Steps Toward a Science of Service Systems

Jim Spohrer

Paul P. Maglio

John Bailey

Dan Gruhl

IBM Research, Almaden Research Center

650 Harry Road, San Jose, CA 95120 USA

{spohrer,pmaglio,baileyj,dgruhl}@us.ibm.com

http://www.almaden.ibm.com/asr

ABSTRACT

The service sector – which includes government, education, medical and healthcare, banking and insurance, consulting, information technology services, retail and wholesale, tourism and hospitality, entertainment, transportation and logistics, and legal among others – accounts for most of the world's economic activity, but is the least studied and least understood part of the economy. Innovation in service in particular is not approached as systematically as innovation in agriculture and manufacturing, which have experienced large productivity and quality gains in the last two hundred years. To remedy this, we propose developing a *science of service*, which aims to provide theory and practice around service innovation. In this paper, we show progress toward this, arguing that the proper basic category is the *service system* in which entities exchange performance of beneficial action, and that a service system can be understood as a system composed of people and technologies that adaptively computes and adjusts to the changing value of knowledge in the system.

INTRODUCTION

The service economy refers both to the service sector of industrialized economies as well as services performed in other sectors. Service industries that show growth in knowledge intensity include government, education, medical and healthcare, banking and insurance, consulting, information technology services, retail and wholesale, tourism and hospitality, entertainment, transportation and logistics, legal, and among others. Over the last 20 years, services have grown to be the largest part of the economies of most industrialized nations. Yet despite such significant growth of the service economy, there is no widely accepted definition of service, and service productivity, quality, compliance, and innovation all remain hard to measure. One main reason is that relatively little attention has been paid to studying service and to educating students in service, both of which are inherently interdisciplinary. A recent National Academy of Engineering report summarized the state of service innovation in the U.S. well:

> Services account for more than 80 percent of the U.S. gross domestic product, employ a large and growing share of the science and engineering workforce, and are the primary users of information technology. … [T]he academic research enterprise has not focused on or been organized to meet the needs of service businesses. Major challenges to services industries that could be taken up by universities include: (1) the adaptation and application of systems and industrial engineering concepts, methodologies, and quality-control processes to service functions and businesses; (2) the integration of technological research and social science, management, and policy research; and the (3) the education and training of engineering and science graduates prepared to deal with management, policy, and social issues. (US National Academy of Sciences, 2003; p. 8)

Perhaps the biggest issue is lack of a general theory of service with well defined questions, tools, methods, and practical implications for society. On one hand, there is the view that economics, industrial engineering, or the science of complex systems is the appropriate starting point for a general theory of service. On the other hand, there is the view that because service is so broad and pervasive in the economy, there can only be many applied or practical sciences rather than a deep scientific area of theoretical inquiry on its own. We take a view somewhere between these – between one large, general complex systems science of service and many small, specific applied sciences of service. Toward this end, we are cultivating an interdisciplinary effort that spans traditional academic areas called *Service Science, Management, and Engineering (SSME)*, which is defined as the application of scientific, management, and engineering disciplines to tasks that one organization beneficially performs for and with another (i.e., "service"). SSME aims to understand how an organization can invest effectively to create service innovations and to realize more predictable outcomes (Chesbrough & Spohrer, 2006; Maglio, Kreulen, Srinivasan, & Spohrer, 2006; Spohrer, McDavid, Maglio, & Cortada, 2006; Spohrer & Reicken, 2006). With information services and business services the fastest growing segments of the service economy – and with the rise of web services, service oriented architectures, and self-service systems – it seems there is a strong relationship between the study of service systems and the more established study of computational systems.

In what follows, we discuss the notions of service and service system, and in the process, we outline a novel approach to understanding service systems in computational terms as complex adaptive systems made of people, technology, and information.

