parameter-based systems amongst novices. The firm needs to be able to effectively manage customer knowledge of their service offerings, in addition to the system designed to allow for the customization of those offerings.

### *3.3 Service System Design*

Recently, researchers have begun to look at how customization systems are designed in a service context. The differences between product and service markets require firms to develop different systems for the effective customization of service offerings. For example, one notable difference between service and product customization is the fact that service customization cannot rely nearly as heavily on the modularity of components to ensure lower costs. Modularity is one of the key cornerstones of product mass customization. Service customization will, therefore, require more creative methods and systems for implementation.

Another major difference between mass customization of product and service offerings is that consumers often have more of a face-to-face relationship in service markets. Customers can provide direct feedback in many service environments, bypassing the information technology that is such a central component of mass customization in product markets. One of the challenges for those looking at service customization is the integration of face-to-face communication with information technology into an effective overall communication system.

Another major difference between product customization and service customization is that consumers are more sensitive to quality errors in service offerings than in products (Da Silveira et al. 2001). This means that customization in service offerings will have to ensure fewer quality errors than is necessary in product customization processes. This will lead to new challenges at effectively delivering customization while not raising costs for the customizer too much to make the strategy unprofitable.

Service offerings also have tighter delivery times than products. Offerings often require direct interaction between the consumer and the service provider. This means that time is an important consideration for service providers. If service providers are unable to provide their services in an effective time period, consumers will move to competitors who are more capable of providing service offerings in a more-timely manner. A related problem when implementing service customization is that service offerings, unlike product offerings, can't be placed in inventory. Therefore, normal variation in demand can be covered by putting additional units into inventory. For example, if a mass customizer in the personal computer market has a drop-off in demand for a particular type of hard drive, the company would be able to store some of their extra units in inventory for a fairly low cost. This action is not an option in service customization environments. Therefore, service customizers need to be able to better predict demand heterogeneity and effectively provide their service offerings in a timely manner to be effective.

The final aspect which Da Silveira et al. (2001) describe as differing between service and product customization is dependence on information reliability.

Specifically, service businesses are more dependent on reliable information than product manufacturing. In the end, however, this is not as important of a difference because both service and product customization require information that is as accurate as possible. Service customizers, like product customizers, do have to develop the best systems for learning customer preferences, which is somewhat related to the research done by Randall et al. (2007) on customization system design. However, this research was conducted in a product setting. In order to effectively research system design within a service customization context, more research needs to be performed on how systems are designed and how this design can be improved to ensure a variety of better outcomes for both the customizer and the consumers.

One area on which service and product customization will differ is customer privacy. Customer privacy is a major issue in a variety of contexts in product customization. In fact, previous research has even been done positing the possible development of markets where levels of privacy are purchasable (Rust et al. 2002). An interesting difference in the nature of privacy in a service context compared to a product context is that service offerings are often inherently less private purchases. Customers' willingness to forego privacy in a service context versus a product context would be an interesting area for future research in service customization.

Another interesting area for research in the area of service customization is the interaction between service offerings, products, and customization. One example provided by Wind and Rangaswamy (2001) is the original concept of garden.com. This company provided consumers with the service of helping them to design a garden for their home. Then the consumer could select products from the website. Next, the firm would coordinate through a network of suppliers to deliver the requested products. Finally, FedEx would deliver the selected products to the consumer. While ultimately unsuccessful, this business model demonstrates the potential interactions between traditional service offerings, traditional products, and mass customization in the delivery of those products and service offerings.

Another example of the interaction between service and product customization is often found in hotel rooms. Many hotels have begun to use systems that allow for customized communications with hotel guests. For example, LodgeNet is a company that provides communication and information technology that allows hotels to customize their service offerings. LodgeNet's system allows for customers to checkout while still in their room. In addition, the system allows the hotel to provide customized television service to certain hotel guests. Finally, this system allows for the hotel to distribute surveys to their guests. This allows for quicker service recovery. The firm provides hotels with a variety of service offerings and products, such as the ability to customize placement of products (in this case the television that is the basis of the system). Therefore, this system, consisting of information technology software, as well as products, allows customers to provide information to the hotel employees, allowing them to provide better service.

### 3.4 Variability in Service Provision

One recent paper that has looked at the area of service customization was written by Kannan and Proenca (2009). This paper deals with the variability both from service personnel and from customers. This additional source of variation in comparison to product customization is a major issue for future research in service customization. One of the primary goals of product mass customization is to use modular components, and thus diminish variability. Service customization, therefore, has the challenge of either managing this variability, which is how traditional research has framed firm strategy for dealing with customization, or by accommodating this variability.

Frei (2006) presents the tension between reducing and accommodating customer-introduced variability. Reducing variation can reduce costs but it can also reduce the quality of the customer's experience. Accommodating variation can improve the customer's experience, while at the same time posing a risk of dramatically escalating the cost of service provision. Frei (2006) then presents five phases in which customer-based variability can occur: customer arrival, customer requests, customer capability with respect to their expected involvement with the process, effort that customers are willing to exert, and subjective preferences of how service should be provided.

In addition, there is also a significant amount of variability that is not attributable to the variability of customers. For example, employees can be heterogeneous in skill levels. In addition, equipment can vary in effectiveness. This can be due to either variability within the equipment or due to outside factors, such as geography. For example, cell phones can vary in effectiveness depending on where the phone is used.

Variation can also be either controllable or not controllable. Some variations can be controlled through effective management and strategy, while other variability, such as the cell phone example above, cannot be controlled. One example of a variability reduction strategy is a training program for service providers within the company. In addition, equipment variation can be reduced by using standardized equipment. Variability in servicescapes can be reduced by providing standard designs and equipment.

However, service providers should not always attempt to reduce variability. Some of the variability, specifically much of the customer-induced variability, holds the potential for increasing profitability. For example, some customers take longer to order food at a restaurant. These customers though could allow greater profitability through a variety of factors, such as filling excess capacity, greater personal profitability (they may take longer to order because they are ordering more expensive service), or by a willingness to pay for the increased usage of the service. Despite the potential advantages of variability on service profitability, service variability is also a great risk. Many negative events can occur due to high variability. In fact, consumers could value service offerings less due to the variability. Demonstrating this, Meyer (1981) shows that variability lowers choice probability. Even the more potentially positive customer-based variability is a potential problem because consumers often evaluate service offerings from their own frame of reference (Kannan and Proenca 2009). Therefore, even if the other customer may be more profitable due to increased use of the service, they could cause other customers to be less satisfied with the service. The key for dealing with these risks is to positively deal with the variability issues. Therefore, some variability is a standard characteristic of service provision, and is a necessary consideration in the customization of service offerings that differs from traditional product customization.

One of the key questions in looking at the issue of variability in service offerings is measurement. Kannan and Proenca (2009) propose the use of conjoint analysis, on which not only means but variances and the interaction between means and variances are recorded in order to get a better picture of the nature of how variability in service offerings is affecting the consumer's overall evaluation of the service. This leads to the need for a framework for service customization and design that will enable us to define clearly the important research issues in this domain.

## 4 Framework for Service Customization and Design

Our framework for service customization and design is based on the commonly used perspective on service offering as illustrated in Fig. 6, where the marketing offering of a firm is broken down into four main components: *physical product, service product, service environment*, and *service delivery* (Rust and Oliver 1994). We will analyze service customization and design from the above perspective, specifically focusing on what customization implies for each of the four main components. We also add a fifth element to this – customers who can play an active role in co-creating the service and hence can interact with all the service elements of

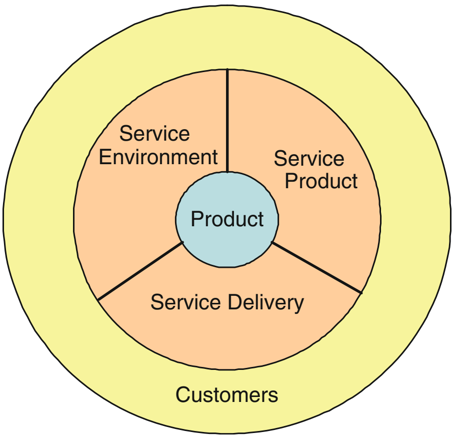



**Fig. 6** Framework for service customization

the offering (see Fig. 6), and thus a critical determinant of service customization and design alternatives. We give some examples below, following Rust and Kannan (2002), to illustrate how this framework will apply to different market contexts.

Applying the framework to the automobile market, we can readily identify the automobile as the physical product, while the service product consists of title exchange, warranty, financing and insurance, etc. The service product is the core performance purchased by the customers, and the flow of events in the service product ensures that the customer receives his/her preferred product. It is the process design that creates the service customers pay for. The servicescape or service environment includes the showroom, product display, decor and the car lot, while service delivery includes the sales function, test drive, price negotiation, etc., all of which comprise the process of purchasing a car. If the market analyzed were college education, the physical product itself (which could be a degree or diploma) may not be as significant as the service product, which might include the fields of study, internship, placement, and so forth. The service environment is made up of classrooms, dormitories, dining hall, sports and recreation complexes, while the service delivery component would include teaching performance, the grading process, the job interview process, etc., with the customers being students. In the context of a business market, an IT service provider could view their offering in terms of any hardware supplied as product, the software package provided as the service product, installation, service quality and maintenance as service delivery, while the service environment could be in-house at the client's premises, or online as in an Application Service Provider model.

It is important to note that customers play a critical role in the service customization framework. The customer component in the framework highlights the importance of accounting for customer preferences, abilities and values and the heterogeneity in those factors, and the importance of managing the heterogeneity in providing service customization. In the framework, customers interface with all components of service: the service product, the service environment and service delivery. The framework suggests an easy approach to analyzing variability in service and service customization – analyzing the interface of customers with each of the service component separately for identifying customization opportunities and appropriate designs for realizing such opportunities. Such an analysis can also reveal the limits to service customization given funding mechanisms for the service offering. As an illustrative example, when Gateway Computers found that they could appropriately target and customize their offerings to novice computer users and first-time owners of PCs, they had to make a clear cut decision to change service environment – move from online environment to brick-and-mortar retail stores, that could enable them to customized their service product and service environment to service a different segment of customers. However, their funding mechanism for this service customization was not robust enough to allow them to compete effectively with other retailers.

The framework also highlights the interaction between the various components in impacting the variability in service and potential for service customization. For example, the service environment in an automobile showroom can be limited in its customization opportunities as customization in such setting can be expensive. However, supplementing the environment with online access can expand the customization opportunities at a low cost of delivery as long as the customers have the ability to use the channel effectively to receive the customization they need through self-service. For novice buyers, this customization may not be effective, and they may need to have a salesperson provide this as part of the service delivery process. Customization in the service delivery stage can be accomplished only through hiring versatile employee who can play several service roles and cater to different needs of different types of customers. This can be expensive and unless the funding mechanism allows such customization (through higher prices for vehicles), the service customization model may not be sustainable. This may also highlight the importance of customer selection and customer management for effective and profitable service delivery.

On a final note, it should be noted that the framework considers product as part of its core and the mass customization techniques addressed in the extant literature are readily applicable to this component. The product customization system (eliciting customer preferences and specifications they desire, as in Dell.com website) would itself be part of the service product, the process that enables the customer to receive his/her preferred/selected product. In the next section we identify several important future research directions on the basis of our framework.

## 5 Research Issues and Future Directions

The current thinking in the design of service systems has focused, rightly so, on the issue of business viability of the service model. The argument goes as follows: There are obvious limitations to service customization. A service business cannot be everything to everybody – the funding mechanism for service usually does not allow this. This implies that a service organization has to pick service attributes that they will excel in, at the cost of other attributes being not being as excellent as they could be (e.g., Frei 2008). It is all a notion of trade-offs – a firm picks the customer segments it wants to target, designs the service product for those segments and delivers service efficiently at a cost that allows it make profits. Unfortunately, service customization becomes one of those service attributes that can be traded-off against other attributes such as service efficiency and service quality (see Anderson et al. 2006). We have philosophical difference with the above argument. We believe that service customization has to be viewed as a separate objective, in and of itself, quite apart from other service attributes which are traded off against each other. This is necessary because paradigm shifts in service design and service customization systems cannot be achieved if service customization is treated as something that could be traded-off against other attributes. Thus, the first research challenge for practitioners and academics is to delink the concept of service customization from those attributes that can be traded-off against each other and instead focus on break-through design possibilities which will contribute to significantly different service models.

## 5.1 Customization and Service Product

Our framework provides the building blocks for such paradigm shifts in design for service customization. The critical component to target is the service product, which along with the service environment determines the scope of service customization that is feasible within the service system. The service at the service delivery stage can be customized only to the extent that service product is flexible enough to accommodate the customization in response to customer variability. Thus, front-line service employees or self-service technologies or the combination of the two can be as effective as what the service product (the processes that allow customers to obtain their preferred product or service) can allow. While much of extant academic research has focused on training and adaptiveness of employees to accommodate flexibility/customization at service delivery stage (e.g., Gwinner et al. 2005) or using self-service technologies to accomplish such customization (Meuter et al. 2000), significant research is needed to understand how service customization can be accomplished at the service product stage. In the context of online service environment there are good examples of such research – design of recommendation systems (Ansari and Mela 2003; Chung et al. 2009) that create service products to provide precise customization of service, be it music or movie rental service. Similar examples exist in the context of online games where learning algorithms are used to infer customer preferences as they play games and develop and design new games to suit their tastes. The research and development challenge is to extend this to offline, face-to-face service environments – such as hospitals, banking, transportation, government services, logistics, B2B service environments, etc. Technology is likely to play as key a role it plays in the online service environment.

