Executive Summary

Workshop to Develop a Research Agenda for Service Innovation

Paul P. Maglio, UC Merced

Stephen K. Kwan, San José State University

Jim Spohrer, IBM

The workshop brought together thought leaders from a variety of disciplines to outline an agenda for scientific and engineering research in service innovation. Solving service problems has enormous practical consequences for the economy and society because (a) more than 80% of jobs in the U.S. are in the service sector, with most Science Technology Engineering and Mathematics (STEM) graduates working in the service sector; (b) many complex service problems resist traditional optimization solutions; (c) private investment in platform technologies that underlie business and societal service innovations (smart service systems) are on the rise; and (d) the U.S. lags in public investment in service research behind countries such as Japan, China, Finland, and Germany. The search for service innovation requires new theories and new methods to address problems unique to services, and what little students are being taught about the service sector has not kept up with the rapid growth of STEM jobs in service or with modern entrepreneurial opportunities. Effective understanding of complex human-centered service systems requires a new approach that combines multiple methods, for example, drawing from industrial engineering and operations research, social and behavioral sciences, information systems, and computer science and computational modeling.

Participants at the workshop discussed specifically the need to create a research agenda focused on *Human-Centered Service Systems* (HCSS), configurations of people, information, organizations, and technologies that operate together for mutual benefit. HCSSs can be distinguished from other types of sociotechnical systems in that they depend critically on sharing capabilities among distinct economic entities to create value. HCSSs include family households, apartment complexes, online social media platforms, global non-profit social enterprises and aid organizations, hotels, hospitals, shopping malls, office complexes, schools, universities, airports, and cities. All exhibit complex behaviors because of the human element, especially during emergency-response situations and other rare events. All contribute to startup ecosystems vitality, from homes (e.g., how many startups began in a garage?) to cities (e.g., regional economic development and innovation zones). The performance of HCSSs depend not only on shared information, individual skills of people, infrastructure technologies, organizations and institutions policies and rules, but also on interactions and independent behaviors, which together have emergent properties. In HCSSs, all actions and interactions cannot be anticipated. Complex HCSSs exhibit interactions resulting from well-scripted design processes, as well as ad hoc, creative, evolved processes that may become standard operating procedures if they generate mutual value. HCSSs should also operate effectively under extreme conditions and extreme events, such as the effect of Hurricane Sandy in New York, or denial of service attacks on business and government online services. HCSSs are important but understudied. We do not

even have the most basic understanding of them, including what kinds there are across multiple scales and exactly what data we need to model them.

The nested, networked structure of HCSSs across multiple scales gives rise to multifaceted interfaces across which people, things, and information flow. An increasingly large amount of data about HCSSs are being generated by people carrying and using smart phones but are barely leveraged. Across time, the complete lifecycle of people and their quality of life in HCSSs is what matters most. To model, simulate, design, and engineer such complex interconnected systems will require new representations and formalisms be developed. Models can be used to identify what problems may arise, what conditions lead to instability, and which parameters to set to make changes effectively and efficiently. As HCSSs evolve and as technology gets smarter over time, we will need ways to engineer improved systems to take advantage of new smart technologies, and we will need to ensure that skills and jobs keep pace.

In the end, we outline a series of broad considerations and concerns, fundamental and applied questions, and specific research agenda items for service system innovation. Specifically, we see questions and research needed in theory creation, data collection, mathematical and computational modeling, service system design, performance measurement, and education for human-centered service systems. Because service system problems relate to many separate areas and disciplines covered by the National Science Foundation (NSF), we highlight relevant NSF programs for which further synergies are both possible and needed to ensure progress. We recommend focusing on specific application areas including urban infrastructure, manufacturing servitization, information and communication technology platforms, healthcare, and education transformation. We hope the proposed research agenda and recommendations will help the NSF assess the level to which its programs are currently addressing important research gaps and establish future programs that aim to improve service system innovation.

Paul P. Maglio, UC Merced

Stephen K. Kwan, San José State University

Jim Spohrer, IBM

In the era of smart service systems, technology is critical to real-world value cocreation, making scientific and engineering research in service innovation critical for the future economic progress. In 1988, the National Academies hosted a workshop on technology in services (Quinn, 1988). In 2003, the National Academies hosted another workshop that considered the impact of service research on business (National Academy of Engineering, 2003). In 2014, the National Science Foundation (NSF) sponsored the *Workshop to Develop a Research Agenda for Service Innovation*, along with sponsorship from the California Center for Service Science, IBM, San José State University, and the National Academies' University-Industry Development Program. The workshop brought together experts from academia, industry, and government to lay out the societal context for service research, identify technology needs and knowledge gaps for service innovation, and develop basic science, social science, and engineering questions to be addressed to satisfy the needs and fill the gaps. Over two days, participants engaged in lively discussion over the context and challenges inherent in service research in general and service innovation research in particular. There were individual presentations, breakout group discussions and presentations, and plenary discussions.

Background

The rise of global service-based business models have transformed the way the world works, enabled by new *Information and Communications Technologies* (ICT), specialization of businesses and professions, global regulations, and increased use of external services (Wirtz & Ehret, 2012). Service innovation is a key priority for nations, businesses, and citizens (Council on Competitiveness, 2005). Now, there is a new awareness of the need for an interdisciplinary science of service to help make innovation more systematic and more sustainable (Abe, 2005; Chesbrough & Spohrer, 2006; Ganz & Meiren, 2003; Horn, 2005; IBM Research, 2004; IfM and IBM, 2008; Maglio, Kieliszewski & Spohrer, 2010; Ostrom et al., 2010; Spohrer, Maglio, Bailey & Gruhl, 2007; U.S. Congress, 2007; UK Royal Academy, 2009).

Over the last two hundred years, there has been a rise and fall in resources allocated to local production of goods, with more reliance on increasingly complex cognitive and social interactions (Bell, 1973; Clark, 1940/1957; Fuchs, 1968; Levitt, 1976; Pine & Gilmore, 1999), resulting in the rise of the so-called "service sector" of the economy (Fitzsimmons & Fitzsimmons, 2010). Though there is a rich and diverse set of disciplinary research on service, including economics, marketing, operations, industrial engineering, computer science, design,

and more (see Chase & Apte, 2007; Fisk & Grove, 2010; Spohrer & Maglio, 2010; Spohrer & Kwan, 2009), there is also fragmentation and a lack of awareness of works by others among researchers and scientists in these disciplines (Rust, 2004; Roth & Menor, 2003; Spohrer & Maglio, 2010). *Service science* aims to draw the various disciplinary threads together into a single, coherent study of service phenomena (Glushko, 2008; Larson; 2008; Maglio, Srinivasan, Kreulen & Spohrer, 2006; Spohrer & Chesbrough, 2006; Spohrer, Maglio, Bailey & Gruhl, 2007).

The traditional view holds that services constitute the third sector of the economy: service activities are those economic activities that are left over after agriculture and manufacturing (Fitzsimmons & Fitzsimmons, 2010). Over time, disciplines including economics, marketing, operations, management, engineering, and more have all focused some attention on service activities, primarily from the perspective of this traditional view (for historical perspectives, see Brown, Fisk & Bitner, 1994, Spohrer & Maglio, 2010, and Vargo & Lusch, 2004). Yet even given this broadly agreed upon view of service, different disciplines have not used the same basic definition of service. For instance, economics defines service as a distinct type of exchange (other than exchange of goods), a category for counting and analyzing jobs, businesses, and exports (e.g., Triplett & Bosworth, 2004). Traditionally, marketing defines service as a distinct type of exchange (Shostack, 1977), delivered by a distinct type of process (Bitner & Brown, 2006), and often characterized by customized human interactions or "moments of truth" with customers (Carlzon, 1987). In the field of operations, service is usually defined as a process that is dependent on customer inputs (Chase, 1978; Sampson & Froehle, 2006). The disciplines of engineering and operations research have defined service by the distinct type of modeling and optimization problems that result from customer variability (Dietrich & Harrison, 2006; Mandelbaum & Zeltyn, 2008; Riordin 1962). In computer science, service is defined by a particular kind of abstraction for network-accessible capabilities with unique discovery, composition, and modeling challenges (Sheth et. al, 2006; Zhang, 2007). There are many more disciplinary views of service (see also Spohrer & Maglio, 2010, and Spohrer & Kwan 2009).