SERVICE AND SERVICE SYSTEMS

Service can be defined as the application of competences for the benefit of another (Lusch & Vargo, 2006), meaning that service is a kind of action, performance, or promise that is exchanged for value. Service performances are done in close contact with a client, and the more knowledge intensive and customized the service, the more the service process depends critically on client participation and input, whether through clients providing labor, property, or information (Sampson & Froehle, 2006). In this way, service systems (Tien & Berg, 2003) comprise service providers and service clients working together. Providers and clients might be individuals, firms, government agencies, or any organization of people and technologies. The key is that providers and clients work together to co-create value – the client owns or controls some state that the provider is responsible for transforming according to some agreement between provider and client (Gadrey, 2002). In this line of thinking, the real competitor of service is self-service – if the client has appropriate competences and prefers self-service to service provisioning from another (Lusch & Vargo, 2006).

For example, consider universities as service providers that aim to transform student knowledge – such transformations depend on agreements, relationships, and other exchanges among students and university faculty, including courses offered and courses taken, and tuition paid and work-study arrangements. Typically, the cost of educational transformations are not borne by students completely; rather, universities are supported by a number of sources, including individual, corporate, non-profit, and government sponsors. This financial support allows universities to invest in infrastructure and other resources, offsetting the difference in the actual cost and what the market can bear in tuition. Although potentially beneficial to everyone involved, this economic arrangement results in a service equation that is much more complex than that of a single, unambiguous service client. Rather than managing a single co-production relationship, universities manage co-production relationships among multiple co-clients, each of whom who may or may not know or care about the others or about their relative needs and expectations. Expectations and results vary by client needs. The student, who experiences the service firsthand, is likely to judge the quality of the service on qualitative measures, whereas a corporate or government supporter might rely more on collective quantitative measures, such as standardized performance measures and number of graduates. Over time, universities have developed sophisticated processes and organizations to manage their complex service relationships. A university that excels in all of these service relationships – producing expected or better than expected outcomes – develops a reputation of excellence, thus generating even more interest from high-potential students and employees. The best get better. The preparedness of the student is crucial in determining the result of the service relationship. The better prepared students are to learn, the more likely their transformations will meet expectations. Excellent universities are very selective in the students they accept, which functions as a kind of standardization of client inputs into the service production system. Just as universities have adapted to support complex service provider-client relationships, and they are now adapting to information technology changes in how education is packaged, delivered, managed, and measured – alternatives to traditional university education services now include remote self-teaching, self-paced learning, and online-learning through role-playing games. In the end, it seems the university cannot be considered simply a service provider, but it is more like a complex adaptive system of people and technologies working together to create value (learning).

More precisely, we define a *service system* 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). This recursive definition of service system highlights that fact that service systems have internal structure (intra-entity services) and external structure (inter-entity services) in which value is coproduced directly or indirectly with other service systems. Individuals, families, firms, nations, and economies are all instances of service systems. The two ends of the spectrum are individuals (who exchange service with external service systems) and the entire global economy (which contains many internal service systems that exchange service). Because most service systems (e.g., families, firms, nations) have both internal service structure as well as external service structure, individuals and the global economy are special cases of service systems.

For example, one complex business-to-business service system is IT outsourcing. An IT outsourcing service provider offers to take over the operation and maintenance of client's IT investments, and to do it better and cheaper than the client can do it themselves. Thus, the provider aims to improve the efficiency of client IT operations, reducing cost over time by applying unique skills, experience, and capabilities that cannot be done effectively by the client. The size and nature of outsourcing service arrangements vary dramatically, from the multi-billion dollar mega-deals, in which the service provider takes over all IT investments of a large Fortune 100 company, to smaller deals in which the provider agrees to just take over a single functional area, such as help-desk operations or web-server operations. There are many ways to structure outsourcing agreements, including transformational or non-transformational, single source or multiple source, and resources located at client location or located at provider location. The exact structure of the deal is worked out during negotiations, and formally captured in the contract. Thus, the contract is jointly produced by provider and client. A large outsourcing deal involves professionals from many areas of the business (e.g., finance, legal, business operations, IT operations, human resources), and each area provides information for the contract. The outsourcing contract specifies the metrics by which the contract can be monitored and verified by the client. Commonly known as the Service Level Agreement (SLA), the metrics match client business objectives to valid, quantifiable service provider performance indicators. IT outsourcing SLAs often include commitments by the provider to perform some activity within an agreed to amount of time (e.g., resolve high severity IT-related problems in less than 60 minutes), or to maintain some minimal level of service availability (e.g., no more than 120 number of minutes down-time per unit month). Though SLAs are conventional and useful, achieving SLAs is just one measure of client satisfaction