## 5.2 Customization Through Co-creation

Customers touch/interact with all components of the service offering in our framework. This recognizes the possibility that customers can co-create service in interacting with all of the service components. Customer co-creation in the service delivery component through self-service technology is only the initial application of this concept and it has been, thus far, motivated primarily as a cost-saving and efficiency increasing move by firms rather than as a service customization initiative. In the context of online service environment, there are examples of customization achieved through co-creation at the service product level – online tax preparation, which involves the customer to make appropriate choices and actions to get the kind of service he/she desires as customized to his/her needs. Designing co-creation systems that allow customers to customize their service and derive the benefit and high-level of satisfaction is an interesting challenge. Depending on the type of service contexts, such service customization can be complex. In some service situations (such as tax preparations), there is an element of information asymmetry between the customer and the service provider ("am I getting the correct advise? How would I know that I am getting all the deductions that I can?") that can be eliminated or reduced through customer co-creation of the service process, which can lead to higher satisfaction. On the other hand, for a customer with little expertise in tax preparation and tax laws, co-creation can be cumbersome. Customizing the extent of co-creation at the service product interface to maximize perceived benefits and satisfaction of customers in different service contexts is a research and development challenge that can be viewed as the holy-grail of service customization.

## 5.3 Customization and Service Pricing

Service customization is limited by the business viability of the service model, which in turn depends to a significant extent on the funding mechanism required for implementing and maintaining a successful customization system. Given that service customization creates value for customers by making the service provided closer to customer's ideal point, customers should be willing to pay for the customization. However, for a "should" to manifest as a "would", customers need to *perceiv*e that they are getting more value and have an increased willingness-to-pay for customization. There has been extensive extant work in the area of pricing services that examine ways to charge for service provision encompassing areas of value pricing, fairness in pricing, and how the nature of the service context changes customers' willingness-to-pay. While customers' are generally willing to pay for the additional customization features in a product (for example, when they order a customized PC through Dell.com), similar customization at a service delivery stage is generally not as readily acceptable. However, when service customization is made at the service product level, they are more readily accepted. For example, Dell.com sells telephone-based customer service at a much higher price that reflects the cost involved, while online web-based services are priced differently. The challenge for firms in this dimension is simple: how can they communicate the value of their service customization and how can they price the customization at the service delivery stage differentially to reflect the costs involved. The conjecture based on our framework will be to use customization at service product stage to fund the customization at the service delivery stage. Clearly, more research is needed to appropriate design pricing and funding mechanisms for service customization.

## 5.4 Customization and Customer Selection

Appropriate customer selection is much more important for service customization initiatives to be successful as compared to even overall selection of customer for regular service provision. For service customization to succeed, customers need to realize the value of customization and be willing to pay for the customization. Customization provides the flexibility some customers seek and selecting such customers who value flexibility is critical. In a similar vein, customers who are willing to and capable of co-creating services for their custom needs would be the right target for a firm focused on such strategies. When technology is used to deliver customized service, customers need to be technology-ready. The design challenge for service firms is to match the appropriate customers to the appropriate means of enabling customization and the appropriate pricing of customized services. This is key in ensuring that firm's customer equity is increased over time.

## 6 Conclusions

It is clear that with advancing technology and methodologies, service customization is going to much more important in the coming years. It will be a critical strategy that will separate winners from losers. In order that it provides a competitive edge to a firm, it is imperative that it is not viewed as a service attribute that can be traded-off against other attributes, but rather viewed as an objective where the bar should be set increasingly higher over time. It is necessary that firms have a learning mind-set when initiating service customization strategies. The strategy is best implemented with the selection of a niche segment of customers, for whom service customization is offered, either through co-creation or through other means. The focus should on ensuring that customers realize the value, willing to fund the customization initiative with their higher than normal willingness-to-pay. If this is successful, then the bar for customization should be increased – another segment of customers should be targeted, which will obviously increase the variability on all factors. However, this will present the firm with a challenge to extend the initiative successfully and maintain the pressure to innovate and maintain the firm's competitive edge. Such a learning process will create the need for both practitioners and academics to focus on design models, technologies and methodologies that can make service customization successful.

## References

Ahlstrom, P. and Westbrook, R. (1999). Implications of Mass Customization for Operations Management: An Exploratory Survey. *International Journal of Operations and Production Management* 19 (3), 262–274.

Anderson, J. C., Narus, J. A. and van Rossum, W. (2006), Customer Value Propositions in Business Markets, *Harvard Business Review*, March, 91–99.

Ansari, A. and Mela, C. (2003). E-Customization. *Journal of Marketing*, 40(2), 131–145, May

Boyton, A., Victor, B., and Pine, J. (1993). New Competitive Strategies: Challenges to Organizations and Information Technology, *IBM Systems Journal* 32 (1), 40–64.

Brown, C. L. and Krishna, A. (2004). The Skeptical Shopper: A Metacognitive Account for the Effects of Default Options on Choice. *Journal of Consumer Research* 31, 529–539.

Chase, R. B. and Apte, U. (2007). A history of research in service operations: What's the big idea?, *Journal of Operations Management*, 25, 375–386.

Chung, T. S., Rust, R. and Wedel, M. (2009). My Mobile Music: An Adaptive Personalization System for Digital Audio Players, *Marketing Science*, 28(1), 52–68.

Da Silveira, G., Borenstein, D., and Fogliatto, F. (2001). Mass Customization: Literature Review and Research Directions. *International Journal of Production Economics* 72, 1–13.

Davis, S. (1987). *Future Perfect*. Addison-Wesley Publishing, Reading, MA.

Davis, S. (1989). From Future Perfect: Mass Customizing. *Planning Review* 17 (2), 16–21.

Demirkan, H., Kauffman, R. J., Vayghan, J. A., Fill, H. and Karagiannis, D. (2008). Service-oriented technology and management: Perspectives on research and practice for the coming decade, Electronic Commerce Research and Applications, 7, 356–376.

Duray, R., Ward, P. T., Milligan, G. W., and Berry, W. L. (2000). Approaches to Mass Customization: Configurations and Empirical Validation. *Journal of Operations Management,* 18, 605–625.

Feitzinger, E. and Lee, H. L. (1997). Hewlett-Packard: The Power of Postponement. *Harvard Business Review* January–February, 116–121.

Fisk, R. P. and Brown, S. W. (1993). Tracking the Evolution of Services Marketing Literature, *Journal of Retailing,* 69 (1), 61–103.

Frei, F. X. (2006). Customer Introduced Variability in Service Operations, HBS 606-063. Harvard Business School Publishing, Boston, MA

Frei, F. X. (2008). The Four Things a Service Business Must Get Right. *Harvard Business Review* April, 70–80.

Gilmore, J. H. and Pine, B. J. II. (1997). The Four Faces of Mass Customization. *Harvard Business Review*. January–February, 91–101.

Gutman, R., Graves, R. (1995). The agile manufacturing enterprise- both a new paradigm and a logical extension of flexible and lean, EAMRI Report ER95-10, Rensselaer Polytechnic Institute, Troy, NY.

Gwinner, K. P, Bitner, M. J., Brown, S. W. and Kumar, A. (2005). Service Customization Through Employee Adaptiveness. Journal of Service Research. 8 (2), 131–148.

Hart, C. W. L. (1994). Mass Customization Conceptual Underpinnings, Opportunities, and Limits. *International Journal of Service Industry Management* 6 (2), 36–45.

Heskett, J. L., Jones, T. O., Loveman, G. W., Sasser Jr., W. E. and Schlesinger, L. A. (1994). Putting the Service-Profit Chain to Work, Harvard Business Review, March–April, 164–172.

Hitt, L. M. and Chen, P. (2001). Bundling with Customized Self-Selection: A Simple Approach to Bundling Low Marginal Cost Goods. Working Paper, http://grace.wharton.upenn.edu/~lhitt/bundling.pdf.

Kannan, P. K. and Proenca, J. F. (2010). Design of Service Systems Under Variability: Research Issues. *Information Systems and e-Business Management*. 8(1),1–11.

Kotha, S. (1995). Mass Customization: Implementing the Emerging Paradigm for Competitive Advantage. *Strategic Management Journal* 16, 21–42.

Lampel, J. and Mintzberg, H. (1996). Customizing Customization. *Sloan Management Review* 28, 21–30.

Liechty, J., Ramaswamy, V., and Cohen, S. H. (2001). Choice Menus for Mass Customization: An Experimental Approach for Analyzing Customer Demand with an Application to a Web-Based Information Service. *Journal of Marketing Research* 38 (2), 183–196.

Maglio, P. P., Srinivsan, S., Kruelen, J. T. and Spohrer, J. (2006). Service Systems, Service Scientists, SSME, and Innovation, Communications of the ACM, 49 (7), 81–85, July.

Meuter, M, Ostrom, A., Roundtree, R. and Bitner, M. J. (2000). Self-Service Technologies: Understanding Customer Satisfaction with Technology-Based Service Encounters, Journal of Marketing, 64 (3), 50–64.

Meyer, R. J. (1981). A Model of Multi-Attribute Judgments under Attribute Uncertainty and Informational Constraint. *Journal of Marketing Research* 18 (4), 428–441.

Murthi, B. P. S. and Sarkar, S. (2003). The Role of Management Sciences in Research on Personalization. *Management Science* 49 (10), 1344–1362.

Owen, D. and Kruse, G. 1997. Follow the Customer. *Manufacturing Engineering* 118 (4), 65–68.

Park, C. W., Jun, S. ., and MacInnis, D. J. (2000). Choosing what I Want Versus Rejecting what I do not Want: An Application of Decision Framing to Product Option Choice Decisions. *Journal of Marketing Research* 37, 187–202.

Pine, B. J. II (1993). Mass Customization: The New Frontier in Business Competition. Harvard Business School Press, Boston, MA.

Randall, T., Terwiesch, C., and Ulrich, K. T. (2007) User Design of Customized Products. *Marketing Science* 26 (2), 268–280.

Rust, R. and Kannan, P. K. (2002). The Era of E-Service. From e-Service: New Directions in Theory and Practice. M.E. Sharpe, Armonk, NY, 3–21.

Rust, R., Kannan, P. K., and Peng, N. (2002) The Customer Economics of Internet Privacy. *Journal of the Academy of Marketing Science* 30 (4), 455–464.

Rust, R. T. and Oliver, R. L. Eds. (1994). Service Quality: New Directions in Theory and Practice. Thousand Oaks, CA: Sage Publications.

Spira, J. (1996). Mass Customization through Training at Lutron Electronics. *Computers in Industry* 30 (3), 171–174.

Spohrer, J., Maglio, P., Bailey, J. and Gruel, D. (2007). Steps Toward a Science of Service Systems, IEEE Computer, January, 71–77.

Teresko, J. (1994). Mass Customization or Mass Confusion. *Industry Week* 20 (June), 45–48.

Ulrich, K., Tung, K. (1991). Fundamentals of product modularity. Proceedings of the 1991 ASME Winter Annual Meeting Symposium on Issues in Design Manufacturing Integration, Atlanta.

Von Hippel, E. (1998). Economics of Product Development by Users: The Impact of "Sticky" Local Information. *Management Science* 44 (5), 631–644.

Wind, J. and Rangaswamy, A. (2001). Customerization: The Next Revolution in Mass Customization. *Journal of Interactive Marketing* 15 (1), 13–32.

Zipkin, P. (2001). The Limits of Mass Customization. *MIT Sloan Management Review* 42 (3), 81–87.

# Service and Science

**James C. Spohrer, Haluk Demirkan, and Vikas Krishna**

**Abstract** While there is a rapid growth in the number of researchers and practitioners joining the service science community, this community has not yet settled on precise answers to two fundamental questions: "What is service?" and "Where is the science (in service science)?" This chapter examines possible answers to these two fundamental questions from multiple disciplinary perspectives, and proposes the Abstract Entity-Interaction-Outcome Universals (AEIOU) theory to frame the science of service systems.

**Keywords** Service science · Service innovation · Service customization · Service systems · Value co-creation · Customer variability

## 1 Introduction

### *1.1 Two Fundamental Questions*

What is service? Where is the science (in service science)? The emerging service science community has not yet settled on precise answers to these two fundamental questions. Existing disciplines from economics to marketing to computer science provide related, but different definitions of service. Also, each discipline contributing to the creation of the service science community has its own scientific approaches and methods that practitioners bring to bear. Service-oriented sub-discipline areas are forming. Some of these sub-disciplines are service oriented architectures in computer science, service systems engineering in industrial engineering, and knowledge-intensive business services in economics. With so many disciplines taking up the

---

J.C. Spohrer (✉)
IBM Almaden Research, San Jose, CA, USA
e-mail: spohrer@almaden.ibm.com

H. Demirkan et al. (eds.), *The Science of Service Systems*,
Service Science: Research and Innovations in the Service Economy,
DOI 10.1007/978-1-4419-8270-4_18, 

study of service phenomena, a deeper integration seems possible and needed. This chapter will gather up evidence and examine possible answers to these two fundamental questions.

In addition to majority views, minority views are on the rise in the service science community. In short, a paradigm shift is underway, as the service science community wrestles with these two fundamental questions. Before foreshadowing the established majority and rising minority views, the nature of the existing service science community is described. Ultimately, this community must reach a new consensus view, or be forced to accept that service science is merely a mosaic of many disciplines.

## *1.2 An Emerging Community*

Ten interrelated drivers are shaping the growth of service phenomena in the world. This rapid growth is increasing the number of researchers and practitioners joining the service science community.

*Global economic change is the first driver*. More nations are investing to improve their service sectors – monitoring productivity growth, quality levels, regulatory compliance and innovativeness. For the last 50 years the economies of most developed nations have been dominated by what traditional economists refer to as the service sector, and yet service has been understudied in academia relative to its economic importance (Chesbrough and Spohrer 2006; Parasuraman et al. 1985, 1990). Economics, marketing and operations (including both operations research and operations management) were some of the first disciplines to begin scientific study of service and service systems, and more recently other areas of management, engineering, computing, design, law, as well as social and behavioral sciences have applied their unique methods in service-oriented specializations or sub-disciplines (Roth and Menor 2003; Demirkan and Goul 2006; Sen 1999; Spohrer and Maglio 2009). Increasing levels of automation and outsourcing in agriculture and manufacturing enterprises, has shifted labor and value creation into what traditional economists call the service sector (Anderson et al. 2007). Nations are a type of service system from a service science perspective. Citizens are both customers and providers. Nations have the responsibility of protecting the rights of their citizens. When the majority of citizens no longer live in nearly self-sufficient farming communities, the unemployment rate among adult citizens becomes a major concern.