Given the traditional view that service activities are separate and left over from agriculture and manufacturing, disciplines have multiplied characterizations and grown apart with unique perspectives on service (Spohrer & Maglio, 2010). Service science aims to bring these perspectives back together, and to do this, we must develop a unified definition. In our view, *capabilities, interaction, change*, and *value* are fundamental to service. At its most basic, service results in change in one entity brought about as a result of interaction with another entity (Hill, 1977). To be effective, this change must be preferable and leave the entities better off than they were before they interacted (Vargo, Maglio & Akaka, 2008). Entities interact because each may have specialized knowledge and capabilities (Bastiat, 1850/1979), and often a group composed of specialized complementary capabilities can achieve more than a group of individuals with multiple generic capabilities (Ricardo, 1817/2004). Simply put, service is the application of competences for the benefit of one another, making all economic activity an exchange of service for service (Vargo & Lusch, 2004). More precisely, service can be defined as *value cocreation*, value as change that people prefer, and value cocreation as a change or set of related changes that people prefer that is realized as a result of communication, planning, or other purposeful actions (Spohrer & Maglio, 2010; Maglio & Spohrer, 2013).

Over the past decade, there has been an explosion of activities aimed at knitting together multiple disciplinary views of service into a single, unified whole (e.g., Demirkan, Spohrer & Krishna, 2011; Salvendy & Karwowski, 2010, Maglio, Kieliszewski & Spohrer, 2010; Hefley & Murphy, 2008; Maglio, Spohrer, Seidman & Risto, 2008; Ostrom et al., 2010; Spohrer & Reicken, 2006; Spohrer, Kwan & Fisk 2014). This has also been spurred by increasing digitization, blurring the boundaries between dynamically reconfigurable material objects and the service the objects are able to perform, resulting in new markets and often disruptive business and economic models (Ng, 2014). Yet there has been little crosstalk among disciplines, and progress toward broad and systematic understanding of service phenomena has been slow. Globally, public investment in service research has increased from less than $100M to more than $1B annually, mostly driven by national funding in Japan, China, Finland, and Germany. National priorities around the world today aim toward economic improvement, driven by scientific understanding and systematic innovation (e.g., Council on Competitiveness, 2005; European Commission, 2011; National Science Board, 2010). Simply put, the U.S. is lagging behind. It is time to focus deep scientific and engineering attention on service innovation (National Academy of Engineering, 2007; Duderstadt, 2008).

Impact

Service activities represent the largest sector of the economy in the U.S. and in all developed countries worldwide (e.g., Spohrer & Maglio, 2008). More people work in service activities than work in either manufacturing or in agriculture activities (International Labor Organization, 2008). Yet improvements and innovations in service do not lie on the same trajectory as improvement in agriculture and manufacturing, mainly because service systems necessarily involve coordinated action among people and technologies and resist traditional kinds of optimization and other interventions. Closing knowledge gaps so that service innovation can be put on as solid a scientific and technological footing as other economic activities is a key national priority (Council on Competitiveness, 2005; European Commission, 2011; National Academy of Engineering, 2007).

Public sector investment in service research is relatively low because of the low margins in some traditional service businesses, which are not knowledge-intensive or technology-intensive, and the U.S. lags well behind countries such as Japan, China, Finland, and Germany, in public investment. In Europe, the *Cambridge Service Alliance* at Cambridge University, UK, the *International Institute for Product & Service Innovation* at University of Warwick, UK, and the *Karlsruhe Service Research Institute* at the Karlsruhe Institute of Technology, Germany, are well known for excellence in service research and education, their close ties to industry partners, and their ability to generate substantial opportunities for external research funding. In the U.S., the *Center for Services Leadership* at Arizona State University, and the *Center for Excellence in Service* at the University of Maryland are established thought leaders in service research, with business, science, and educational missions. In addition, the University of California has established the multi-campus *California Center for Service Science* to help advance the frontier of service research and education in California and the U.S. One can ask, "what are the long-standing engineering centers of excellence in human-centered service systems engineering?" that help us prevent the outsourcing of engineering service to other nations (Duderstadt, 2008).

Now, NSF has the opportunity to focus sustained attention on service problems and prospects. The Service Enterprise Systems (SES) program at NSF has supported fundamental research in service for many years. Though it has broad applicability, the program is focused particularly on optimization and policy development in the areas of healthcare and public service. Recent projects funded by SES include "Stochastic Modeling and Optimization of Longitudinal Health Care Coordination", "Models For Designing Evidence-Based Patient-Centered Health Care Systems", and "Health System Modeling and Simulation: Coordinated Care Example". The Civil Infrastructure Systems (CIS) program at NSF also includes many service-focused projects, which often come from the most critical service areas in the economy, including cities, buildings, water systems, cyber infrastructure (communications, data), and transportation. The new System Science (SYS) program at NSF aims to fund research that creates a solid foundation for systems engineering, including work that takes account of how individuals and organizations work with one another and with technologies to create complex and large scale engineered systems. The solicitation, "NSF/Intel Partnership on Cyber-Physical Systems Security and Privacy" from the Computer and Information Science and Engineering Directorate (CISE) seeks multidisciplinary proposals that take a holistic view of challenges in protecting cyber-physical systems, including service systems, accounting not only for technical solutions but also the human factors, policies, and economics. The recent funding opportunity advanced by the Partnerships for Innovation (PFI) program in Building Innovation Capacity (BIC) program supported academe-industry partnerships led by an interdisciplinary academic research team with at least one industry partner, and focused on novel applications motivated by existing research discoveries and based on a platform technology with the potential to achieve transformational change in existing service systems or to spur entirely new service systems. Evaluation and Assessment Programs (EAP) at NSF provide effective processes to chart the path between societal needs and NSF programs, which can help us determine how the outcomes of this workshop might be implemented in future programs. SES, CIS, SYS, CISE, PFI, and EAP all represent potential stakeholders in outcomes of the workshop: SES focuses on service and optimization, CIS focuses on critical infrastructure systems and services, SYS focuses on engineered (sociotechnical) systems and complexity, PFI focuses on applications and innovation, and EAP focuses on evaluation of research program effectiveness across the board. To put service research and innovation on the same scientific foundation as technology innovation, we must focus both on societally important service systems and on complex sociotechnical systems at the same time.

Workshop

Over two days, 43 representatives from academia, industry, and government met to develop a potential research agenda for service (see the appendices of this report for workshop participant list and agenda, see http://ccss.ucmerced.edu/nsf-workshop/ for position papers and presentation materials, and see NAS/UIDP URL for comprehensive summary of the presentations and discussions).