IT outsourcing arrangements often involve rather complicated types of service. What are the simplest types of service? If the application of competence can be reduced to a list of instructions that one system can communicate to another, and if these instructions can be used to gain the benefit of the competence (say, through self-service), then customer input in the production process (Sampson & Frohle 2006) and application of competence for the benefit of another (Lusch & Vargo, 2006) come together as a “tell me” type of service. Thus, a conversation is a building block type of service (in which two systems exchange self-service executable competence of benefit to both). Self-help books are an example of providers trying to reduce service to a set of instructions. More sophisticated service categories include “show me,” “help me,” and “do it for me.” IT outsourcing is an example of “do it for me” type of service.

Most of the time, of course, the real world is not so simple. Many competences cannot be easily reduced to a list of easily executed instructions (e.g., riding a bike, transforming the supply chain of a business). Some service systems may not have all the requisite skills to execute the instructions (e.g., a business with a new employee who does not know the corporate culture and IT systems), or it may just be physically impossible at the current technology level for a system to perform the service themselves (e.g., heart surgeons operating on themselves) Some services lose their significance when not performed by specific entities (e.g., elevator safety inspection done by a vendor versus appropriate city agency). The execution of some competences may have side-effects and associated risks to other service systems if not executed properly, and so certification may be required as well as proof of responsibility in dealing with unintended consequences (e.g., driver licenses and car liability insurance, hospital certification and malpractice insurance). A general theory of service must clarify the characteristics of service systems and service competences that we see in everyday life – and must also clarify the value of different kinds of knowledge (e.g., “tell me versus “do it for me” and so on).

Regardless of how competence leads to action and value, shared information is required for coordination and governance. Three key types of shared information are language, laws, and prices. Without some form of language, signaling, or standard encoding of information, coordination may be difficult, leading to missed opportunities for innovation or efficiency gains (Gorman, 2004; Paton 2004). Without laws (as far as we know today), sophisticated service cannot be provisioned, and complex service systems cannot be maintained. Typically, every service system has a governing authority that seeks to ensure that all those in the service system can communicate in shared languages and abide by shared laws. In families, it is the parents; in firms, it is the CEO and Board of Directors; in cities, it is the mayor and city board; and in nations, it is government leaders and agencies, as well as shared legal documents and enforcement agencies (see also Johnson, 2002, for discussion of possible exceptions). Linguistic evolution, political science, information economics, as well as economics and law are all relevant to a general theory of service, and a deeper understanding of service system design and evolution.

Background for a Theory of Service Systems

It seems a theory of service systems – or SSME – ought to explain what service systems are and are not, how they arise and evolve, the relation between internal and external service systems, and the role of people, technology, and shared information in the system. But what motivates the choice of the four components – or building blocks – of a service system – people, technology, internal and external service systems, and shared information? Hunt (2000) refers to seven types of resources of the firm: financial, physical, legal, human, organizational, informational, and relational. These seven types of resources map well to the four service system components: people (human), technology (physical), internal and external service systems (organizational, relational), shared information (informational, legal, and financial). Nelson and Winter (2000) make the distinction between physical technology and social technology. Physical technology maps to the traditional notion of technology. Social technology maps to people (changing modes of division of labor), other service systems (new ways of organizing and governing work) and shared information (laws and language). The competences or capabilities required to provision a service between service systems are distributed among people, technology, other service systems (internal and external), and shared information. Engelbart (1962, 1980) makes similar distinctions when he refers to basic human capabilities (sensory-motor) coevolving with a human system (social technology – language, methodology, skills and knowledge, attitudes and beliefs) and tool system (physical technology - artifacts). The result of the coevolution is a capability infrastructure that can be used to augment knowledge workers and improve the collective intelligence of organizations.