*ICT-enablement or technology change is the second driver*. For the last 50 years, integrated circuits and other advanced technologies have increased in capability at an exponential rate. Nevertheless, many of the grand challenges facing the world's growing population, such as hunger, poverty, unemployment, and corruption can be framed as lack of access to resources and opportunities in a world of increasing abundance (Sen 1999, 2001). Information Technology (IT) or Information-and-Communications Technologies (ICT) is both enabling and stimulating the growth of new types of service offerings that can reach the under-served members of society to help them participate in new on-line labor markets as well as help people and organizations in need connect with people and organizations with value propositions that address those needs (Rai and Sambamurthy 2006; Sen 2001). ICT-enablement is helping all types of service systems improve internal operations as well as external interaction capabilities with other service systems.

*Outsourcing is the third driver*. Businesses whose customers are other businesses are on the rise. The growth of business-to-business (B2B) service is highly correlated with the amount of outsourcing by existing firms. This driver is also closely related to the rise in the use of ICT, which enables outsourcing. Service delivery centers have sprung up in India, China, Egypt, Philippines, and other emerging market nations, as work shifts to where the best skills are available at the lowest cost. The ability to enforce service level agreements (SLA), switch to alternative service providers easily, and resolve legal disputes across national boundaries has also helped enable outsourcing to flourish, and given rise to the rapid growth of B2B service. Businesses are a type of service system (Demirkan et al. 2005). Their sustained vitality depends on maintaining profitability or being acquired.

*Business model change (value migration) is the fourth driver*. As products become more complex, many customers will not buy a product without a service plan, and they often prefer access (leasing) over ownership. Therefore, traditional manufacturing firms like GE, IBM, Xerox, Rolls Royce, John Deere, and other have seen an increasing percentage of their revenue come from service offerings, rather than simply the sale of products. IBM has played a major role in helping to establish the service science community (IfM and IBM 2008; Spohrer and Maglio 2008). Modern businesses, including agricultural and manufacturing businesses, are service systems from a service science perspective. This new perspective breaks with the current majority view.

*Where people live (demographic change) is the fifth driver*. Cities and suburban areas are where most people are born or move to for a job, and therefore end up living their lives there. Most of the world used to live on farms in rural areas. Cities with their diverse jobs and service conveniences are attracting more and more of the world's population. As the world's population shifts from rural to urban areas and as national economies become dominated by the what economist call the service sector, or the knowledge economy, interest in service science has also been growing. Cities are a type of service system from a service science perspective (Heskett 1987; Heskett et al. 1990, 1994, 1997a, b).

*How long people live (another demographic change) is a sixth driver*. Also, an aging population world-wide is a related demographic change. People are living longer. This is creating more dependence on hospitals and hospital operations. Hospitals are a type of service system from a service science perspective.

*The nature of family life is the seventh driver*. The role of women in society has been changing rapidly in the last 100 years. As women have entered the workforce in developed nations, family incomes have risen and the demand for personal services has skyrocketed. Demand for child care, retail, hospitality, entertainment, information, mobile communications, fitness, and more are surging. Managing dual careers in volatile job markets has also increased demand for education and life-long-learning, fueling a growth in educational service for working professionals. Families are a very special type of service system from a service science perspective.

*A rising education level is the eighth driver*. Employees find higher education levels and life-long-learning required to participate in many career paths (Hefley and Murphy 2008; Mandelbaum and Zeltyn 2008). On the flip side, employers face the challenge of creating career paths to elevate employees over time into higher value creation and higher compensation roles. On the one hand, employers in both the private and public sector are using technology to reduce labor costs (number of employees used to provision a service) and improve reliability of outcomes per unit of management and governance costs through a higher degree of standardization and automation. The labor (employees) that are no longer needed must either be elevated into new roles or eliminated from the enterprise. Elevation into new roles typically requires a simultaneous increase in intra-and-inter-organizational communication skills and/or multidisciplinary project team communication skills (breadth) as well as specialized problem solving skills and new areas of expertise (depth). So called T-shaped professionals have both depth and breadth, allowing them to be more productive on teams and more productive life-long-learners who can adapt to new opportunities and challenges (Donofrio et al. 2009). The ability to lead and start new ventures, both inside and outside firm boundaries is also, highly sought. Service science provides a transdisciplinary framework that helps I-shaped professionals become more T-shaped over time. Individual people are service systems from a service science perspective.

*A rising dependence on universities is the ninth driver*. Universities create the skilled human-capital essential to national prosperity, and are also the source of new knowledge which is also essential to national competitiveness. The academic ranking of universities is driven by the quality of faculty and research centers at a university. In great cities with great universities, universities are also often in the top ten employers of their regions, helping to create many jobs for knowledge-workers. These great universities in many cases have a medical center and hospital as part of their operations, and in these situations the university is often in the top five employers of the region. Universities play a key role in society, providing a bridge for young adults into higher learning, jobs and independent living. Universities are service systems from a service science perspective.

*A rising dependence on non-profit organizations is a tenth driver*. Non-profit organizations exist at two ends of a spectrum and all points in between. At one end, are foundations with collectively trillions of dollars of wealth that they must invest in creating benefits for society consistent with their founder's intentions. At the other end of the spectrum, are non-profits that struggle to remain viable while delivering service to some of societies most under-served, who have nearly dropped out of modern society for reasons of mental illness, drug addictions, or in some cases those left homeless through a string of bad luck or non-productive life choices. In the middle of the spectrum, is a rich diversity of public broadcasting, museums, galleries, orchestra, religious organizations, educational institutions, charities, research centers, professional association, community athletic associations, and much more. Non-profits exist because increasing levels of wealth allow people to make donations, and increasing amounts of leisure time allow people to volunteer more. Non-profits are service systems from a service science perspective.

The above ten drivers are highly inter-related and interconnected. The growth in the diversity and number of entities interacting to create mutual benefits is driving the growth of service phenomena in the world. The growth of service phenomena is incenting disciplines to create service-oriented sub-disciplines to remain relevant. The growth of service-oriented sub-disciplines is in turn driving participation in the emerging service science community. Researchers join the community to look for coherence and deeper insights into service phenomena. Practitioners join the community to look for applications and insights that might improve operations or help create sustainable innovation, and thereby elevate the value of their service offerings to their customers and other stakeholders (Chase 1978, 1981; Chase and Dasu 2001). "Service up! Value up!" is one catch phrase used by practitioners.

As it matures, the service science community is gradually becoming increasingly focused on the study of holistic service systems, such as cities, universities, hospitals, luxury resort hotels, cruise ships, and the like, that can be described as somewhat self-contained entities that are a complex system of systems. In each of these somewhat self-contained entities, one finds a range of systems including transportation, water, food, energy, communications, buildings, retail, finance, health, education, and governance. The study of holistic service systems is especially challenging, because local optimization does not necessarily lead to global optimization and small changes in one subsystem can lead to large consequences in other systems (Alter 2008a, b; Blomberg 2008; Maglio et al. 2006, 2009; Spohrer et al. 2007). IBM's Smart Planet initiative and the US National Academy of Engineering's Grand Challenges of Engineering initiative have both brought a great deal of attention to system of systems, including cities, and many other types of engineered human-made systems (Donofrio et al. 2009; IBM 2004, 2009).

In sum, service science is an emerging area of research and practice for the transdisciplinary study and improvement of service systems (Chesbrough and Spohrer 2006; Demirkan et al. 2008; Spohrer and Riecken 2006; Spohrer et al. 2007). Service systems are complex business and societal systems that create benefits for customers, providers, and other stakeholders, and include all human-made systems that enable and/or grant diverse entities access to resources and capabilities such as transportation, water, food, energy, communications, buildings, retail, finance, health, education, and governance.

## *1.3 Majority and Minority Views*

The next two sections explore important views on possible answers to the two fundamental questions. In both cases the majority view comes from a traditional economics perspective. The first question (what is service?) has a current majority view that is based on the traditional economist perspective (intangible product and service sector) and an emerging minority view that is based on a splinter marketing perspective (service-dominant-logic and value-cocreation). The second question (where is the science?) has a current majority view that is based on the traditional economist perspective (prices and productivity) and an emerging minority view that is based on a splinter systems perspective, closer to ecology (diversity, sustainability and quality of life).

## 2 What Is Service?

### *2.1 Tangible Versus Intangible*

The majority view (established by traditional economists over 200 years ago) is that service is intangible product. Product is the output of an entity's efforts that may have value to other entities. If an entity produces a physical output that can be weighed, measured (using the physical sciences to ascertain its quality relative to a standard), and stored, then that entity (according to the majority view) is counted as a product-producing entity, and not-counted as a service-producing entity. For example, a farm produces bushels of corn that can be weighed and inspected via the methods of the physical science. Another classic example is that of a pin shop that produces tiny pieces of metal used to sew clothing or join sheets of material. These are physical or tangible outputs that can be weighed, inspected, and stored.

In contrast, the classic example of a service is a musician or a string quartet music group. Music is produced, but unless you are in the audience, you do not experience it. However, already we see our worldview today is quite different than 200 years ago. Two hundred years ago music could not be recorded and stored on digital media. Furthermore, measuring the frequency characteristics of the music would have been unimaginable except to a few members of the scientific community. To be sure, music boxes did exist and they were tangible products, but the majority of entities that produced music did so in live performances.

So 200 years ago, music required human labor to produce and could not be easily stored. So 200 years ago, music was a service. Today music is still a service in traditional economic statistics, even though music is most often listened to, by first being recorded and then played back by any number of devices, mundane and sophisticated. Because of technology, the majority of musical production has gone from the intangible product realm to the tangible product realm. And yet the older means of categorization and accounting are still used.

Without belaboring the point, if what is and is not a service is dependent on the technological capabilities of the time, then a precise definition is difficult as technological capabilities change rapidly, and we do not want our definitions to change that rapidly.

## 2.2 *Ownership Versus Access*

Another product-oriented approach to defining which entities produce service is based on the notion of ownership versus access. If an entity does not transfer ownership of a tangible product, but merely provides access, then that entity should be counted as a service-producing entity. So in the case of music, when you play back the song, you do not "own the song." You merely have "access to the song." Similarly, if a company makes cars to sell to customers, it is a product-producing entity, but if it rents the cars to customers, it is a service-producing entity.

The definition of service is now a legal definition. A service-producing entity is one that by definition provides access to resources it owns, but does not transfer ownership.

Again, without belaboring the point, what is and is not classified as a service-producing entity in national accounts is largely a matter of decisions made about entities at some point in history. Two more examples are needed before we suggest an alternative paradigm that avoids the problems of technological change and historical precedent.

## 2.3 *Production Versus Coproduction/Transformation*

By 1980, a number of economists were troubled by the lack of a positive definition for service-producing entities. Defining service-producing entities as a heterogeneous group of entities that were clearly not agriculture or manufacturing in nature was a negative definition that was for a number of reasons unsatisfying (Hill 1977). By this time the information economy was the focus of attention of many economists, and some of them set out to create a positive definition of service-producing entities (the service sector) that would fit the historical context well and accommodate the many new types of information services arising (Spohrer 1999).

Economists had already observed that in many service situations the cooperation of the customer was an essential characteristic (Fuchs 1968). For example, in education that student must labor to provide reasonable effort to gain benefits, and in health care the patient must eat right and exercise to gain benefits. Even listening to music requires some attention or cognitive resources of the customers to be committed. Coproduction of value was highly characteristic of many service situations, but not all. For example, newspaper delivery service requires very little customer effort. Nevertheless the commitment of customer resources and granting provider access to those resources, opened the doors for some new efforts to define "what is service?"

Within the product-centered or producing-centered worldview, some economists realized that an even more general framework would be needed to distinguish service-producing entities from product-producing entities. The key insight was noticing that many service-producing entities transform the customer entity in some way (e.g., education and health care) or transform a possession of the customer entity (e.g., washing the customer's car or depositing a newspaper on the customer's driveway).

Service as the transformation of an entity or an entity's possessions is a powerful, positive definition of service. A product-producing entity does not need customer resources during the production process, but a service-producing entity does need access to the customer or the customer's resources.

The only problem now was that the number of product-producing entities was dwindling, as economies of scales allowed fewer and fewer entities to produce most of the tangible products that customers need. Even more, with automation and off-shoring, the number of employees in developed economies needed by product-producing entities was dwindling as well. What had been the dominant part of the economy two hundred, even 100 years ago, was rapidly dwindling in number, though not dwindling in economic and political importance.

## 2.4 Outsourcing and Servitization

Just as some economists were celebrating a useful positive definition of service-producing entities by the end of the 1980s, one that was not dependent on technological capabilities of the time, two other dynamics began to raise concerns about the definition of product-producing entities. The first was outsourcing. Large manufacturing companies (product-producing entities) began depending on supply chains and procurement procedures, rather than vertical integration. In just a few decades, jobs that had been counted as part of product-producing entities shifted to service-producing entities. For example, janitors employed by a car manufacturer are not consider part of the service sector, but when the same employees doing the same work on the same assets are part of a cleaning service, suddenly they are counted as jobs in a service-producing entity.

The fact that an organizational change caused by outsourcing decisions could impact national statistics so substantially caused economists to scrutinize both their definitions of service-producing entities and goods-producing entities, but also the purpose of making this distinction (Argyris 1999).

Compounding the problems brought on by outsourcing, manufacturing companies began doing what might have been unthinkable a few decades earlier – they began adding service offerings to their revenue mix. From financing to maintenance to help-desks, expensive and complex manufactured products needed more customer service to appeal to customers.

## 2.5 Other Disciplines Join In

Economics was not the only discipline working to adapt their concepts and methods to better recognize the phenomenal growth of the service sector. Many academic disciplines that had grown up at a time dominated by product-producing entities were now seeking to prepare graduates who could solve problems and create innovations for a growing landscape of service-producing entities. Marketing, operations, management, engineering, computing, design, law, as well as social and behavioral sciences to name a few, were all adapting their content to prepare the majority of their students for jobs in the service sector.