Human-Centered Service Systems

In the discussion, participants agreed that service system modeling is key, but that the system boundaries were fluid, and that human roles are often hard to model. Service system modeling requires a common language across multiple disciplines. Prediction in the context of service

systems requires understanding individual values, and multiple stakeholder perspectives. These comprise the critical differences between systems and service systems, and led participants to focus on *Human-Centered Service Systems (HCSSs)*. HCSSs are configurations of people, information, organizations, and technologies that operate together for mutual benefit. They can be distinguished from other types of sociotechnical systems in that they depend critically on sharing capabilities among distinct economic entities. HCSSs include services such as hospitality, healthcare, e-commerce, retail, finance, government, infrastructure, and much more. Some such systems are designed, like a university, and some evolve, like a city. In HCSSs, all the action and interactions cannot all be anticipated beforehand. The performance of HCSSs depend not only on people, information, organizations, and technologies, but also on interactions and independent behaviors, which together have emergent properties.

The key problem in HCSSs is in understanding the role of people. We can distinguish four levels in such systems: the service ecosystem (society), system structure (organization), operations (processes), and practices (people), all dynamically connected by shifting norms, values, beliefs, as well as diverse contexts for acting. Cities are just big human-centered service systems. For example, cities cannot be studied like businesses because they are not engineered; they grow organically. For cities, the technical problem is getting things to work, keeping them working, and understanding impacts of threats from nature, infrastructure outages, and terrorist acts. The associated behavioral and social problem is in trying to understand human, perceptions, expectations, and inclinations in the context of social networks, communications, and warnings. The contextual problem lies in trying to understand how norms, values, and beliefs affect people, including the sources of these norms, values, and beliefs. Simply put, value is subjective. Sometimes we have to compare and trade-off among very different kinds of things to assess value. On the one hand, there may be money, and on the other, speed of performance or health of a population. Moreover, value systems may change over time, and an individual's perception of what is valuable may change as well. And service systems must take account of dynamics of the environment.

In what follows, we provide some examples that highlight the broad relevance of service innovation across business and society, hinting at some of what may be needed for a research agenda that spans all sectors and levels.

Cities

Consider resilience in the context of cities (Olson, 2011). Every natural disaster that impacts a city, from Hurricane Katrina in New Orleans to Super Storm Sandy in New York City, creates a plethora of case studies from panels of experts, but cries out for a more human-centered service system framework to be established to make sense of innovation, disruption, recovery, and growth of service in urban environments. Viewed as human-centered service systems, cities exhibit a nested and networked structure that is complex and dynamic, from individuals and families to streets and communities to businesses and other institutions (Spohrer et al, 2012). Globally, roughly 2% of land area, 50% of the population, 70% of energy use, and 80% of carbon emissions are associated with cities. Social, technological, economic, environmental, and political forces interact to drive change across all sectors, including transportation and supply chains, water and utilities, agriculture and manufacturing, electricity and energy, information and

communications, buildings and construction, retail and hospitality, financial and professional services, healthcare, education, and government. Despite their importance, even after major disasters and recoveries, panels of experts find it difficult to do more than scratch the surface of the complexity and dynamics of cities when making recommendations for future service resilience and innovation. Resilience is "the ability to prepare and plan for, absorb, recover from, or more successfully adapt to actual or potential adverse event" (Olson, 2011). Children represent nearly 25 percent of the U.S. population, but disaster preparedness plans often do not include specific considerations for children and families (Wizemann et al, 2013). In some cases, social-ecological resilience may in fact benefit from remembering and re-instituting older ways of doing things that are more human-centered (Adger et al, 2005). Given the importance of cities as human-centered service systems, the research and development of new and better methods need to be encouraged and explored (see also Kline, 1995).

Some key questions concerning cities as HCSSs include: How can cities best be understood as a collection of communities and neighborhoods, all served by common urban infrastructures? How does policy (e.g., zoning, codes, taxes), development (e.g., real estate, business formation and relocation), migration, etc. affect the evolution of communities and neighborhoods within a city? When technical problems arise, what message is appropriate and who should deliver it to each significantly different community and neighborhood within the city? And how can we project and monitor the responses of each community and neighborhood to the information communicated, especially as it is shared across social networks? In sum, we cannot address cities or other human-centered service systems in the same ways we address airlines, factories, and power plants. Cities include too many complex behavioral and social phenomena. But we can systematically explore the ways in which cities might respond to opportunities, incentives, and inhibitions, and we can then identify conditions that are likely to lead to one system response rather than another.

Health

Consider the complex system of population health. It embodies a critical and typical *human-centered* service system. It is vitally important and extremely expensive: Healthcare spending in the U.S. is greater than the GDP of the seventh largest country in the world.[1] But what could be more human-centered than human health? And yet human health and healthcare are embedded in and depend on a complex constellation of natural and human-made systems (Maglio, Sepulveda & Mabry, 2014), and which operate on across multiple system levels, including the service ecosystem or society, system structure or organization, operations or processes, and practices or people (Rouse & Cortese, 2010). Major health challenges, such as cardiovascular diseases, diabetes, and cancer, are rooted in complex interactions among multiple variables, including people, genes, social, economic, and physical environments (World Health Organization, 2010). These variables, in turn, are often complex systems themselves, each part of the broader interdependent system of human health, including food, agriculture, transportation, education, and healthcare delivery systems. And their interactions can result in outcomes that are difficult to understand or predict, and that often cannot be traced reliably to any single component.

---

[1] See Wang (2013) and http://en.wikipedia.org/wiki/List_of_countries_by_GDP_%28nominal%29

Nevertheless, prevalent approaches to solving complex problems often involve decomposing them into component parts and analyzing some subset individually to identify candidate interventions. For example, many proposed solutions to non-communicable diseases in high-income countries have focused primarily on healthcare delivery. In the U.S., population health challenges resulting from non-communicable diseases are being addressed by increasing access to health services through government subsidized health insurance, delivery system expansion of primary care, improvements in the quality of clinical practice, and new performance-sensitive payment mechanisms (Orzag & Emanuel, 2010). Yet, it is not known whether the reforms will improve population health. Essential components of health maintenance, such as exercise, better nutrition and weight management, medication effectiveness, and stress management, can be thwarted by outdoor public safety issues in neighborhoods, prohibitive costs of fresh fruits and vegetables, housing with smokers in indoor environments, and time demands on patients from work or elder- or child-care responsibilities. Though it may be theoretically possible to model all of the interactions among all of these systems either analytically or by simulation, the sheer number of component systems, the networked and nested networked structure of the component systems, and the inherent uncertainty of human behavior make it practically impossible. But what else can we do? This is why we need new methods and new approaches to understanding complex human-centered service systems.

Manufacturing

The U.S. manufacturing sector was the envy of the world with its capacity, manpower, and innovativeness after the Second World War. Since then, the sector had gone through many disruptive episodes, which led to substantial job loss, a decline in productivity, quality, economic competitiveness, "rustiness", and eventual movement to overseas production. The manufacturing sector accounted for about 28% of the U.S. GDP in 2013. Many of the jobs remaining in the sector are higher paying and require more skills than before, which does not bode well for significant job growth. Yet one area of manufacturing has shown promises of revitalizing the sector and job growth. Some manufacturers are experiencing success in changing their business models from goods production to service provision based on the goods they make. This is sometimes referred to as servitization, the creation of services from goods (Neely, 2008). There are notable success stories from the U.S. as well as from abroad. Rolls Royce completely changed its business model from selling jet engines to selling hours of jet engine thrust as a service (Ng et al. 2012). John Deere still sells tractors but also increased its business by providing soil and watering analysis from satellites together with recommendations for crops, fertilizers, irrigation regimes, etc. as services. Research has also shown that the change of business models from asset transfer to a service that is outcome-based paradoxically requires the firm to redesign the physical product to achieve better scalability and agility of the overall service system (Ng & Briscoe, 2012). The marriage of the telecommunication and entertainment industries has seen tremendous business growth in providing content as a service. New generations of smart phones and other mobile devices connect users to content and other revenue-generating services. Other examples include the boom of the "sharing economy" in which the use of an object (e.g., automobile, tools, rooms, bicycles, etc.) is offered and consumed as a service as a viable and economical alternative to ownership. Does this change in perspective from the manufacture of goods to the provision of human-centered services based on

goods have the potential to transform the manufacturing by stimulating innovation to create new businesses and new jobs? How do community scale recycling and "makers movements" have the potential for revitalizing manufacturing at the local HCSS level?