Baldwin and Clark (2000) provide an in-depth analysis of the coevolution of the tools system (artifact) and the human system (industry SIC codes) for the computer industry. They identify six modular operators – (1) splitting, (2) substituting, (3) augmenting, (4) excluding, (5) inverting (such as reversing an automation step), and (6) porting (to a new standard platform) – that cover the full range of operations that service system designers can do to service systems or to any other type of human-designed artifact or system. Baldwin and Clark examine the short-term and long-term economic impact of a modularity decision (e.g., the effect of module size and visibility on incentive to experiment). Sanford (2006) explores the role of the component business model (CBM) for business design and evolution in the context of an ongoing improvement cycle: productivity (exploitation), innovation (exploration), and collaboration (internal and external value proposition revisions for sustainability and standardization). Hunt (2000) describes the role of the entrepreneur and innovation in the context of a general theory of competition, and the disequilibrium-provoking impact that innovation produces. What emerges is a picture of service systems with complex *internal* service system structure embedded in ecosystems with complex *external* service system structure.

In sum, the building blocks of service systems have figured in a number of theories, but no theory of service systems has yet been developed.

Toward a Theory of Service Systems

A general theory of service systems should consist of three bodies of knowledge:

(1) Service Systems and Their Services: Understand the origins of new service systems and new services. Understand what is and is not a service system, and what services are produced and consumed by instances and classes of services systems, both externally and internally. The role of people, technology, shared information, as well as the role of customer input in production processes and the application of competences to benefit others must be defined as well.

(2) Service System Improvements: Understand the ways a service system improves or can be improved over time through investments, including improving efficiency (improved plans, methods, and techniques for a service system), effectiveness (improved measures, goals, purpose, and key performance indicators for a service system), and sustainability (improved

value proposition results, robustness and versatility with more old and new service systems).

(3) Service System Scaling: Understand the ways improvements (new competencies) in one service system can be spread (scale out and scale up) to other service systems, both within and between types of service systems. Practically, understand the way to grow profits at an increasing rate as revenues grow, thereby creating an incentive to invest in service system scaling.

We consider each of these in turn.

First, from an economic perspective, there is a global trend in which human labor is increasingly shifting into the service industries (see Figure 1). One accelerator of this trend toward service is substitution of technology for human labor in many agricultural and manufacturing processes. Human labor involves a range of physical, mental, and social actions, from routine to highly custom and improvisational performances. Routine physical and mental human actions that need to be repeated identically, rapidly, precisely to schedule, and under precisely measurable circumstances (cf. mimeomorphic actions; Collins and Kusch, 1999), can sometimes be done more cost effectively and at higher quality levels by machines. Even some types of routine social interactions, such a selecting an item from a menu of choices, can be done with self service technologies, such as ATMS, kiosks, and e-commerce web sites. Another accelerator of this trend towards service is the decomposition of work into separable service components that allow labor to be shifted to low cost geographies (move the work to the people who can do it most cost effectively). All employees in an organization render services to complete their tasks. When work practices are reconfigured by outsourcing components (move work to people in low cost geographies, and create new work to coordinate supply and demand) or substituting technology for components (move work to technology, and create new work to build the technology), it is not uncommon to refer to the reconfiguration as a decomposition of the work into separate services as well as the creation of new services. With the rise of the internet and web services, enterprise architects are increasingly making use of service-oriented architectures (SOA) to flexibly integrate and dynamically reconfigure both human and computational services.