Alternative definitions of service have been offered over time and together they could fill a large book (Edvardsson et al. 2005a, b). A sampling to illustrate the variety of ways to define service is presented below:

### 2.5.1 Economics

- Intangible products, unlike the tangible products of agriculture or manufacturing
- An exchange between economic entities that do not transfer ownership, but does grant access to resources and capabilities (access not ownership)
- An economic activity that requires access to customer resources or capabilities (coproduction)
- A transformation that one economic entity performs with the permission of a second entity, that transforms the second entity or a possession of the second entity (transformation)

### 2.5.2 Marketing

- The solution to a customer's problem
- A result customers want
- A customer-provider interaction that creates mutual benefits
- An economic exchange that does not transfer ownership to customers
- Customer benefits that are intangible, heterogeneous, inseparable, perishable
- The application of competence (e.g., resources, skills, capabilities) for the benefit of another entity

### 2.5.3 Operations

- Activities, deeds or processes, interactions that do not produce goods
- A process or performance, rather than a thing
- A production process that requires inputs from a customer entity

### 2.5.4 Computer Science

- A modular capability that can be computationally accessed and composed with others

#### 2.5.5 Systems Engineering

- A system (with inputs, outputs, capacity limits, and performance characteristics) which is interconnected with other systems that may seek to access its capabilities to create benefits, and in which local optimization of the system interactions may not lead to global performance improvements

#### 2.5.6 Design and Psychology

- An experience of a customer entity that results from that customer entity interacting with provider entities' offerings

#### 2.5.7 Service Science

- Value-cocreation phenomena between interacting service system entities

What is common is the notion of entities interacting to achieve outcomes that are mutually agreeable and beneficial. What differs is contrasting the presence of tangible goods with intangible goods, contrasting access to resources with ownership of resources, contrasting implicitly agreeing with explicitly agreeing, contrasting directly interacting with indirectly interacting, etc. However, each discipline seems to focus on some aspect of the entities, interactions, and outcomes, and leaves out parts or add embellishments to suit their own specific disciplinary interests.

### *2.6 Enter Service-Dominant Logic*

Clearly, economics is not alone. Other disciplines are working to adapt their concepts and methods to better recognize the phenomenal growth of the service sector. Over the last 50 years, marketing and operations were also evaluating alternative definitions of service. Courses taught traditional definitions to students, even as researchers pointed out the inadequacies and inconsistency in those definitions (Lovelock and Gummesson 2004). These same authors suggested that a paradigm shift might be necessary to make progress, and address the many anomalies resulting from inadequate definitions of service.

Within the marketing discipline, a view emerged known as service-dominant logic (Vargo and Lusch 2004a, b, 2006). Service-Dominant Logic (SDL) begins by suggesting that Goods-Dominant Logic (GDL) or the concept of product-producing entities as central, normal, and good is in fact exactly backwards. They begin by proposing that all economic interactions are service for service exchanges. Instead of service being intangible products, products are a form of packaged service or tangible service. The knowledge, competencies, and resources of the entity that offers the product are embedded in the product. For example, if a fish is offered, the fish embeds the competency of fishing, say baiting a hook, attaching the hook to a line and pole, knowing where to put the hook in the water, etc. In today's knowledge economy, this explanation resonates well with many people. All exchange is service for service (value-cocreation), because even when a tangible service (product) is part of the exchange, the product embodies the knowledge, competencies, and resources of the provider. Vargo and Lusch acknowledge this view was proposed in the early 1800s by the political economist Bastiat (Bastiat 1850/1979), and suggest Adam Smith's view of service was closely aligned with this view, but because of some misinterpreted examples in Smith's early writing the Goods-Dominant Logic view of service took hold (1776/1904, 1776/2000).

In the SDL view, products exist to make self-service easier, but having another entity provide the service may in fact be preferable. For example, one could use a lawn mower to mow one's lawn, or one could hire a yard service. What matters in the end is a mown lawn; both the lawn mower and the yard service are simply means to an end, or outcome. Levitt also noted that no one really wants a 1/8 in. drill, they want a 1/8 in. hole (Levitt 1972, 1976). The physical product is the means to an end, and the end or outcome is what is valued. The complexity of the means is a cost to achieve the desired outcome.

More recently, Vargo and Lusch argue that the entities capable of service for service exchange should be viewed from a systems perspective (2008a, b). While most of marketing has focused on B2C (Business to Consumer) exchange, they argue that from a systems perspective both the provider and the customer are complex systems, or resource integrators. For example, in one exchange an entity will be the customer, but in the next exchange that same entity may be a provider. B2B (Business to Business) exchange, clearly fits this pattern. In fact, entities are part of vast networks of other entities engaged in service for service exchange, as they apply their knowledge, competencies, and resources to create mutual benefits (Gummesson 1977, 2007).

## *2.7 New Questions*

The majority view that service is intangible product is flawed. The music industry is categorized in the service sector, even though technological advances allow music to be easily recorded, stored, and distributed. The quality of music reproduction can be easily analyzed with today's technology, and precisely measured with the help of the physical sciences. As technological capabilities continue to advance, other supposedly service sector entities or intangible-product producers will be made tangible in a more advanced technological form. In addition, some businesses that are categorized as manufacturing businesses have completed outsourced their design and production to other businesses. They market and sell products (transfer ownership), but they do not contain a single manufacturing process or job in house (e.g, on-line T-shirt companies). The majority view of service as tangible product is flawed and no longer tenable, and yet national statistics still use categories that mischaracterize the in-house competencies of some firms and/or the characteristics of the output of some firms. In short, anomalies exist using the majority view.

If we accept what is still the minority (though rapidly growing) view of SDL that all economic exchange is service for service exchange, and that products are tangible service, then what is service? Service is the application of knowledge, competence, and resources for the benefit of another entity, and national economies and global markets can be viewed as entities engaged in service for service exchange (value-cocreation phenomena). To elevate their productivity, quality, compliance, and innovativeness entities need new knowledge, competencies, and resources. In short, anomalies can be resolved using the minority view.

Adopting the minority view of SDL, service interactions can be seen as service for service exchange, or value-cocreation phenomena between entities. These interactions may involve goods and money, which are viewed as mechanisms of indirect service for service exchange. Goods and money are tangible service (embodiments of past service). This view leads to a new set of questions for service scientists to answer, about the nature of entities, interactions, outcomes, and their dynamics over time:

- What types of entities are capable of service interactions?
- What types of interactions do service system entities engage in?
- What types of outcomes can result when service system entities interact?
- How do the types of entities and interactions change over time?
- How do the spatial distributions of types of entities change over time?
- How do the hierarchical structure and network relationships of entities change over time?
- How do the knowledge, competencies, resources owned and accessed by the entities change over time?

Some progress has been made by the emerging service science community in generating initial answers to these questions (Spohrer and Maglio 2009). However, nothing is settled, and much work remains.

## *2.8 Holistic Service Systems*

Before addressing the second fundamental questions, *where is the science (in service science)?* which is the focus of the next section, it will be useful to further explore one class of service system entities known as holistic service systems (Spohrer and Maglio 2008; Donofrio et al. 2009). These types of systems vary enormously in scale and are very complex, but they also may be entering an era of accelerated innovation, or rapid learning from each other’s best practices.

The types of entities that are capable of service interactions (service for service exchange) vary enormously in scale and structure. Nations, states, cities, hospitals, universities, businesses, non-profits, families, and individual people are capable of service interactions. They apply knowledge, competencies, and resources for the benefit of other entities, and engage in service for service exchange (value-cocreation). For example across nations, the populations can vary from hundreds of thousands (Iceland) to over a billion people (China), with differences in the structures associated with transportation, water, food, energy, communications, buildings, retail, finance, health, education, and governance.

Throughout most of history, farming communities existed as somewhat self-contained entities. Cities, surrounded by a network of smaller farming communities, were also somewhat self-contained. Similarly, for states and nations, throughout much of history they were largely self-contained entities that could exist for many generations with only minimal interactions with outside entities.

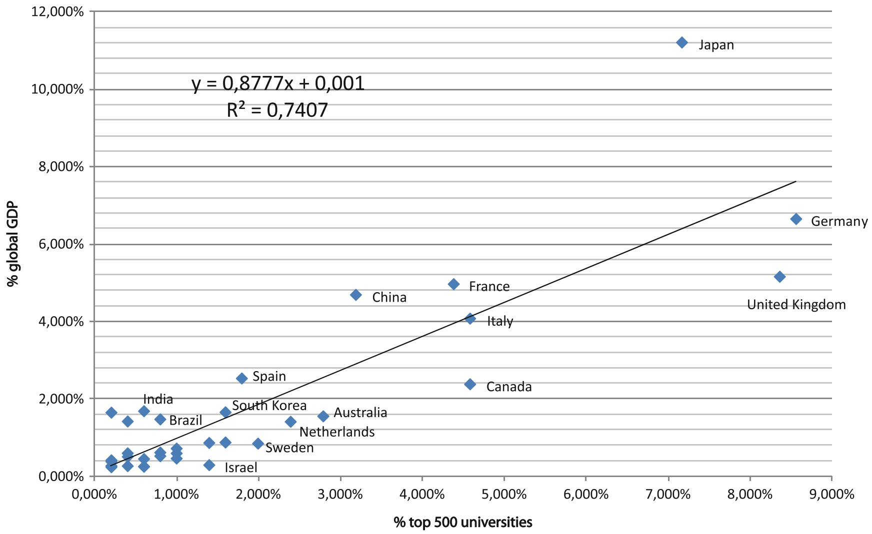
In short, they were (or at least had the potential to be) largely self sufficient. The knowledge, competencies, and resources, they needed to survive were largely contained within their population and local environment. While there are many benefits of being largely self sufficient, nevertheless, because they had minimal interaction with other entities, processes such as learning and sharing innovations, or best practices could be quite slow, and take many generations to jump from one holistic service system to another (Arc et al. 2003; Baumol 2002; Gadrey 2002; Gustafsson and Johnson 2003; Miles 2006, 2008; Pal and Zimmerie 2005; Spath and Fähnrich 2007).

In the interconnected world of today, if a nation, state, or city were to become cutoff from the rest of the world, quality of life would begin to suffer almost immediately. There is a much greater degree of interdependence amount service system entities today than in the past. Quality of life is a function of the quality of service from many systems such as transportation, water, food, energy, communications, buildings, retail, finance, health, education, and governance. In the world of today, quality of life is also a function of the quality of jobs in each of those systems. Furthermore, long-term, quality of life is a function of the quality of investments available to improve those systems year over year, so each generation benefits from a rising standard of living.

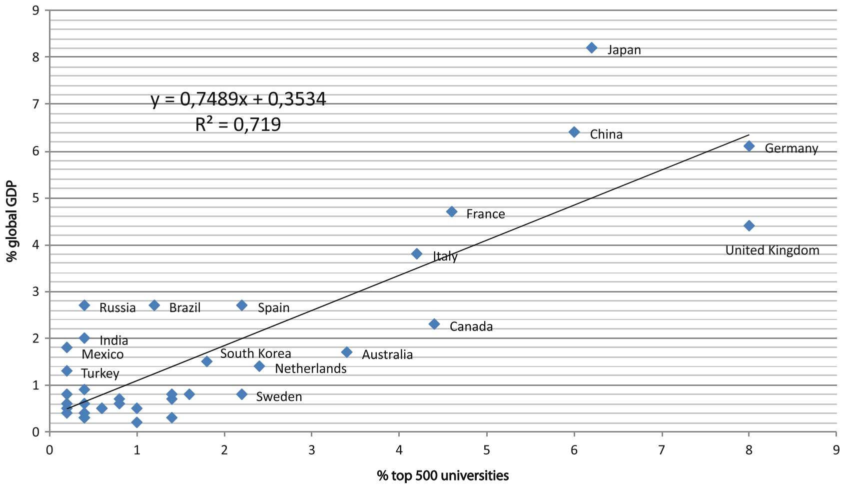
As noted in the introductory section above, the service science community is gradually becoming increasingly focused on the study of holistic service systems, such as cities, universities, hospitals, luxury resort hotels, cruise ships, and the like, that can be described as somewhat self-contained entities that are a complex system of systems.

Holistic service systems can improve by generating innovations on their own or copying the innovations of other holistic service systems. Holistic service systems include (to some degree) all of those sub-systems necessary for quality of life. Therefore, they can potentially benefit from improvements that first arise in another holistic service system.

Could we be entering an era of dramatically accelerated improvement of holistic service systems? There is some data that suggests this may be the case. For example, Fig. 1 below shows the correlation between a nation's percentages of world-wide GDP (Gross Domestic Product) and percentage of top-500-ranked universities. The strong correlation exists over time, and for nations like South Korea and China that have seen rapid GDP growth, there is also a rapid growth in




Correlating Nation's (2004) - % of WW GDP to % of WW Top-Ranked Universities
US is literally "off the chart" – but including US make high correlation even higher:
US % of WW Top-Ranked Universities: 33,865 %; US % of WW GDP: 28,365 %




2004-2009: Relative Change - China (+3,+2), US (–3.5,–5)
US is still "off the chart" – China projected to be "off the chart" in less than 10 years:
US % of WW Top-Ranked Universities: 30,3 %; US % of WW GDP: 23,3 %

**Fig. 1** The correlation between a nation's percentages of world-wide GDP and % of top-500-ranked universities. (Source: http://www.arwu.org/ARWUAnalysis2009.jsp)

top ranked universities. This is likely a case of dual causality, in the sense that improved universities can help boost GDP, and improved GDP can help boost the quality of faculty, facilities, and graduates at the university.