Information and Communication Technology (ICT)

Consider the rapid proliferation of Information and Communication Technology (ICT), specifically internet-enabled HCSSs over the last decade and a half (Davis, Spohrer, & Maglio, 2011). By 2014, over two billion people used social media platforms, rapidly approaching one third of the world's population (Kemp 2014). Facebook, LinkedIn, Twitter, Google+, and many other social media platforms provide "free" offerings to users, in exchange for usage rights to their user-to-user/customer-to-customer generated content. Without low-cost ICT, these platforms and business models would not be feasible. The growth of both users and data are enabling a next generation of intelligent platforms for human-centered service systems, powered by big data, machine learning, mobile, and the Internet-of-Things. Robots and 3-D printing, through use of new materials with new properties, will transform manufacturing. This second generation of platforms will include cognitive systems that use natural language, learn, and can provide recommendations with levels of confidence based on the wisdom of the crowd (e.g., IBM's Watson). ICT-enabled human-centered service systems often include a keystone business that provides the platform as well as many thousands or even millions of ecosystem partners (Iansiti & Levien 2004). Often the boundary between provider and customer is blurred, and startups companies can grow valuations and sometimes revenue exceptionally rapidly. Airbnb and Uber are also examples of the ICT-enabled HCSS that encourage micro-entrepreneurs in a so-called sharing economy. Some key questions concerning ICT-enabled HCSS include: As the cost of ICT capabilities continues to decline, what impact will this have the design of HCSS? If the overall quality-of-life of people in HCSS is a function of their individual decision-making, what impact will second generations platforms with embedded cognitive assistants have? How can ICT-enabled HCSSs be better engineered on dimensions ranging from sustainable energy use to productive time/attention use?   To inform better-engineered solutions, how can empirical studies of users in ICT-enabled HCSSs be performed ethically with the consent of users?

Education

In terms of size, the education industry at 10% of U.S. GDP is right behind that of healthcare at 17%. It is a very important, if not the most important, industry for the maintenance of U.S. competitiveness in the world (Larson, 2009). Just as in healthcare, education is a quintessential human-center service system. The current U.S. educational system, from K-12 to higher education, has been in place for a long time. The industry has often been cited as the one that has seen little, if at all, productivity improvement since the 1800's. Recently delivery technology advances, pedagogical innovation, state funding cuts, and for-profit business models have created much disruption in the industry (Christensen, Horn & Johnson, 2011). This disruption was not welcome by some traditional educational institutions with entrenched faculty who believe that education can only be delivered in a lecture format, together with the intellectual stimulation that could only come from face to face discussions. Many of these disruptions were

driven by innovators who saw the industry as broken (cf. healthcare) and by customers who carry a heavy burden for its inefficiency and ineffectiveness. Student loan debt in 2014 amounted to $1.2 trillion and surpassed consumer credit card debt (Andriotis, 2014). Some studies have shown that a college education provides more value to graduates in the long run (e.g., Pew Research Center, 2011), yet the burden of debt and the inflexibility of the educational system are not helping educational institutions that face new competition (such as comparatively inexpensive online degrees) in creating attractive value propositions to prospective students. This could potentially have a devastating and long lasting effect on the U.S. economy and the country's ability to maintain its competitive edge in the world.

Some advocate moving from the "comfortable and efficient" traditional industrial engineering and operations research ideas applied to the education industry to more "transformative" redesign of education to improve the teaching and learning functions (Larson, 2009). This fundamental shift from an institution-centric (centralized service delivery requiring physical presence) to student-centric (decentralized physical/virtual service delivery with customized consumption) approach can potentially enhance the learning process and improve the efficiency and effectiveness of the educational institutions, which will go a long way in increasing the innovative capacity and competitiveness of the country.

Summary

HCSSs are important but understudied. Relative to their importance, we do not even have the most basic understanding of them, including what kinds there are across multiple scales and exactly what data we need to model them. Nested, networked structure across multiple scales is important. To model such complex systems, new representations and formalisms will be required for modeling to identify what problems may arise, what conditions lead to instability, and which parameters to set to make changes effectively and efficiently. As HCSSs evolve and as technology gets smarter over time, we will need ways to engineer improved systems to take advantage of new smart technologies, and we will need to ensure that skills and jobs keep pace.

Toward a Research Agenda

Workshop participants identified a set of basic scientific and engineering questions concerning HCSSs. We have organized and consolidated the many questions that were presented and discussed into six broad categories.

Theory

The fundamental laws or principles that govern human-centered service systems are yet to be discovered. And though we are not even sure what underlying theoretical frameworks ought to be used, we suspect that multiple disciplinary perspectives will be important. Some of the questions discussed included:

- **Fundamental laws:** What are the fundamental laws of that can be used to describe, explain, and predict the possible behaviors of HCSSs? How can these laws be best hypothesized and tested? What can be learned from existing laws of learning systems and self-correcting systems? Why are some systems more innovative than others? How is the landscape of roles and occupations likely to change over time? How can the patterns of augmentation of people with technology/smarter environments and organizations/smarter institutions be captured in a set of laws?
- **Theoretical underpinnings:** How are the fundamental underpinnings of human-centered service systems different from those of others types of systems? What are the theoretical underpinnings of engineered systems, multi-stakeholder systems, cooperative systems, competitive systems? What are the best new mathematical models for nested, networks of processes? What theoretical constructs do we need to understand the co-evolution of technology and service systems?
- **Multi-disciplinary frameworks:** How can industrial and systems engineering, computer science, behavioral sciences, and other disciplines contribute to creating the needed theory? What is the relationship between laws of nature, laws of natural systems, and human-made laws and systems? How are the multiple feedback loops in biological systems be used to model possible components of a framework for human-centered service systems? How can the laws of multiple disciplines be compared and composed? What can a common language and typology of service systems be created? What are the context, phenomena, attributes, and units of analyses?

The primary question is whether in fact there are new principles or laws to be discovered about the operation of human-centered service systems. The secondary question is where -- what disciplines -- new insights will come from.

Data

Building better theories of human-centered service systems will depend on improved data sets, better measurements, and addressing ethical issues. Some of the questions included:
- **Data sets:** What are the most critical fine-grained interaction data sets that can be captured over long periods? Is the existing historical record able to shed useful insights? What data should be captured from service encounters? What visualization tools can be used to understand the data sets? How can the increasing volume of personal data generated from smart devices be useful to stimulate new markets in the digital economy?
- **Instrumentation:** What smart technologies (e.g., sensors, monitors, smart phone apps, etc.) are needed to capture the data sets and extract useful measures? How can facial expressions, gestures, and other forms of subtle interactions be captured and analyzed? How can trust (value, satisfaction, brand loyalty, risk adversity) be measured with instrumentation?
- **Ethical issues:** What are the privacy, data security, ownership, appropriate use, and monetization issues that must be addressed? Can data anonymization techniques and regulations that allow the use of different data sets over different time scales be implemented to make progress easier? How should we treat the increasing volume of personal data and issues of privacy, trust, confidentiality and security?

Key to understanding and improving service systems is gathering data about them. But exactly what data, and how can we manage it?