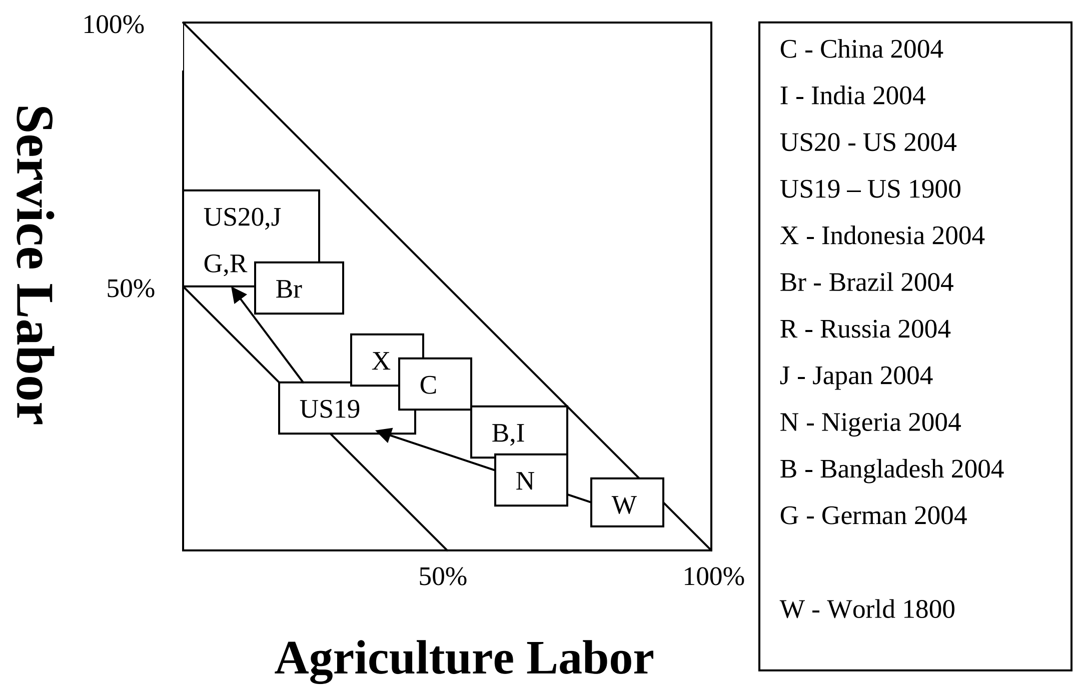

Figure 1: Labor that contributes to GDP (gross domestic product) is shifting from agriculture to services in all nations. The ten nations with the largest populations are shown.

Knowledge intensity is increasingly a part of modern service value propositions. Nearly all service industries show growth in knowledge intensity, both through more skilled labor (advanced degrees, years of experience, and certification required) and more use of advanced technology. Even service industries, such as retail and hospitality franchises, with value propositions based on low cost and generic skill labor, invest heavily in advanced technological and organizational infrastructures that ensure quality, compliance with standards, and productivity.

Second, understanding service system improvements and failures to improve is important to a theory of service systems. A service system that is improving year over year can be viewed as a learning organization (March, 1999), seeking to balance exploitation of known competence with exploration for new competence. We propose a triple loop learning model (related to double loop learning, see Argyris, 1999) that is based on evaluating return on investments of transformation efforts to improve:

(1) Efficiency (Plans): Things are done in the right way.

(2) Effectiveness (Goals): The right things get done.

(3) Sustainability (Relationships): The right relationships exist with other service systems so that diverse options for future value propositions are possible (dependent sustainability), as well as self service is an option based on internal competences (independent sustainability).

Using shared information that ranges from news reports to polls and surveys to comprehensive government and scientific studies, service systems are able to compare themselves to each other along the efficiency, effectiveness, and sustainability dimensions. Using private internal information, service systems are also able to compare their current state to previous states, and identify historical trends in key performance indicators or KPIs. Well known service systems with excellent reputations routinely receive many value proposition proposals from other service systems to coproduce value. Reputation is often critically important to sustainability. Sustainability is also enhanced in another way by the amount of shared information available to all service systems in an ecology of service systems. Access to shared information that describes how to perform many different types services can enhance the versatility of service systems and allow service systems to exploit self service when there is a paucity of external value propositions from which to choose. Efficiency concerns tend to push service systems towards over specialization, while sustainability concerns tend to push service systems towards diversification and general competences. Effectiveness concerns tend to push service systems towards value propositions with the highest returns and longest expected time horizon for high returns to continue, to lower expensive transformation cost run rates.