<table>
<tr><th></th><th>2006</th><th>1995</th><th>1984</th><th>Average Growth 1984-2006</th><td rowspan="14">*Includes University hospitals and SLAC (Note: LPCH's 2,037 employees were added 1995 with 2006 data)<br><br>Datasources: All data except Stanford, Kaiser Permanente and Google, are from IT Business Journal. Data for Stanford, Kaiser Permanente and Google are self reported.</td></tr>
<tr><td>Stanford*</td><td>20,452</td><td>16,587</td><td>16,500</td><td>1.0%</td></tr>
<tr><td>Cisco Sys. Inc.</td><td>16,500</td><td>1,023</td><td>n/a</td><td></td></tr>
<tr><td>AT&T Inc.</td><td>15,500</td><td>n/a</td><td>n/a</td><td></td></tr>
<tr><td>Santa Clara County</td><td>15,012</td><td>13,512</td><td>9,600</td><td>2.1%</td></tr>
<tr><td>Kaiser Permanente</td><td>9,845</td><td>n/a</td><td>n/a</td><td></td></tr>
<tr><td>Lockheed Martin</td><td>7,951</td><td>10,200</td><td>21,992</td><td>–4.5%</td></tr>
<tr><td>Oracle Corporation</td><td>7,500</td><td>n/a</td><td>n/a</td><td></td></tr>
<tr><td>City of San Jose</td><td>7,169</td><td>5,218</td><td>4,310</td><td>2.3%</td></tr>
<tr><td>Hewlett-Packard Co.</td><td>7,000</td><td>15,000</td><td>18,033</td><td>–4.2%</td></tr>
<tr><td>IBM</td><td>6,500</td><td>7,000</td><td>13,500</td><td>–3.3%</td></tr>
<tr><td>Intel</td><td>5,700</td><td>5,000</td><td>6,000</td><td>–0.2%</td></tr>
<tr><td>Google</td><td>5,337</td><td>n/a</td><td>n/a</td><td></td></tr>
<tr><td>Applied Materials</td><td>4,156</td><td>5,122</td><td>n/a</td><td></td></tr>
<tr><td colspan="6">Between 1990 and 2008, private payroll employment in the Boston area grew by 10.2 percent; during the same period, employment at private colleges and universities rose by 18.4 percent.</td></tr>
</table>

**Fig. 2** University in the top ten largest employers

Furthermore, Fig. 2 below shows that universities are often in the top ranked 10 employers of a city or urban region, and often in the top 5 if the university includes a medical school and a hospital.

Cities and universities are tightly coupled holistic service systems. To a great degree, they rise and fall together. Changes in one affect the other. Furthermore, it appears we are entering an era, where our understanding of holistic service systems, will enable accelerated improvements, as they learn best practices from each other. Quality of life has the potential to improve consistently generation after generation, including quality of service from multiple systems, quality of jobs in those systems, and quality of investment opportunities based on more predictable change. The service science community is composed of researchers and practitioners working together to better understand service systems and to manage, engineer, and design best practice improvements.

## 3 Where Is the Science?

According to Webster's New Collegiate Dictionary, the definition of science is "knowledge attained through study or practice," or "knowledge covering general truths of the operation of general laws, esp. as obtained and tested through scientific method and concerned with the physical world" or "the organized body of knowledge people have gained using that system". Basically science refers to a system of acquiring knowledge – answering important questions about change and limits. This system uses observation, experimentation, and mathematics to describe, explain, and quantify phenomena. Less formally, the word science often describes any systematic field of study or the knowledge gained from it. What is the purpose of science? Perhaps the most general description is that the purpose of science is to produce useful models of reality.

Our second question (where is the science in service science?) has a current majority view that is based on the traditional economist perspective (prices and productivity) and an emerging minority view that is based on a splinter systems perspective (ecology and quality-of-life). Before describing the current majority view, which argues that service science is a sub-discipline of economics concerned with a particular type of economic production system that does not produce physical output, we briefly mention two other views that are more common than the emerging minority view. One suggests that service science is a misnomer, and that service management, service engineering, and service design are more appropriate terms. Supporters of this view argue that science is about the study of systems as they have evolved naturally, and that the quest for better service innovation is about better design, engineering, and management of service systems, not science (Bolton et al. 2003; Gluhsko and Tabas 2009; Tidd and Hull 2003; Tien and Berg 2003, 2007; UK Royal Society 2009). However, just as mechanical engineering is informed by the physics of mechanics, service engineering (and the others) can be informed by a science of service. In fact, management science, engineering science, design science, and even engineering economics are all important emerging areas of study, not unrelated to service science. So this view is not really arguing against a science of service, as much as it is arguing for the need for an increase in community activities associated with service management, service engineering, and service design.

The second widely held view, that is not the majority view, is the view that service science is in fact a mosaic of many discipline aligned around the better understanding and innovation of service systems – and so many (all?) sciences contribute to service science (Spohrer and Maglio 2009). Figure 3 below shows the service science transdisciplinary framework, and the thirteen vertical columns represent different types of service systems (all part of holistic service systems in one way or another), and each row corresponds to areas of disciplinary knowledge: marketing (behavioral science), operations (management sciences), governance (political science), strategy (game theory and learning sciences), psychology (cognitive science), industrial engineering (system sciences), computer science (information sciences), knowledge management (organization theory and administrative sciences), economics and law (social sciences), and management of innovation (decision sciences). Again, while there is truth in this view, it does not provide a very satisfying answer to the question of where is the science in service science. If service science has core questions, then the science in service science "must" (in the view of the critics) provide clear mathematical principles and laws that are at the core of the science, as well as methods of observation and experimentation that can grow the body of knowledge and provide deeper answers as well as answers to related questions.

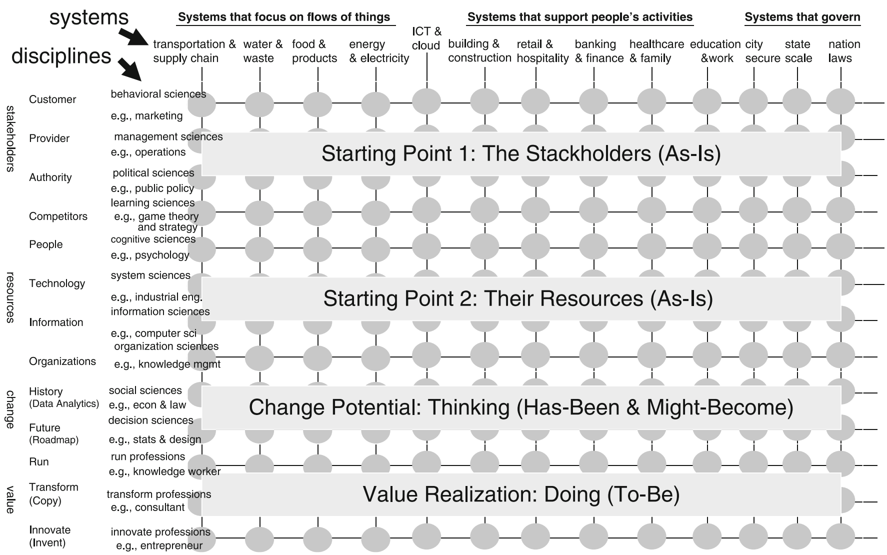



**Fig. 3** Service science transdisciplinary framework. (adapted from Spohrer and Maglio 2009)

Despite the prominence of these two alternative views, the majority view in the service science community is based on traditional economics. Just as the majority view of the definition of service is based on the traditional economics view, the majority view on where is the science is based on a traditional economics view. This majority view starts with a question that economists have answered with a mathematically formal model of interaction of entities. When two service systems interact, how likely is it that there exists a value proposition that, if realized, can co-create value for both of them? In economics, Ricardo's Law (1817/2004) says that the law of comparative advantage refers to the ability of an entity (such as an individual, a firm, or a nation) to produce a particular good or service at a lower opportunity cost than another entity. It is the ability to perform work at the highest *relative* efficiency given all possible work allocations that matters most (Normann 2001; Normann and Ramirez 1993). Nations include many businesses that thrive on a variety of types of exchange, and so if in aggregate two nations have complementary competences (i.e., one does one thing better, and the other does another thing better, and both nations need both competences), then clearly a basis for exchange is established, and each nation does a little more of what they do best, and little less of what they do less well. This is the case of complementary competences. However, what Ricardo was able to show was that under a wide range of circumstances, one nation could have superior competencies in all areas, and there still could be an improvement for both entities through interactions that allocate work loads. Furthermore, since experience or learning curves exist in most activities, the longer one engaged in exchange the more benefit both parties could potentially achieve, as increased frequency of work accelerates learning to do the work more efficiently! (Spohrer and Engelbart 2004).

In fact, Ricardo's Law is the starting point to understand "where is the science in service science." Ricardo's Law tells us that distributing work activities or jobs among entities makes quantifiable mathematical sense especially when variations in capabilities exist, even when one entity can do every type of work better than all other entities. In general, value cocreation (or service) opportunities increase rapidly as the number and diversity of entities and types of entities increase. The science of service science asks important questions about the dynamics of value cocreation across space, time, and scale of entities and types of interactions (see question in Sect. 2.7 above).

However, the science of understanding how diverse populations of entities interact with each other and their environment is not the science of economics; it is in fact the science of ecology. Therefore the rising minority view in the service science community is that service science should not be seen as a sub-discipline of economics, and therefore the social science, but instead be seen as a sub-discipline of ecology (writ large) and therefore more of a general systems science. Given the rapid growth of the service economy globally in the last century, one can reasonably ask should service science be thought of as a specialization of economics or ecology? Both of these established sciences, include the term "eco" meaning household, and not surprisingly families are the first types of holistic service systems, and families often become especially stable households when they settle down in a city, a second type of holistic service systems.

But can we say more about where is the science in service science, besides the study of evolution of entities and their interactions within a service (value cocreation) ecology that expands out from families to cities, with their many households and other service systems? And are the service system structure determined only by Ricardo's law and the efficiency of work allocation among entities across space, time, and scale? Holistic service systems like households and cities are important types of entities, but the study of change and limits associated with service (value cocreation) is not complete without including another more recent holistic service system – the university. The increasing knowledge-intensity of the service economy is accelerated by the rise of global universities as holistic service systems. Universities are like mini-cities. Universities are like big-households. The family-household, university, and city are three important types of holistic service systems and the service science community is increasing its study of these types of entities. It should also be noted that hotels are examples of holistic service systems, and the service operations and service marketing communities have made extensive studies of these entities (Fitzsimmons and Fitzsimmons 2007). What principles and laws, beyond Ricardo's Law, can help service scientists understand the dynamics (change, limits) associated with the evolution of value cocreation?

It is beyond the scope of this paper to go deeper into the successes and challenges of this majority view, which suggests that economics is where the science is in service science. Nevertheless, economists have done a remarkable job including households (e.g, family social interactions (Becker 1991)), law (e.g., economics and law (Posner 1973), and resolutions of Pigou's Example (Pigou 1920, 1932) and Braess's Paradox (Braess 1968; Braess et al. 2005; Roughgarden 2001)), and institutional structure (e.g., transaction costs, governance, and new institutional economics (Williamson 1998)), in terms of economic efficiency arguments, which fit within traditional pricing and productivity reasoning of rational agents. However, the predictive powers of which institutional and organizational forms will arise, and even which business models and value propositions will arise, has not been a strong suit of economics (Engelbart 1962, 1980). While economics provides a powerful analytical view of the history of service system evolution, economics has been less successful predicting future forms of service system entities and the value propositions that connect them.

In addition to the Ricardo's Law, "systems-thinking" is another way of reviving the science in service science (Simon 1945/1997, 1996). Systems thinking is the process of understanding how things – systems – influence one another within a whole. Systems thinking is various elements such as air, water, movement, plant and animals work together to survive or perish in ecosystems (Bertalanffy 1976). In organizations, systems consist of people, structures, and processes that work together to provide value. Service, which can be defined as the application of competence and knowledge to create benefit (or value) for another, derives from the interactions of entities known as service systems. Service science (or sciences of the artificial human-made world) has been described as specialization of systems science (Simon 1996).

Systems sciences are scientific disciplines partly based on systems thinking such as Chaos theory, Complex systems, Control theory, Cybernetics, Sociotechnical systems theory, Systems biology, Systems ecology, Systems psychology and the already mentioned Systems dynamics, Systems engineering and Systems theory.

Basically, we can say that the purpose of service science is to study the establishment of an environment for entities to co-create value with benefits to all. Within this context, in the next section, we introduce universal patterns that can possibly occur when abstract entities (service systems) interact and produce outcomes, or Abstract Entity-Interaction-Outcome Universals (AEIOU Theory). AEIOU Theory is part of the emerging minority view, from a systems and ecology "writ large" perspective, of where is the science in service science.

## 4 AEIOU Theory (Abstract Entity-Interaction-Outcome-Universals)

Where is the science in service science? In the last section, the majority view was introduced with as an economic focus on efficient allocation and distribution of work, guided by the surprising principle of Ricardo's law which factors in the opportunity cost of work, and hence concludes that value propositions can be found between almost all entities, even when one entity does everything better than another. In this section, the emerging minority view is introduced with an ecological focus on sustainability. The emerging principle from this perspective relates to predicting what types of new service system entities are likely to emerge, and suggests a balance exists between productivity and sustainability, between exploitation and exploration (March 1991), and between boredom and challenge (Csíkszentmihályi 1990). Before describing this principle and AEIOU Theory (Abstract-Entity-Interaction-Outcome-Universals), this section first provides an introduction to ecology ("writ large") and suggests that all service scientists should be grounded in this broad view of ecology. The broad view of ecology is not just limited to biology species and environments, but is the science of populations and how they change and limits to growth, and diversity of populations. Ecology ("writ large") is the study of the abundance and distribution of entities in an environment, and how the entities interact with each other and their environment over successive generations of entities (Smith 1986; Begon et al. 2006) (Fig. 4).