Modeling

There was complete agreement that modeling and simulation will be critical in understanding and predicting behavior of HCSSs. Nevertheless, there were some differences of opinion as to how HCSSs differ from other kinds of engineering systems for modeling purposes, what some specific modeling challenges are, and what appropriate tools and techniques will be required. Basic questions included:

- **Modeling human-centered service system complexity**. What new theoretical constructs do we need to model/simulate/optimize human experience, decision-making and behavior in HCSSs? How can we account for emergent (human) behavior in optimization, simulation, and decision models? How can we formalize the dynamics of HCSSs to model them in all their complexity and connections? How can we integrate culturally driven value propositions in optimization models? What methods can we use to predict social and economic behaviors, combining cognitive and behavioral research methods in the context of HCSSs?
- **Modeling future service innovation**. What are the tools and methods to model new and significant innovations that can alter human behavior individually and collectively? What is the shelf life of service innovation models, and how does this vary by industry?
- **Techniques for service system modeling**. What old or new visualization and mathematical methods do we need? What is a robust ontology for modeling service and service systems? How do we develop appropriate governance and interaction models in service system networks? How can we study the dynamic interactions among service subsystems, their dynamism, and equilibrium-seeking behavior after natural or human-created system shocks?

The key issue in modeling human-centered service systems lies in modeling the humans. Simplifying assumptions may sometimes make human behavioral and cognitive modeling possible, but modeling complexity explodes when nested networks for coordination, cultural factors, and individual preferences are taken into account.

Design

Some workshop participants discussed the need for a multi-disciplinary, team-based approach to designing human-centered service systems that takes into account human, technical, and business considerations.

- **Design Team** - How do we create the common language that enables the multi-functional/multi-disciplinary/multi-stakeholder teams to do the analysis that they need to do? How can we develop diverse design teams to foster collective IQ and the ability to generate new ideas?

- **Human** - Is the service desirable? How can the dynamic decision-making behavior of stakeholders be incorporated in service systems? What are the cultural, economic, value systems, and environmental factors that affect the desirability of service offerings? What are the essential human-human, human-machine interactions? Where can human-machine interactions supplement or even supplant human-human interactions and what are the trade-offs? What are the ethical considerations in designing human-centered service systems? What are the governance models of human-centered service systems where networks of stakeholders with various value propositions are in play?
- **Technical** - Is the service feasible? How can we develop technologies by taking social and economic factors into consideration? What are the effects of service modularization (e.g., from some ontology) in the adoption of new technologies? How can we design learning and self-correcting service systems with feedback loops that take into consideration of inherent time delays? How can we design service systems that scale? What is the role of technology in human-centered service systems? Can technology in service systems play a role in reviving the manufacturing industry?
- **Business** - Is the service viable? How can we design productive service systems that are resilient to unforeseen and potentially extreme disruptions (such as weather, natural, and man-made disasters)? How can we design to mitigate the long horizon of climate change on the delivery of services (e.g., city infrastructure services)? What are the design issues associated with organizational transformations such as changing from goods-dominant to service-dominant business models (e.g., servitization)? What are the trust issues involved in value cocreation where sharing (e.g. data), identity management, and entitlement are paramount? What are the trade-offs between risks and trust in value cocreation?

Measurement

Many participants mentioned problems related to measuring service system performance or the impact of different design choices on service system performance. Questions included:

- **Overall performance measures**. What are the key performance indicators for HCSSs? How do we support formative evaluation of HCSS engineering? How does our ontology support understanding the delta between as-is and to-be service systems? What are the fundamental methodologies for evaluation?
- **Value and other measures**. How should value be defined and specified? How is value contextual? How is value non-stationary? How can modeling and simulation methods be applied to evaluate new value creation based on bundling and unbundling of value constellations? How is value multi-dimensional? How can service systems be scaled? What methodologies can be used to measure or evaluate scalability? How can we measure the risks inherent in service?
- **Test environments.** How can we build rigorous testing systems for service that accommodates a natural development environment, human-centered design, and smart service design while at the same time avoid unforeseen consequences?

The key issue in measuring HCSS performance lies in measuring *value,* which as mentioned, is subjective. From an optimization perspective, it requires putting people in the objective function, and reconciling incommensurate measures in multi-objective optimization problems.

The challenge is to improve overall value creation by improving human capabilities in complex service systems. If the real performance metrics relate to value, there may be a trade-off between technical performance and overall system (human) performance and value. What are the methods and metrics for designing a human-centered service system that effectively integrates "smart" technologies and systems engineering?

Education

Workshop participants also focused attention on questions related to education, particularly how new knowledge about HCSSs can be disseminated and sustained. Some of the research questions discussed were:

- **Societal Context** - How can we, as educators, ensure the steady flow of skills for industry and career paths for individuals as job roles and occupations change given new services, service innovation, and new service configurations? How can we identify knowledge and skills gaps so that we can adapt education and training in time, minimizing the barriers to service industry growth?
- **Sustainability** - How to prepare the next-generation innovators, educated citizens, and entrepreneurs for effective service innovation? Equally important is the preparation of educators and researchers to create and disseminate new knowledge in the field. What roles do government and industry play together with academia in innovating and sustaining such efforts?

One key question is how the kind of multidisciplinary knowledge and skills required for HCSSs can be effectively disseminated, and what disciplines (or interdisciplines) will start to maintain such knowledge.

Recommendations and Application Areas

Though participants at the workshop did not fully converge on specific recommendations for a research agenda in human-centered service systems, our analysis of the questions generated and topics discussed suggest several important directions for future work. We characterize these directions in terms of five application areas. The underlying question is what does the human focus of HCCSs require that is new, unique, and significant in terms of theory, data, modeling, design, measurement, and education? The overarching theme tying all areas together is multidisciplinarity or transdisciplinarity, borrowing from many disciplines without replacing any (Kline 1995). The need for the education systems to support the lifelong learning of T-shaped professionals to design service innovations is clear (Peters, 2012). T-shaped professionals are *deep* in their home discipline, but also excellent collaborators *across* the disciplines of science and engineering, management and public policy, social sciences and law, and arts and humanities (Hansen & Nohria, 2004). T-shaped professionals can be more agile and adaptive for organizational and behavior pattern changes that accompany most service innovations in business and society (Barile, Saviano & Simone, 2014).

Urban Infrastructure. Universities, airports, highways, ports, and cities are all human-centered service systems. Building anyone of these and keeping it operating effectively is at once a technical feat, an organizational feat, and a human feat. It requires engineering knowledge, joint coordinated action on a large scale, and understanding of human behavior and human values, among other things. Though we routinely build and maintain these sorts of infrastructure systems, we do not understand how they work, we do not know the optimal approaches for changing them, and we do not know the most effective ways to make them robust and resilient to either internal or external shocks. Focusing on infrastructure systems means creating and operating HCSSs at scale. It is hard to make simplifying assumptions on any one part and still get the overall system right.

Manufacturing Servitization. Modern businesses often prefer selling capabilities to selling things, now placing manufacturing firms at the center of certain kinds of human-centered service systems. But what counts as innovation in manufacturing does not count as innovation in service. What characteristics of the manufacturing ecosystem encourage service innovation? What factors need to be considered to create both process and product innovation in services (e.g., culture, critical mass of skills and expertise, platforms, and empathy)? Servitization in particular requires deep understanding of value in use, which in turn requires both technical and human understanding of HCSSs. In this context, knowledge, skills, education, and creation of a competitive global workforce is a priority for closing the "service knowledge gap".