Most people think of ecology in terms of living organisms, like plants and animals in a natural environment. However, the concept of ecology is more general and can be applied to entities as diverse as the populations of types of atoms in stars to the types of businesses in a national economy. To relate ecology to service, we must start by thinking broadly about ecologies of entities and their interactions. Eventually, we will get to human-made service system entities and human-made value-cocreation mechanisms… but first, let's really start at the very beginning – the big bang. About 14B years ago (indicated by the top of this purple bar), our universe started with a big bang. And through a process of known as fusion, stars


**Fig. 4** Ecology

turned populations of lighter atoms like hydrogen into heavier atoms like helium, and when stars of a certain size have done all the fusion they could, they would start slowing down, and eventually collapse rapidly, go nova, explode and send heavier atoms out into the universe, and eventually new stars form, and the process repeats over and over, creating stars with different populations of types of atoms, including heavier and heavier elements. So where did our sun and the earth come from…. Eventually after about 10B years in the ecology of stars and atoms within stars, a very important star formed our sun (the yellow on the left) – and there were plenty of iron and nickel atoms swirling about as our sun formed, and began to burn 4.5B years ago, and the Earth formed about 4.3B years ago (the blue on the left)… In less than a billion years, the early earth evolved a remarkable ecology of complex molecules, including amino acids, and after less than a billion years, an ecology of bacteria took hold on early earth (the bright green on the left).

The ecology of single cell bacteria flourished and after another billion years of interactions between the bacteria, the first multi cellular organisms formed, and soon the ecology of sponges (the light blue on the left) and other multi-cellular entities began to spread out across the earth. Then after nearly 2B years, a type of division of labor between the cells in multi cellular organism lead to entities with cells acting as neurons in the first clams (the red on the left), and these neurons allowed the clams to open and close at the right time. After only 200 million years, trilobites appeared the first organisms with dense neural structures that could be called brains appeared (the black on the left), and then after about 300 million years, multi-cellular organisms as complex as bees appeared (the olive on the left), and these were social insects, with division of labor among individuals in a population, with queens, drones, worker bees. So 200 million years ago, over 13B years after the big bang, the ecology of living entities is well established on planet earth, including social entities with brains and division of labor between individuals in a population….

Living in colonies that some have compared to human cities – where thousands of individuals live in close proximity and divide up the work that needs to be done to help the colony survive through many, many generations of individuals that come and go. Bees are still here today. And their wingless cousins, called ants, have taken division of labor to incredible levels of complexity in ant cities in nearly every ecological niche on the planet. Now let's look at the human ecology and the formation of service system entities and value-cocreation mechanisms, a small portion of which is represented by the colored bar on the right.

Recall bees appeared about 200 million years ago, a small but still noticeable fraction of the age of the universe as shown on the bar on the left. Now take 1% of this little olive slice, which is 2 million years… that is how long people have been on earth, just one percent of the little olive slice on the left. What did people do in most of that 2 million years? Basically, they spread out to every corner of the planet, and changed their skin color, eye colors, and hair colors, they spread out and became diverse with many different appearances and languages. It took most of that 200 millions just to spread out and cover most of the planet with people. When there was no more room to spread out the density of people in regions went up…

Now take 1% of that 2 million years of human history which basically involved spreading out to every corner of the planet and becoming more diverse, recall ecology is the study of abundance and distribution and types of interactions, and 1% of that 2 million years is just 20,000 years, and now divide that in half and that represents 10,000 years. The bar on the right represents 10,000 years or just 500 generations of people, if a generation is about 20 years. 500 generations ago humans built the first cities, prior to this there were no cities so the roughly 100M people spread out around the world 0% lived in cities, but about 500 generations ago the first cities formed, and division of labor and human-made service interactions based on division of labor took off – this is our human big bang – the explosion of division of labor in cities.

Cities were the big bang for service scientists, because that is when the diversity of specialized roles and division of labor, which is at the heart of a knowledge-based service economy really begins to take off.... So cities are the first really important type of human-made service system entities for service scientists to study, the people living in the city, the urban dwellers or citizens are both customers of and providers of service to each other, and division of labor is the first really important type of human-made value-cocreation mechanism for service scientists to study. (Note families are a very important type of service system entity, arguably more important than cities and certainly much older – however, family structure is more an evolution of primate family structure – and so in a sense is less of a human-made service system entity and more of an inherited service system entity... however, in the early cities often the trades were handed down father to son, and mother to daughter as early service businesses were often family run enterprises in which the children participated – so families specialized and the family names often reflect those specialization – for example, much later in England we get the family names like smith, mason, taylor, cooper, etc.) These family businesses and the specialization of knowledge was like the first B2B outsourcing, but it was F2F (family to family outsourcing). In patriarchal societies, the head man usually was responsible for holding the knowledge and training the apprentices in the next generation.

So to a service scientist, we are very excited about cities as important types of service system entities, and division of labor as an important type of value-cocreation mechanism, and all this really takes off in a big way just 500 generations ago when the world population was just getting to around 100M people spread out all around the world – so 10,000 years about 1% of the worlds population was living in early versions of cities. It wasn't until 1900 that 10% of the world's then nearly 2B people lived in cities, and just this last decade that 50% of the worlds 6B people lived in cities, and by 2050 75% of the worlds projected 10B population will be urban dwellers. If there is a human-made service system that we need to design right, it is cities. It should be noted that the growth of what economist call the service sector, parallels almost exactly the growth of urban population size and increased division-of-labor opportunities that cities enable – so in a very real sense SERVICE GROWTH IS CITY GROWTH OR URBAN POPULATION GROWTH... in the last decade service jobs passed agriculture jobs for the first time, and urban dwellers passed rural dwellers for the first time.

But we are starting to get ahead of ourselves, let's look at how the human-made ecology of service system entities and value-cocreation mechanisms evolved over the last 10,000 years or 500 generations. The population of artifacts with written language on them takes off about 6,000 years ago or about 300 generations ago (the yellow bar on the right). Expertise with symbols helped certain professions form – and the first computers were people writing and processing symbols – scribes were required, another division of labor – so the service of reading and writing, which had a limited market at first began to emerge to help keep better records. Scribes were in many ways the first computers, writing and reading back symbols – and could remember more and more accurately than anyone else.

Written laws (blue on right) that govern human behavior in cities takes off about 5,000 years ago – and this includes laws about property rights, and punishment for crimes. Shortly thereafter, coins become quite common as the first type of standard monetary and weight measurement system (green on right). So legal and economic infrastructure for future service system entities come along about 5,000 years ago, or 250 generations ago, with perhaps 2% of the population living in cities. . ..

(Historical footnote: Paper money doesn't appear much until around about 1,400 years ago – then called bank notes, so use of coins is significantly older than paper money, and paper money really required banks as service system entities before paper money could succeed.).

About 50 generations ago, we get the emergence of another one of the great types of service system entities – namely universities (light blue line) – students are the customers, as well as the employers that need the students. Universities accelerate the division of labor in cities and the supply and demand for specialized skills, including the research discipline skills needed to deepen bodies of knowledge in particular discipline areas. The red line indicates the population of printing presses taking off in the world, and hence the number of books and newspapers. This was only about 500 years or 25 generations ago. Now university faculty and students could more easily get books, and cities began to expand as the world's population grew, and more cities had universities as well. The black line indicates the beginning of the industrial revolution about 200 years ago or 10 generations ago, the steam engine, railroads, telegraph and proliferation of the next great type of service system entity – the manufacturing businesses that benefited from standard parts, technological advances and scale economies, and required professional managers and engineers. About 100 years ago or just 5 generations ago, universities began adding business schools to keep up with the demand for specialized business management skills, and many new engineering disciplines including civil engineering, mechanical engineering, chemical engineering, and electrical engineering, fuel specialization and division of labor (Donofrio et al., 2009). By 1900, just over 100 years ago, or 5 generations ago, 10% of the world's population, or about 200 million people were living in cities and many of those cities had universities or were starting universities. Again fueling specialization, division of labor and the growth of service as a component of the economy are measured by traditional economists.

Finally, just 60 years ago or 3 generations ago, the electronic semiconductor transistor was developed (indicated by the olive colored line on the right), and the information age took off, and many information intensive service activities could now benefit from computers to improve technology (e.g., accounting) and many other areas.

So to recap, cities are one of the oldest and most important type of service system and universities are an important and old type of service system, as well as many types of businesses. Service science is the study of service system entities, their abundance and distribution, and their interactions. Division of labor is one of the most important types of value cocreation mechanisms, and people often need specialized skills to fill roles in service systems. Service science like ecology studies entities and their interactions over successive generations. New types of human-made service system entities and value-cocreation mechanisms continue to form, like Wikipedia and peer production systems. More complex types of holistic service systems, like nations, states, cities/regions, universities, luxury hotels and cruise ships only arise as sustainable entities, if the atomic service system on which they are based has a certainly level of symbolic reasoning capabilities. While "eco" the household, house, or family relationships are the core holistic service system, the atomic service system is the individual person. As we will see in the remainder of this section, *AEIOU Theory provides a way to begin to rank order the capabilities of entities and the types of interactions they can sustain in network structures.*

In Spohrer and Maglio (2009), the authors suggest that the concept of physical symbol system with the capability of reasoning-about-value "symbolically" may provide a fruitful direction of inquiry, when it comes to understanding the range of resource integrators that can design and improve markets. Using the physical symbol system (PSS) criterion, animals and technology (as generic actors and PSS) have a very crude potential to participate in markets as resource integrators, as they have not yet developed adequate symbolic processes-of-valuing capabilities, nor additional capabilities to model other such entities, to realize that potential to design and improve markets (Newell and Simon 1976). So while animals and computers may someday evolve these capabilities, so far markets are a purely human endeavor. The point is simply that the resource integrators must be able to give symbolic names to resources, and reason symbolically about their value to different entities that are also resource integrators. So animals and computers are not generic actors, in the sense that "it is all B2B" implies.

Of course any integrators/actors or resources require interactions. Usually, there are two types of interactions, relational interactions versus transactional interactions. Giddens (1984a, b) provides the philosophical foundations for reasoning about systems in which entities and interactions co-evolve – each shaping the other. Markets emerge when certain types of routine exchange interactions take hold between actors in a population, and those interactions result in sustainable, mutual benefit outcomes. A systems-oriented framework must also examine the types of interactions and outcomes that are possible. The ISPAR (Interact-Service-Propose-Agree-Realize) model is a one of the first steps in this direction (Maglio et al. 2009), but more is needed. ISPAR generalizes the four possible outcomes of a two player game (e.g., win–win, lose–win, win–lose, lose–lose) to include ten possible outcomes of service system entities. Service system entities are the generic actors of service science (Spohrer et al. 2007; Spohrer and Maglio 2009). ISPAR is an example of generalized interactions and outcomes. AEIOU Theory (Abstract Entity-Interaction-Outcome-Universals) is introduced here as an even more abstract systems-oriented framework than ISPAR that may provide a further fruitful path for exploration in looking for universals associated with resource integration and value co-creation phenomena.

Everyday descriptions of entity-interaction-outcome patterns exist for many domains (see Table 1), but, as we will show, AEIOU theory seeks a more formal and universal framework in which to understand entity, interaction, outcome (E-I-O) patterns.

A bit of groundwork connecting service-dominant (S-D) logic and service science is needed, before explaining the details of AEIOU Theory. First, S-D logic is fundamental to the foundations of service science (Maglio and Spohrer 2008). Figure 5 summarizes the ten foundational concepts of service science. Service science is the specialization of systems science that studies value-cocreation interactions between service system entities (Spohrer and Maglio 2009). Elsewhere, these ten concepts of service science have been connected to the ten foundational premises of S-D logic (Service is the fundamental basis of exchange, Indirect exchange masks the fundamental basis of exchange, Goods are distribution mechanisms for service provision, Operant resources are the fundamental source of competitive advantage, All economies are service economies, The customer is always

**Table 1** Everyday descriptions of E-I-O patterns for multiple domains

| Domain | Entities | Pattern |
|---|---|---|
| Physics | Atoms | Fission, fusion, reactions |
| Physics | celestial bodies | Orbit, collide, sling shot |
| Chemistry | Molecules | Equilibrium, reactions |
| Biology | Organisms | Mutualism, consumption |
| Business | Firms | Exchange, divest, merge |
| Government | Nations | Trade, dissolution, annex |

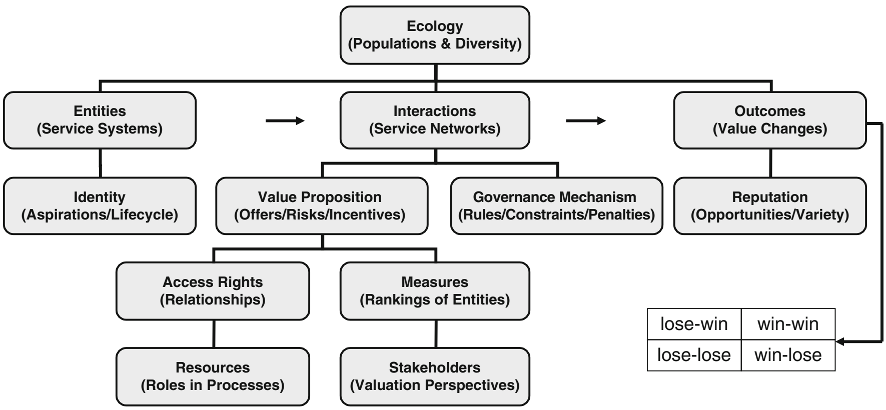



**Fig. 5** Ten foundational concepts of service science (Adapted from Spohrer and Maglio 2009)

**Table 2** Six questions that AEIOU theory need to answer

| Question | Description |
|---|---|
| 1. Does the entity still exist after the interaction? | Some interactions do or do not preserve (conserve) entities. |
| 2. Does the interaction giver rise to new entities? | Some interactions do or do not give rise to new entities. |
| 3. Does the interaction change the state of the entities? | Some interactions do or do not change an entity's state. |
| 4. Does the state change include a record of the interaction? | Some entities can and some cannot record interaction histories. |
| 5. Does the state change include a process-of-valuing the outcome? | Some entities can and some cannot estimate value of outcomes. |
| 6. Does the state change include the result of simulating other entities? | Some entities can and some cannot simulate other entities valuing. |

a co-creator of value, The enterprise cannot deliver value, but only offer value propositions, A service-centered view is inherently customer oriented and relational, All economic and social actors are resource integrators, Value is always uniquely and phenomenological determined by the beneficiary) (Lusch and Vargo 2006; Lusch et al. 2008, 2010; Vargo and Lusch 2004a, b). The main concept is that of an *ecology* of entities interacting. The term ecology is preferred over ecosystem to emphasize that population of entities come and go, but the diversity of populations is one measure of the health of the ecology. In fact, we propose that *a service system ecology is a suitable generalization of a market from a systems perspective*.

AEIOU Theory proposes a sequence of binary conditions that can be used to connect generalized systems science to service science and S-D logic. The binary conditions describe the outcomes and capabilities of abstracted entities (Vargo and Lusch's generic actors) when they interact. For example, the first condition is: Does the entity still exist after the interaction? Table 2 summarizes the six conditions that are necessary to achieve entities with value co-creation interaction capabilities that can also design and improve markets.

## 5 Produce-Distribute-Consume Model

AEIOU Theory could also be called the create-transport-destroy model, or the begin-change-end model, or the input-process-output model. As an example of a more formal framework, Table 3 is one such formalization devised by Betancourt and Gautschi (2001) for the analysis of service institutions based on three primitive economic activities (production-distribution-consumption) that can occur jointly or separately in time and space.

In their conceptual model, Betancourt and Gautschi (2001), they constructed the table based on time and space. On each dimension, they identify five different combinations of these three primitive economic activities (production, distribution,

**Table 3** A tableau of primitive economic activities (adapted from Betancourt and Gautschi (2001))

| Production, Distribution, Consumption: Jointness { } and Separation I | | Time | | | | |
|---|---|---|---|---|---|---|
| | | {P,D,C} | DI{P,C} | CI{P,D} | PI{C,D} | PIDIC |
| Space | {P,D,C} | 1 | 2 | 3 | 4 | 5 |
| | DI{P,C} | 6 | 7 | 8 | 9 | 10 |
| | CI{P,D} | 11 | 12 | 13 | 14 | 15 |
| | PI{C,D} | 16 | 17 | 18 | 19 | 20 |
| | PIDIC | 21 | 22 | 23 | 24 | 25 |

and consumption), depending on whether they are carried out jointly or separately with one another in each dimension. The table includes two cases: joint-ness in time and space of production, distribution, and consumption, and separation in time and space of production, distribution, and consumption. They identify twenty five configurations of the primitive economic activities. They define that all economic agents (producers, distributors and consumers) have production functions. The boundary between production and distribution is determined in any context by the consumption. The output of a production is intended to fulfill a consumption of customer; the output of a distribution activity is intended to permit such fulfillment. The conceptual distinction of the primitives and the ordered connections between them implies the imposition of certain relational constraints. These relational constraints, for example, restrict how a commodity can be consumed and, consequently, have the welfare enhancing effect of reducing uncertainty with respect to the feasibility of alternative consumption procedures.

Interactions between these economic agents can be spread out across scale as well as space and time – sort of up and down hierarchically more complex systems – like people inside departments inside businesses inside nations, etc. – all different scale entities. We propose the Abstract Entity-Interaction-Outcomes (AEIOU) theory to discuss the science of service systems.

Recent research suggests that inseparability is not a universal distinguishing characteristic of services and that the consumption of many services is or can be separated from their production. The AEIOU theory defines service separation as customers' absence from service production, which denotes the spatial separation between service production and consumption. We assume that service separation increases customers' perceptions of not only access convenience and benefit convenience but also performance risk and psychological risk. Furthermore, these effects differ across services. Specifically, relative to experience services, for credence services, the effects of separation on service convenience are mitigated, and the effects on perceived risk are magnified. Subsequently, the convenience and risk perceptions induced by service separation can influence customers' purchase decisions and post-experience evaluations. Customers prefer separation for experience services and when they have an established relationship with the service provider.

In "Sciences of the Artificial," Simon (1996) embarked on an inquiry not unlike service science. As natural sciences explain the origin and evolution of natural things, so sciences of the artificial explain the origin and evolution of artificial things. Artificial things are designed by humans to serve a human purpose. Value cocreation is an example of a general human purpose. If interactions are costly but necessary, and they are, then value cocreation is a logical purpose, which when achieved can grow and sustain interactions. In this sense, value cocreation is autocatalytic and self reinforcing (Bardhan et al. 2010). More simply, value cocreation is the type of human purpose that can amplify itself. Service science is value cocreation science, and studies service system entities and their interaction mechanisms, both value-proposition-based and governance-mechanism-based according to the AEIOU theory.

We claim the human purpose of science is to understand ultimately how things change, and thereby better understand where we came from (satisfy curiosity) and where we can go (create opportunity). Because we are aware of the world and our lack of knowledge limits our ability to shape both own individual destiny as well as the destiny of others, we humans have developed science as a tool with a purpose. Therefore, we might propose that the purpose of science is for the human population to gain and apply knowledge to benefit ourselves and others. Given this proposed purpose of science, how can we better understand the type of science that service science is seeking to become? For example, how are we to understand abstract entities (service systems), interactions (value cocreation mechanisms) and outcomes in the service ecology?

## 6 Concluding Remarks

Change happens for a reason. Mechanisms underlie all events, and all change. Scientists work to identify and validate symbolic representations of mechanisms. For example, "F=MA" and "E=MC2" are two well-known, beautifully concise, symbolic representations that reflect underlying mechanisms of change in the world. If change is predictable (by humans), it is because the mechanisms are stable. From a service science perspective, the human-made world arose from the physical-chemical-biological-social world when people began to trust and depend on service (value cocreation) mechanisms (e.g., division of labor) the way they trust and depend on natural mechanisms (e.g., this tree will bear fruit next season). Of course, a tree bearing fruit does not require trust to operate, but division of labor does. Nevertheless, our point is a simple one: *service science seeks to be a science based on reliable mechanisms*, just as natural science is based on reliable mechanisms. From a human perspective, sometimes natural mechanisms (seemingly) fail to act reliably. This may be because assumptions are invalid, or other mechanisms are at work (e.g., a plane would fall from the sky, if not for Bernoulli's principle). The same is true of service (value cocreation) mechanisms. If assumptions are invalid or other mechanisms are at work, then predictions may not be reliable. For example, when a computer program does not operate as predicted, we know it is because of invalid assumptions or other mechanisms at work. Science works to discover mechanisms, and to expose invalid assumptions and other mechanisms at work.

In the human-made world of service system entities interacting, trust is an important input to ensure mechanisms (value propositions) work as agreed. When value propositions fail, trust begins to diminish. Restoring trust between entities can be difficult. As outlined in AEIOU Theory, entities must have internal mechanisms that allow them to model other entities and evaluate value propositions proposed by those other entities. Service system entities are a type of physical symbol system, and that level of entity is required to model other entities, evaluate value propositions, and factor in levels of trust (Spohrer and Maglio 2009).

For service science to graduate to the level of the natural sciences, new representation languages are needed to express valid symbolic representations of mechanisms. In general, the systems sciences that study complex systems and networks struggle with this challenge. Much of economics and ecology still depend on differential equations to model the quantitative interactions. The system sciences, economics, ecology, and now service science must work to identify and validate symbolic representations of mechanisms far more complex that can be adequately captured even with a system of differential equations. Much fundamental work in mathematical representations of systems and networks remains to be done to enable the service science community to identify and validate symbolic representations of mechanisms.

However, before those valid symbolic representations of mechanisms can be identified, service science needs to establish a community of researchers who agree on a common set of concept and a world view that allows them to ensure they are talking about the same set of entities, interactions, and outcomes. This has been one of the main contributions of the service science community to date. Vargo and Lusch have provided a framework that allows all interactions to be seen as service for service exchange (2007, 2008, 2008a, b, 2009). Gummesson has provided a framework that allows very practical everyday experiences to be seen as networks of interacting service system entities (Gummesson 2007). Bitner and colleagues have developed Service Blueprinting as a framework for modeling many of the service interactions people engage in everyday (Bitner 1995; Bitner and Brown 2006). Maglio et al. (2009) have provided a framework for understanding the possible outcomes when service system entities interact, both service and non-service interactions. Rust and colleagues have provided frameworks for understanding the life-time value of customers, as well as interactions of investments in productivity and quality over the life-time of provider entities in competitive environments (Rust 2004; Rust et al. 2000). Ng and colleagues have provided a framework for understanding and managing for outcomes. Spohrer and Maglio (2008, 2009) have summarized the foundational concepts, as well as the four fundamental types of resources, access rights, stakeholders, and measures associated with service system entities interacting via value propositions and governance mechanisms. March (1991), Csíkszentmihályi (1990), as well as Spohrer and Maglio (2008, 2009) have provided frameworks for how organizations

(Exploitation and Exploration), individuals (Flow, balancing Boredom and Challenge), and service system entities (Run-Transform-Innovate Investments) change over time. All of these and many more of the contributions of the service science community to date are summarized in the Handbook of Service Science (Maglio et al. 2010). In addition, Demirkan and his colleagues provided frameworks to evaluate the impact of service orientation, as well as coordination mechanisms for service oriented supply chain mechanisms, and defined research priorities for the Science of Service (Demirkan and Goul 2008; Demirkan and Spohrer 2010; Demirkan et al. 2010; Harmon and Demirkan 2011; Ostrom et al. 2010).

While the work in mathematics is probably the most fundamental work that needs progress in order to accelerate advancements in service science, the ability to model hierarchical networks of some ten billion service system entities with computational tools (e.g., Computer-Aided Design or CAD tools) is also currently lacking. Real progress in answering the second question "Where is the science in service science?" will depend on progress in these two areas, mathematics and computer modeling. However, we should not under value the decades of empirical studies of the service research community, nor the pioneering works in these two volumes by the growing service science community, gradually aligning around common language and definition of terms. The foundations being put in place today by the service science community are fundamental in nature. Though much work remains ahead, and nothing is settled.

## References

Alter, S. (2008a). *Service system fundamentals: Work system, value chain, and life cycle*. IBM Systems Journal, 47, 71–85.

Alter, S. (2008b). *Service System Innovation. In Information Technology in the Service Economy: Challenges and Possibilities for the 21st Century*. In: M. Barrett, E. Davidson, C. Middleton, J.I. DeGross (eds.) IFIP International Federation for Information Processing. Springer: Boston. Pp. 61–80.

Anderson, J.C., Kumar, N. and Narus, J. A. (2007). *Value Merchants: Demonstrating and Documenting Superior Value in Business Markets*. Cambridge, MA: Harvard Business School.

Argyris, C. (1999). *On Organizational Learning*. Oxford, England: Blackwell.

Ark, B. van, Broersma, L. and den Hertog, P. (2003). *Services Innovation, Performance and Policy: A Review*, Research Series No. 6, Strategy, Research & International Co-operation Department, Ministry of Economic Affairs, The Hague.

Bardhan, I., Demirkan, H., Kannan, P.K., Kauffman, R. J. and Sougstad, R. (2010). An interdisciplinary perspective on IT services management and services science. *Journal of Management Information Systems*, 26(4), 13–65.

Bastiat, F. (1850/1979). *Economic Harmonies. The Foundation for Economics Education*. NY: Irvington-on-Hudson.

Baumol, W.J. (2002). *Services as Leaders and the Leader of the Services* (Chapter 7). In: Jean Gadrey and Faïz Gallouj (Eds) *Productivity, Innovation and Knowledge in Services: New*

*Economic & Socio-Economic Approaches*, Cheltenham, United Kingdom and Northampton, Massachusetts: Edward Elgar, pp. 147–163.

Becker, G.S. (1991). *A Treatise on the Family*. Cambridge, MA: Harvard University, ISBN 0-674-90698-5

Begon, M., Townsend, C.R. and Harper, J.L. (2006). *Ecology: From Individuals to Ecosystems*. United Kingdom: Blackwell.

Bertalanffy, L. (1976*). General System Theory: Foundations, Development, Applications*. New York: George Braziller.

Betancourt, R. and Gautschi, D. (2001). *Product innovation in services: A framework for analysis*. Book Series: Advances in Applied Microeconomics, 10, 155–183.

Bitner, M.J. (1995). Building service relationships: It's all about promises. *Journal of the Academy of Marketing Science*, 23 (Fall), 246–251.

Bitner, M.J. and Brown, S.W. (2006). The evolution and discovery of services science in business schools. *Communications of the ACM*, 49(7), 73–78.

Blomberg, J. (2008). Negotiating meaning of shared information in service system encounters. *European Management Journal,* 26, 213–222.

Bolton, R.N., Smith, A.K., Wagner, J. (2003). Striking the right balance: Designing service to enhance business-to-business relationships. *Journal of Service Research*, 5(4), 271–291.

Braess, D. (1968). Über ein Paradoxon aus der Verkehrsplanung. Unternehmensforschung 12, 258–268.

Braess, D., Nagurney, A. and Wakolbinger, T. (2005). Translation of the Braess 1968 article from German to English appears as the article "On a paradox of traffic planning". *The journal Transportation Science*, volume 39, pp. 446–450.

Chase, R.B. (1978). Where does the customer fit in a service operation? *Harvard Business Review,* 56, 137–142.

Chase, R.B. (1981). The customer contact approach to services: Theoretical bases and practical extensions. *Operations Research*, 29(4), 698–706, Operations Management (Jul–Aug).

Chase, R.B. and Dasu, S. (2001). Want to perfect your company's service? Use behavioral science. *Harvard Business Review*, 79(6), 78–84.

Chesbrough, H. and Spohrer, J. (2006). A research manifesto for services science. *Communications of the ACM*, 49(7), 35–40, July.

Csíkszentmihályi, M. (1990). *Flow: The Psychology of Optimal Experience*. New York: Harper and Row.

Demirkan, H. and Goul, M. (2006). Towards the service-oriented enterprise vision: Bridging industry and academics. *Communications of the AIS*, 18(26), 546–556.

Demirkan, H. and Goul, M. (2008). Process and services fusion impact assessment: SSME findings from industry collaboration and the need for competency centers. In B. Hefley and W. Murphy (eds.), *Service Science, Management and Engineering: Education for the 21st Century*, New York: Springer, pp. 257–262.