Information and Communication Technology Platforms. Cognitive systems, social platforms, mobile technologies, and the Internet of Things are just some modern service-based information and communication technologies. Big data and new analytics techniques lead to better understanding of customer value systems, behavior, expectations, and experience. Web services and cyber-physical systems are always embedded in human-centered service systems. Thus, ICT serves as both an application area for learning about HCSSs and also an enabler of HCSSs. It is the key to data collection, analysis, and system measurement. New ideas in security and privacy at the intersection of technology, policy, economics, and social aspects will be critical for enabling these ICT-based HCSSs. It is also the key to computational modeling of complex service systems, from both analytical and simulation perspectives. Understanding of technology, business, social, and human systems are needed to increase innovation in ICT-based service systems, creating offerings that are more agile and adaptive to dynamic environments.

Healthcare Re-imagined. In the U.S., recent changes to the healthcare HCSS, primarily from the legal and regulatory side, are already having unpredicted and emergent consequences. The context, laws, value systems and technology are all changing at once, causing cost functions to change and benefit functions to change, including more family-based self-service. Understanding the scope of change and the far-flung interactions is limited by our ability to understand and manage complexity. It is difficult to drive effective changes in context or drive effective changes in behavior when the changes have emergent properties. Healthcare represents a typical and important cross-boundary service system that depends on self-service technologies, laws and regulations, culture, living standards, expectations, government, public-private partnerships, technology, and more.

Education Transformation. The rise of HCSSs, and the need to understand, design, and improve them, raises multiple issues for education. We need to educate a workforce with skills that are at once broader and deeper than ever before. Knowledge and skills needs are always increasing, but

the multidisciplinary -- even interdisciplinary -- requirements for HCSS skills may mean big changes for education itself. Distance learning and massive online courses are only the beginning. Education is shifting from disciplinary silos to cross-functional and cost-cutting programs. Obviously, these changes are appropriate in the context of human-centered service systems. Yet to be effective and lasting, such changes require deep changes to academic incentive systems and to the mindset of educators. Student concerns about jobs and debt, combined with new innovation platforms for entrepreneurs create transformation opportunities for educational institutions at all levels.

Each of these applications areas already has one or more platforms (typically provided by large enterprises or governments) that provide diverse opportunities for startups to rapidly develop and deploy new service offerings, enrich the ecosystem, and enhance the capabilities of the platforms. We can imagine creating recognizable centers of excellence for service innovation in each of these areas as well as others. Privacy and regulatory concerns associated with service innovations is another possible area. Though not a clearly recognizable engineering area, privacy and regulatory issues may have a real impact on technical standards for the secure sharing of customer data to enable greater levels of value cocreation. Such concerns might also relate to development of simulation and computer-aided design tools for modeling the bundling and unbundling of resources in value constellations based on alternative public policy models. Each center could be a regional hub for other universities, businesses, and governments large and small to share best practices and cocreate next practices.

Furthermore, although we conceived of each of the main five application areas as clearly recognizable engineering areas, there is a large body of interdisciplinary literature in social, behavioral, and economic sciences on the theory of institutions that is applicable to the discussion of HCSSs. This literature spans economics, psychology, sociology, political science, management and organization theory, and encompasses some of the recent thinking on relations among organizations and societies. This body of knowledge will help conceptualize the connections among the varied actors and entities in HCSSs.

Future

We plan to assess the workshop's outcomes over the short term and long term. In the short-term, one measure is the number of service system research proposals submitted to the NSF and other agencies for funding. This is a good measure of how the workshop and the dissemination of its report stimulate the interest of the community in pursuing research in the area. As part of this measure, the extent to which the workshop participants take part in and spawn other proposals directly and indirectly can also be observed. Another measure is the number of research programs at NSF and other funding agencies that solicit service system research proposals. A third measure is the percentage of successful proposals that receive funding. A fourth measure relates to expansion of the research agenda and of involvement from disciplines beyond those involved in the workshop. This is a good measure of the extent to which the workshop has catalyzed new multidisciplinary approaches to the study of complex service system. In the longer-term, the number of key publications and citations, conferences and journals, as well as aligned professional association memberships will be important measures. Real impact measures will also include the number and rate of innovative service offerings in business and society,

both by established enterprises and startups and by for-profit and social enterprises. Ultimately, measuring impact requires better measures for quality-of-life. What are the service innovation that we cannot even imagine today that will have the biggest impacts on quality-of-life six generations from now? A follow-up study several years from now will investigate the workshop's lasting impact.

References

Abe, T. (2005). What is service science? Fujitsu Research Institute. Research Report 254, December 2005. Available at http://jp.fujitsu.com/group/fri/downloads/en/economic/publications/report/2005/246.pdf (accessed December 12, 2012).

Adger, W. N., Hughes, T. P., Folke, C., Carpenter, S. R., & Rockström, J. (2005). Social-ecological resilience to coastal disasters. *Science*, 309(5737), 1036-1039.

Andriotis, A. (2014) "College Debt: How to Ease the Burden of Loans". The Wall Street Journal, January 14th. http://online.wsj.com/articles/college-debt-easing-the-burden-1402697979 retrieved July 20th, 2014.

Barile, S., Saviano, M., & Simone, C. (2014). Service economy, knowledge, and the need for T-shaped innovators. *World Wide Web*, 1-21.

Bastiat, F. (1850/1979). *Economic harmonies. The foundation for economics education*. Irvington-on-Hudson, NY: Foundation for Economic Education.

Bell, D. (1973). *The coming of post-industrial society*. New York: Basic Books.

Bitner, M.J. & Brown, S.W. (2006). The Evolution and Discovery of Services Science in Business Schools, *Communications of the ACM*, 49(7), 73-78.

Brown, S. W., Fisk, R. P., Bitner, M. J. (1994). The Development and Emergence of Services Marketing Thought. *International Journal of Service Industry Management*. 5(1), 21-48.

Carlzon, J. (1987). *Moments of Truth*. Cambridge, MA: Ballinger.

Chase, R. B. (1978). Where does the customer fit in a service operation? *Harvard Business Review*, 56, 137 – 142.

Chase, R. B., & Apte, U. M. (2007). A history of research in service operations: What's the big idea? *Journal of Operations Management*, *25*(2), 375–386.

Chesbrough, H. & Spohrer, J. (2006). A research manifesto for services science. *Communications of the ACM*, 49(7), 35-40.

Christensen, C. M., Horn, M. B., Johnson, C. W. (2011) *Disrupting Class – How Disruptive Innovation Will Change the Way the World Learns*. McGraw-Hill.

Clark, C. (1940/1957). *Conditions of economic progress*. Third Edition. New York: Macmillan.

Council on Competitiveness (2005). *Innovate America: National Innovation Initiative Summit and Report.* Available at http://www.innovationtaskforce.org/docs/NII%20Innovate%20America.pdf (accessed June 7, 2013).

Davis, M. M., Spohrer, J. C. & Maglio, P. P. (2011). Guest editorial: How technology is changing the design and delivery of services. *Operations Management Research,* 4(1-2), 1-5.

Demirkan, H., Spohrer, J. C. Krishnan, V. (2011). *The Science of Service Systems***.** New York: Springer.

Dietrich, B. & Harrison, T. (2006). Serving the Services Industry. *OR/MS Today*, 33(3) (June).

Duderstadt, J. J. 2008. Engineering for a changing world: A roadmap to the future engineering practice, research, and education. Ann Arbor, MI: The University of Michigan.

European Commission (2011). *Policies in Support of Service Innovation*. INNO-Grips project Policy Brief No. 3. Available at http://ec.europa.eu/enterprise/policies/innovation/files/proinno/inno-grips-policy-brief-3_en.pdf (accessed June 7, 2013).

Fisk, R. P. and Grove, S. J. (2010). The Evolution and Future of Service: Building and Broadening a Multidisciplinary Field, in P.P. Maglio, C. A. Kieliszewki and J. C. Spohrer (eds.), Handbook of Service Science (pp. 643-664), New York, NY: Springer (2010).