Demirkan, H. and Spohrer, J.C. (2010). Servitized enterprises for distributed collaborative commerce, *International Journal of Service Science, Management, Engineering and Technology,* 1(1), 68–81.

Demirkan, H., Cheng, H.K. and Bandyopadhyay, S. (2010). Coordination strategies in a SaaS supply chain. *Journal of Management Information Systems*, 26(4), 121–146, Spring 2010.

Demirkan, H., Kauffman, R.J., Vayghan, J., Fill, H.G., Karagiannis, D. and Maglio, P.P. (2008). Service-oriented technology and management: Perspectives on research and practice for the coming decade. *Electronic Commerce Research and Applications*, 7 (4), 356–376.

Demirkan, H., Soper, D. and Goul, M. (2005). Service-level agreement negotiation: a theory-based exploratory study as a starting point for identifying negotiation support system requirements. In R. Sprague (ed.), *Proceedings of the 38th Hawaii International Conference on Systems Science*, Los Alamitos, CA: IEEE Computer Society.

Donofrio, N., Sanchez, C. and Spohrer, J. (2009). *Collaborative Innovation and Service Systems: Implications for Institutions and Disciplines, in "Holistic Engineering"*, Edited by Domenico Grasso.

Edvardsson, B., Enquist, B. and Johnston, R. (2005a). Cocreating customer value through hyper-reality in the prepurchase service experience. *Journal of Service Research*, 8(2), 149–161.

Edvardsson, B., Gustafsson, A. and Roos, I. (2005b). Service portraits in service research: A critical. *International Journal of Service Industry Management*, 16(1), 107–121.

Engelbart, D.C. (1962). *Augmenting Human Intellect: A Conceptual Framework*. Summary Report AFOSR-3223 under Contract AF 49(638)-1024, SRI Project 3578 for Air Force Office of Scientific Research, Stanford Research Institute, Menlo Park, CA, October 1962.

Engelbart, D.C. (1980). Evolving the Organization of the Future: A Point of View, *Proceedings of the Stanford International Symposium on Office Automation*, March 23–25, 1980.

Fitzsimmons, J.A. and Fitzsimmons, M.J. (2007). *Service Management: Operations, Strategy, Information Technology,* Sixth edition. McGrawNew York, NY: -Hill Irwin.

Fuchs, V.R. (1968). The Service Economy. *National Bureau of Economic Research*. Number 87, General Series. Distributed by Columbia University Press. New York, NY.

Gadrey, J. (2002). The misuse of productivity concepts in services: Lessons from a comparison between France and the United States, in J. Gadrey, and F. Gallouj, (Eds). *Productivity, Innovation and Knowledge in Services: New Economic and Socio-Economic Approaches*. Cheltenham, UK: Edward Elgar.

Giddens A. (1984a). *The Constitution of Society: Outline of a Theory of Structuration*. Berkeley: University of California.

Giddens, A. (1984b). *The Constitution of Society*. Berkeley: University of California.

Gluhsko, R.J. and Tabas, L. (2009). Designing service systems by bridging the "front stage" and "back stage." Information Systems and E-Business Management, 7, 407–427.

Gummesson, E. (1977). *The Marketing and Purchasing of Professional Services*. Stockholm: Marketing Technology Center.

Gummesson, E. (2007). Exit Services marketing – Enter service marketing. *Journal of Consumer Behaviour*, 6(2), 113–141.

Gustafsson, A. and Johnson, M.D. (2003). *Competing in a Service Economy: How to Create Competitive Advantage Through Service Development and Innovation.* San Francisco, CA: Wiley/Jossey-Bass.

Harmon, R. and Demirkan, H. (2011). IT Services Innovation: The Next Wave of Sustainable IT? *IEEE IT Professional on Green IT*, 19–25, Jan/Feb.

Hefley, B. and Murphy, W. (2008). *Service Science, Management and Engineering: Education for the 21st Century.* New York: Springer.

Heskett, J.L. (1987). Lessons in the service sector. *Harvard Business Review*, 65, 118–126.

Heskett, J.L., Sasser, Jr., W E. and Hart, C. (1990). *Service Breakthroughs: Changing the Rules of the Game*. New York: Free.

Heskett, J.L., Jones, T.O., Loveman, G.O., Sasser, W.E. and Schlesinger, L.A. (1994). Putting the service profit chain to work. *Harvard Business Review*, 72, 164–174.

Heskett, J., Sasser, W.E., Jr. and Schlesinger, L. (1997a). *The Service Profit Chain: How Leading Companies Link Profit and Growth to Loyalty, Satisfaction, and Value*. New York: Free.

Heskett, J.L., Sasser Jr., W.E., and Schlesinger, L.A. (1997b). *The Service Profit Chain*. New York, NY: Free.

Hill, T.P. (1977). *On goods and services.* Review of Income and Wealth, 23(4), 314–339.

IBM (2004). Services science: A new academic discipline. Report, http://domino.research.ibm.com/comm/www_fs.nsf/ images/fsr/$FILE/summit_report.pdf

IBM (2009). *Smarter Planet Initiative*. URL: http://www.ibm.com/think

IfM & IBM. (2008). *Succeeding Through Service Innovation: A Service Perspective for Education, Research, Business and Government*. Cambridge, UK: University of Cambridge Institute for Manufacturing. ISBN: 978-1-902546-65-0

Levitt, T. (1976). The industrialization of service. *Harvard Business Review*, 54(5), 63–74.

Levitt, T., (1972). Production-line approach to services. *Harvard Business Review*, September–October, 41–52.

Lovelock, C. and Gummesson, E. (2004). Whither services marketing? In search of a new paradigm and fresh perspectives. *Journal of Service Research*, 7(1), 20–41.

Lusch, R.F. and Vargo, S.L. (2006). *The Service-Dominant Logic of Marketing: Dialog, Debate and Directions.* Armonk, NY: M.E. Sharpe.

Lusch, R., Vargo, S.L. and Wessels, G. (2008). Toward a conceptual foundation for service science: Contributions from service-dominant logic. *IBM Systems Journal*, 47(1), 5–14.

Lusch, R., Vargo, S.L. and Tanniru, M. (2010). Service, value networks and learning. *Journal of the Academy of Marketing Science,* 38(1), 19–31.

Maglio, P.P. and Spohrer, J. (2008). Fundamentals of service science. *Journal of the Academy of Marketing Science*, 36(1), 18–20.

Maglio, P.P., Srinivasan, S., Kreulen, J. T. and Spohrer, J. (2006). Service systems, service scientists, SSME, and innovation. *Communications of the ACM*, 49(7), 81–85.

Maglio, P.P., Vargo, S.L., Caswell, N. and Spohrer, J. (2009). The service system is the basic abstraction of service science. *Information Systems and e-business Management*, 7, 395–406.

Maglio, P.P., Kieliszewski, C.A. and Spohrer, J.C. (2010). *Handbook of Service Science.* New York, NY: Springer.

Mandelbaum, A. and Zeltyn, S (2008). Service Engineering of Call Centers: Research, Teaching, and Practice. In: Bill Hefley and Wendy Murphy, (Eds). *Service Science, Management, and Engineering: Education for the 21st Century*. New York, NY: Springer.

March, J.G. (1991). Exploration and exploitation in organizational learning. *Organization Science*, 2(1), 71–87.

Miles, I. (2006). Innovation in Services. In: Fagerberg J, Mowery DC, Nelson RR (Eds) *The Oxford Handbook of Innovation*. Oxford, UK: Oxford University.

Miles, I. (2008). Patterns of innovation in service industries. *IBM Systems Journal*, 47(1), 115–128.

Newell, A. and Simon, H.A. (1976). Computer science as empirical inquiry: symbols and search, *Communications of the ACM*, 19, 113–126.

Normann, R. (2001). *Reframing Business: When the Map Changes the Landscape*. Chichester, New Sussex: Wiley.

Normann, R. and Ramirez, R. (1993). From value chain to value constellation: Designing interactive strategy. *Harvard Business Review*, 71(4), 65–77.

Ostrom, A.L., Bitner, M.J., Brown, S.W., Burkhard, K.A., Goul, M., Smith-Daniels, V., Demirkan, H. and Rabinovich, E. (2010). Moving forward and making a difference: Research priorities for the science of service. *Journal of Service Research*, 13(1), 4–36, February.

Pal, N. and Zimmerie R. (2005). *Service innovation: A framework for success*. eBRC White Paper, The Penn State eBusiness Research Center, SMEAL College of Business, Pennsylvania State University, University Park, PA.

Parasuraman, A., Zeithaml, V.A. and Berry, L.L. (1985). A conceptual model of service quality and its implications for future research. *Journal of Marketing*, 49, 41–50.

Parasuraman A., Berry, L.L. and Zeithaml, V.A. (1990). *Understanding Measuring and Improving Service Quality: Findings from a Multiphase Research Program*. New York: Free.

Pigou, A.C. (1920). *Economics of Welfare*, 1st edition. London: Macmillan.

Pigou, A.C. (1932). *Economics of Welfare,* 4th edition. London: Macmillan.

Posner, R.A. (1973). *Economic Analysis of Law*, New York: Little, Brown and Co.

Rai, A. and Sambamurthy, V. (2006). Editorial notes: The growth of interest in services management: Opportunities for Information system scholars. *Information Systems Research*, 17(4), 327–331, December.

Ricardo, D. (1817). *The Principles of Political Economy and Taxation*. Mineola, NY: Dover.

Roth, A.V. and Menor, L.J. (2003). Insights into service operations management: A research agenda. *POMS*, 12(2), 145–164, Summer.

Roughgarden, T. (2001). Designing Networks for Selfish Users is Hard, *the Proceedings of the 42nd Annual IEEE Symposium on Foundations of Computer Science,* October 2001.

Rust, R.T. (2004). A call for a wider range of service research. *Journal of Service Research*, 6, 211.
Rust, R.T., Zeithaml, V.A. and Lemon, K.N. (2000). *Driving Customer Equity : How Customer Lifetime Value is Reshaping Corporate Strategy*. New York: Free.
Sen, A. (1999). *Development as Freedom*, Oxford: Oxford University.
Sen, A. (2001). Economic development and capability expansion in historical perspective. *Pacific Economic Review*, 6(2), 179–191.
Simon, H.A. (1996). *Sciences of the Artificial. 3rd Edition*. Cambridge, Mass: MIT.
Simon, H.A. (1945/1997). *Administrative Behavior: A Study of Decision-Making Processes in Administrative Organizations*. New York, NY: Free.
Smith, A. (1776/1904). *An Inquiry into the Nature and Causes of the Wealth of Nations*. London, UK: W. Strahan and T. Cadell.
Simons, A. (1776/2000). *The Wealth of Nations*. New York: The Modern Library.
Smith, R.H. (1986). *Ecology writ large,* Nature 319, 809.
Spath, D. and Fähnrich, K.P. (2007). *Advances in Services Innovations*. Berlin: Springer.
Spohrer, J. (1999). Information in places. *IBM Systems Journal*, 38(4), 602–628.
Spohrer, J.C. and Engelbart, D.C. (2004). Converging technologies for enhancing human performance: Science and business perspectives. *Annals of the New York Academy of Sciences,* 1013, 50–82.
Spohrer, J. and Riecken, D. (2006). Special issue: Services science. *Communications of the ACM*, 49(7), 30–87, July.
Spohrer, J. and Maglio, P.P. (2008). The emergence of service science: Toward systematic service innovations to accelerate co-creation of value. *Production and Operations Management*, 17, 1–9.
Spohrer, J. and Maglio, P.P. (2009). Service science: Toward a smarter planet. In W. Karwowski and G. Salvendy (Eds.), *Introduction to Service Engineering*. New York: Wiley.
Spohrer, J., Maglio, P.P., Bailey, J. and Gruhl, D. (2007). Steps toward a science of service systems. *Computer*, 40, 71–77.
Tidd, J. and Hull, F.M. (2003). *Service Innovation: Organizational Responses to Technological Opportunities and Market Imperatives*. London: World Scientific.
Tien, J.M. and Berg, D. (2003). A case for service systems engineering. *The Journal of Systems Science and Systems Engineering*, 12(1), 113–128.
Tien, J.M. and Berg, D. (2007). A calculus for services innovation. *J Sys Sci Syst Eng* (June), 16(2), 129–165.
UK Royal Society (2009). *Hidden wealth: the contribution of science to service sector innovation*. RS Policy document 09/09. RS1496.
Vargo, S.L. (2007). On a theory of markets and marketing: From positively normative to normatively positive. *Australasian Marketing Journal*, 15(1), 53–60
Vargo, S.L. (2009). Toward a transcending conceptualization of relationship: A service-dominant logic perspective. *The Journal of Business and Industrial Marketing,* 24(5–6), 373–379.
Vargo, S.L. and Lusch, R.F. (2004a). Evolving to a new dominant logic for marketing. *Journal of Marketing*, 68(1), 1–17.
Vargo, S.L. and Lusch, R.F. (2004b). The four service marketing myths – Remnants of a goods-based, manufacturing model. *Journal of Service Research*, 6(4), 324–335.
Vargo, S.L. and Lusch, R.F. (2006). Service-Dominant Logic: What It Is, What It Is Not, What It Might Be. in, R. F. Lusch and S. L. Vargo (eds) *The Service-Dominant Logic of Marketing: Dialog, Debate, and Directions*, M.E. Sharpe, Armonk, NY.
Vargo, S.L. and Lusch, R.F. (2008a). Service-dominant logic: Continuing the evolution. *Journal of the Academy of Marketing Science*, 36(1), 1–10.
Vargo, S.L. and Lusch, R.F. (2008b). From goods to service(s): Divergences and convergences of logics. *Industrial Marketing Management*, 37(3), 254–259.
Vargo, S.L., Maglio, P.P. and Akaka, M.A. (2008). On value and value co-creation: A service systems and service logic perspective. *European Management Journal*, 26(3), 145–152.
Williamson, O.E. (1998). *The Economics Institution of Capitalism: Firms, Markets, Relational Contracting*. New York: Free, Young.