Fitzsimmons, J. A. & Fitzsimmons, M. (2010). *Service management: Operations, strategy, and information technology* (Seventh Edition). New York: McGraw Hill.

Fuchs, V. R. (1968). The service economy. National Bureau of Economic Research, Number 87, General Series. Distributed by Columbia University Press, New York, NY.

Ganz, W. & Meiren, T. (2003). *Service research today and tomorrow: spotlight on international activities*. Stuttgart: Fraunhofer-IRB-Verl.

Glushko, R.J. (2008). Designing a Service Science Discipline with Discipline. *IBM Systems Journal*, 47(1): 15-27.

Hansen, M. T., & Nohria, N. (2004). How to build collaborative advantage. *MIT Sloan Management Review*, *46*(1), 22-30.

Hefley, B. & Murphy, W. (2008). *Service science, management and engineering: Education for the 21st century*. New York: Springer.

Hill, T. P. (1977). On Goods and Services. *Review of Income and Wealth*. 23(4), 314–339.

Horn, P. (2005, January 21). The new discipline of Services Science: It's a melding of technology with an understanding of business processes and organization -- and it's crucial to the economy's next wave. *Business Week*.

Iansiti, M., & Levien, R. (2004). The keystone advantage. *Harvard Business School Press, Boston*.

IBM Research (2004). *Services science: A new academic discipline?* May 17-18, 2004.

IfM & IBM (2008). *Succeeding through service innovation: A service perspective for education, research, business and government*. Cambridge, UK: University of Cambridge Institute for Manufacturing.

International Labor Organization (2008). *Global employment trends: January 2008*. Geneva: International Labor Organization.

Kemp, S. (2014). Global social media users pass 2 billion. *We Are Social*. URL accesses Aug 9, 2014: http://wearesocial.net/blog/2014/08/global-social-media-users-pass-2-billion/?utm_source=HS

Kline, SJ (1995) .*Conceptual Foundations For Multi-Disciplinary Thinking*. Stanford University Press. Stanford, CA.

Larson. R. C. (2008). Service science: At the intersection of management, social, and engineering sciences. *IBM Systems Journal*, 47(1), 41-52.

Larson, R. C. (2009) Editorial Column—Education: Our Most Important Service Sector. *Service Science* 1(4):i-iii.

Levitt, T. (1976). The industrialization of service. *Harvard Business Review*, 54(5), 63-74.

Maglio, P. P. (2011). Modeling complex service systems. *Service Science*, 3(4), i-ii.

Maglio, P. P., Kieliszewski, C. A. & Spohrer, J. C. (2010). *Handbook of service science.* New York: Springer.

Maglio, P. P., Sepulveda, M-J. & Mabry, P. L. (2014). Mainstreaming modeling and simulation is essential for public health innovation. *American Journal of Public Health,* 104(7), 1181-1186.

Maglio, P. P., & Spohrer, J. (2013). A service science perspective on business model innovation. *Industrial Marketing Management*, *42*(5), 665-670.

Maglio, P. P., Spohrer, J., Seidman, D. I, & Ritsko, J. J. (2008). Special Issue on SSME. *IBM Systems Journal, 47.*

Maglio, P. P., Srinivasan, S., Kreulen, J. T. & Spohrer, J. (2006). Service systems, service scientists, SSME, and innovation. *Communication*s of th*e ACM*, *49(7)*, 81-85.

Mandelbaum, A. & Zeltyn, S. (2008). Service Engineering of Call Centers: Research, Teaching, and Practice. In B. Hefley & W. Murphy (eds.) *Service Science, Management, and Engineering: Education for the 21st Century*. Springer. New York, NY.

National Academy of Engineering. (2003). *The Impact of Academic Research on Industrial Performance*. Washington D.C.: The National Academies Press.

National Academy of Engineering (2007). *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington D.C.: National Academies Press.

National Science Board (2010). *Science and Engineering Indicators: 2010*. National Science Foundation, National Center for Science and Engineering Statistics. Available at http://www.nsf.gov/statistics/seind10/start.htm (accessed June 6, 2013).

Neely, A. (2008). Exploring the financial consequences of the servitization of manufacturing. *Operations Management Research,* 1, 103-118.

Ng, I. (2014). *Creating new markets in the digital economy*. Cambridge University Press.

Ng, I. C.L. & Briscoe, G. (2012). Value, Variety and Viability: New Business Models for Co-Creation in Outcome-based Contracts, I*nternational Journal of Service Science, Management, Engineering, and Technology*, 3(3), 26-48.

Ng, I. C.L., Parry, G., Maull, R., Smith, L., Briscoe, G. (2012), Transitioning from a Goods-Dominant to a Service-Dominant Logic: Visualising the Value Proposition of Rolls Royce, *Journal of Service Management*, 23(3), 416-439.

Olson, S. (2011). *Increasing National Resilience to Hazards and Disasters: The Perspective from the Gulf Coast of Louisiana and Mississippi: Summary of a Workshop. Committee on*

Increasing National Resilience to Hazards and Disasters. National Research Council URL: http://www.nap.edu/catalog.php?record_id=13178

Orzag PR, Emanuel E. (2010). Health care reform and cost control. *New England Journal of Medicine*, 363(7), 601-603.

Ostrom, A., Bitner, M. J., Brown, S. W., Goul, M. Smith-Daniels, V., Demirkan, H. & Rabinovich, E. (2010) Moving forward and making a difference: Research priorities for the science of service. *Journal of Service Research,* 13, 4-36.

Pew Research Center (2011) *Is College Worth It?* Pew Social and Demographic Trends.

Peters, J. (2012). Educating Designers to a T. *Design Management Review*, *23*(4), 62-70.

Pine, B. J. & Gilmore, J. H. (1999). *The experience economy: Work is theatre and every business a stage*. Boston, MA: Harvard Business School Press.

Quinn, J.B. *Technology in services: Past myths and future challenges. Technology in Services: Policies for Growth, Trade, and Employment*. National Academy of Engineering, 1988.

Ricardo, D. (1817/2004). *The Principles of Political Economy and Taxation*. Dover Publications. Mineola, NY.

Riordan, J. (1962). S*tochastic Service Systems.* New York: Wiley.

Roth, A. V., & Menor, L. J. (2003). Insights into service operations management: a research agenda. *Production and Operations management*, *12*(2), 145–164.

Rouse, W. B. & Cortese, D. A. (2010). Introduction, in W.B. Rouse and D.A. Cortese (Eds.), *Engineering the System of Healthcare Delivery*. IOS Press.

Rust, R. T. (2004). A call for a wider range of service research. *Journal of Service Research*, 6.

Salvendy, G. & Karwowski, W. (Eds.) (2010) *Introduction to Service Engineering*, John Wiley & Sons, Hoboken, NJ.

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

Sheth, A., Verma, K. & Gomadam, K. (2006). Semantics to energize the full services spectrum. *Communications of the ACM*, 49(7), 55–61.

Shostack, G. L. (1977). Breaking free from product marketing. *Journal of Marketing*, 41, 73-80.

Spohrer, J., Kwan, S. K. & Fisk, R. (2014) "Marketing: A Service Science and Arts Perspective," in R. T. Rust & M. H. Huang (eds.) *Handbook of Service Marketing Research,* Cheltenham, UK: Edward Elgar Publishers.

Spohrer, J. & Kwan, S. K. (2009). Service science, management, engineering, and design (SSMED): An emerging discipline – Outline and references. *International Journal of Information Systems in the Service Sector,* 1(3).

Spohrer, J. & Maglio, P. P. (2010). Toward a science of service systems: Value and symbols. In P. P. Maglio, C. A. Kieliszewski & J. C. Spohrer (Eds.), *Handbook of service science*. New York: Springer.

Spohrer, J. & Maglio, P. P. (2008). The emergence of service science: Toward systematic service innovations to accelerate cocreation of value. *Production and Operations Management*, 17(3), 1-9.

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

Spohrer, J., Piciocchi, P., & Bassano, C. (2012). Three frameworks for service research: exploring multilevel governance in nested, networked systems. *Service Science*, 4(2), 147-160.

Spohrer, J. & Riecken, D. (2006). Special Issue on Services Science, *Communications of the ACM*, 49(7).

Triplett, J. E. & Bosworth, B. P. (2004). *Productivity in the U.S. Services Sector: New Sources of Economic Growth*. The Brookings Institute. Washington, DC.

UK Royal Society (2009). *Hidden wealth: the contribution of science to service sector innovation.* RS Policy document 09/09. RS1496.

U.S. Congress (2007). *America COMPETES Act. H.R. 2272. Sec. 1005*. Study of service science.

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

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.

Wang, S. S. (2013) U.S. Health Spending One of these things not like others. *The Wall Street Journal*, July 23rd, 2013. URL: http://blogs.wsj.com/economics/2013/07/23/u-s-health-spending-one-of-these-things-not-like-others

Wirtz, J. & Ehret, M. (2012). Service-based business models: Transforming businesses, industries, and economies, in R. Fisk, R. Russell-Bennett, L. C. Harris (Eds.), *Serving customers: A global perspective*. Tilde University Press.

Wizemann, T, Reeve, M, and Altevogt, B (2013). *Preparedness, Response, and Recovery Considerations for Children and Families: Workshop Summary. Forum on Medical and Public Health Preparedness for Catastrophic Events*. Board on Health Sciences Policy; Institute of Medicine. URL: http://www.nap.edu/catalog.php?record_id=18550

World Health Organization (2010). *Global status report on non-communicable diseases*. Available at: http://www.who.int/nmh/publications/ncd_report_full_en.pdf (accessed June 2013).

Zhang, L. J. (2007). *Modern Technologies in Web Services Research*. IGI Publishing. Hershey, .

Appendices

A. Participants

Last Name	First Name	email	Institution
Apte	Uday	umapte@nps.edu	Naval Postgraduate School
Baba	Marietta	Marietta.Baba@ssc.msu.edu	Michigan State University
Badinelli	Ralph	ralphb@vt.edu	Vigrinia Tech
Bess	Charlie	charlie.bess@hp.com	HP
Bitner	Mary Jo	maryjo.bitner@asu.edu	Arizona State University
Boccanfuso	Tony	aboccanfuso@nas.edu	UIDP
Braxton	Melissa	braxtm@uw.edu	U Washington
Breidbach	Christoph	cbreidbach@ucmerced.edu	UC Merced
Brooks	Jessica	jnbrooks@ida.org	Science and Technology Policy Institute
Clark	Bradford	Bradford.D.Clark@uscg.mil	U.S. Coast Guard
Correa	Dan	dcorrea@ida.org	Science and Technology Policy Institute
Drobnis	Ann	adrobnis@cra.org	CRA
Ganz	Walter	Walter.Ganz@iao.fraunhofer.de	Fraunhofer Institute, Germany

Garrow	Laurie	laurie.garrow@ce.gatech.edu	Georgia Tech
Haselkorn	Mark	markh@u.washington.edu	U of Washington
Hazelrigg	George	ghazelri@nsf.gov	NSF
Hefley	Bill	wehefley@katz.pitt.edu	U of Pittsburgh
Holiday	Kenneth	KENNEGH2@dni.gov	National Intelligence
Karmarkar	Uday	uday.karmarkar@anderson.ucla.edu	UCLA
Kwan	Stephen	stephen.kwan@sjsu.edu	San José State University
Larson	Dick	rclarson@MIT.EDU	MIT
Maglio	Paul	pmaglio@ucmerced.edu	UC Merced
Medina-Borja	Alexandra	amedinab@nsf.gov	NSF and University of Puerto Rico
Miller	Mark	Mark.T.Miller@uscg.mil	U.S. Coast Guard
Nerlove	Sara	snerlove@nsf.gov	NSF
Ng	Irene	irene.ng@wmg.warwick.ac.uk	Warwick University, UK
Ouyang	Yanfeng	yfouyang@illinois.edu	University of Illinois
Parish	Leslie	lparish@nmic.navy.mil	National Maritime Intelligence
Ramming	James	james.c.ramming@intel.com	Intel

Rayes	Ammar	rayes@cisco.com	Cisco
Romeijn	Edwin	eromeijn@nsf.gov	NSF
Rouse	Bill	wrouse@stevens.edu	Stevens Institute of Technology
Sawatani	Yuriko	sawatani@aoni.waseda.jp	Waseda University, Japan
Sloan	Susan	ssloan@nas.edu	NAS
Spohrer	Jim	spohrer@us.ibm.com	IBM
Straf	Miron	mstraf@nas.edu	NAS
Tanninen-Ahonen	Tiina	tiina.tanninen-ahonen@tekes.fi	Tekes, Finland
Tinkle	Sally	stinkle@ida.org	Science and Technology Policy Institute
Triantis	Kostas	ktrianti@nsf.gov	NSF
Tweed-Kent	Sean	stweed@nmic.navy.mil	National Maritime Intelligence-Integration Office (NMIO)
Verma	Rohit	rv54@cornell.edu	Cornell University
Wang	Grace	jiwang@nsf.gov	NSF

B. Workshop Agenda

April 10, 2014	
08:00 – 08:45	**Breakfast**
08:45 – 09:00	**Welcome and Agenda** **Jim Spohrer, IBM** **Stephen Kwan, San José State University** **Paul Maglio, UC Merced**
09:00 – 09:15	**A Perspective on Service Innovation at NSF – Chair: Paul Maglio** **Grace Wang, Division Director, Industrial Innovation and Partnerships, NSF**
09:15 – 10:45	**Individual presentations – Chair: Jim Spohrer**
10:45 – 11:00	**Break**
11:00 – 12:30	**Brainstorming – Chair: Stephen Kwan**
12:30 – 13:30	**Lunch**
13:30 – 14:30	**Break out session – Chair: Paul Maglio**
14:30 – 15:30	**Industry and government perspective – Chair: Stephen Kwan** **Ammar Reyes, Cisco** **Jim Spohrer, IBM** **Alexandra Medina-Borja, NSF** **Sally Tinkle, Science and Technology Policy Institute**

15:30 – 16:00	**Break**
16:00 – 17:30	**Team break out session – Chair: Jim Spohrer**
17:30 – 18:00	**Team preliminary report out – Chair: Paul Maglio**
18:00 – 20:00	**Reception**
April 11, 2014	
09:00 – 09:30	**Breakfast**
09:30 – 10:30	**International perspective – Chair: Stephen Kwan** **Walter Ganz, Fraunhofer Institute, Germany** **Irene Ng, Warwick University, UK** **Yuiko Sawatani, University of Waseda, Japan** **Tiina Tanninen-Ahonen, Tekes, Finland**
10:30 – 10:45	**Break**
10:45 – 12:00	**Team break out session – Chair: Jim Spohrer**
12:00 – 13:00	**Lunch**
13:00 – 14:30	**Team presentations – Chair: Paul Maglio**
14:30 – 15:00	**Group discussion and wrap up** **Jim Spohrer, IBM** **Stephen Kwan, San José State University** **Paul Maglio, UC Merced**
15:00	**Workshop ends**