Third, under what conditions does a service system expand its boundaries, that is, scale up and grow? For example, consider franchises and on-line e-commerce. In the last fifty years, the business landscape has been transformed by the growth of franchises. Franchises have been able to attract both owners and employees of local, homegrown businesses to shift to the franchise model. The franchise model enjoys many economies of scale that local, homegrown businesses do not. Marketing, supply chain, and R&D for continuous improvement to name a few. From the perspective of mobile service clients, franchises exploit shared information to provide a standard service experience and value proposition, independent of location. Another recent advance related to scaling of service systems are e-commerce web sites. Access to a standard on-line service, independent of geographic constraints, can allow a service system to scale up external service transactions (sales) as well as internal service transactions (capacity) more efficiently. The ability of a service system to scale up depends on many factors, but most important is the nature of the resources that the service system is integrating to realize the competence being delivered as service. Consider the three types of key resources that make up all service:

(1) People: Human resources typically become more expensive the more they are needed and the longer it takes to educate them or get them to competent performace. For example, there are only a limited number of people in any profession, and to create more people with those professional skills takes time and educational investments. So to scale a service system that depends on human resources may require seeking out labor from another less expensive geography (e.g., India), repurposing and retraining people from another industry sector (e.g., manufacturing or agriculture migrate to services, see Figure 1), or identifying demographic segments yet to join the labor force (e.g., woman joining the workforce).

(2) Technology: Technological resources are like most physical material supplies in that typically the more one buys, the lower the price one can obtain from vendors.

The incremental cost of the next unit of production is lower than the last. Thus, advantages of scale can typically be realized if a service system is an integrator of technology or other types of physical material resources.

(3) Shared Information: Informational resources (e.g., software) enjoy incredible scale efficiency because of the small incremental cost in duplicating them. The next unit of an informational resource has virtually zero cost to create. Nevertheless, pirating and illegal copying can erode some of the advantages of scaling service systems based on informational resources.

Service systems integrate people, technology, and information resources in different proportions. As a result, service systems are all unique, resulting in situations where revenue and profits scale differently. The revenue and profit scaling properties of firms based on software (information, intellectual property), product (technology), software as a service (SaaS), as well as high and low skill labor based services are often compared (see Figure 2).

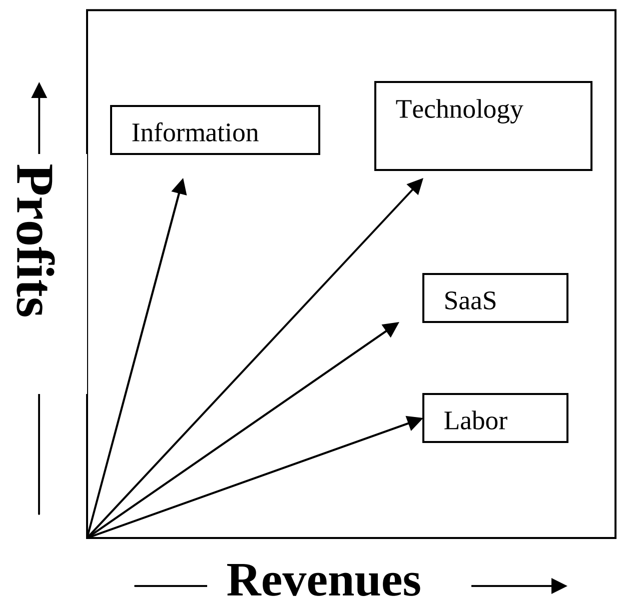

Figure 2: Revenue and profits scale differently in service systems that integrate different types of resources. In general, cost of duplicating information is lowest, technology medium, and labor highest. Software as a Service (SaaS) requires labor to run the technology hosting centers that run the software.

A general theory of service systems should include at least three bodies of knowledge: What they are, how they improve, and how they scale. Because information technology is such an important part of service systems today, one good question is "How are service systems similar to and different from computational systems?" The main difference is people. The largest service system, the global economy, includes more than six billion of them. Some large firms have hundreds of thousands of employees. People do a lot of the work – and that work can be physical, mental, or social in nature. Furthermore, unlike components of computational systems, behavior of people doing work in service systems cannot be easily modeled and simulated. For instance, people are only partially governed by laws and policies. Even when citizens and employees know government laws and corporate policies (and they often don't), there is not 100% compliance. This creates risk. So perhaps modeling people as components with stochastic behavior would allow existing theories of computational systems to be applied to service systems. For example, the notion of trust is well developed in fields of computer science that deal with privacy protection and secure systems. But non-compliance not only creates modeling complexities and risks, it also creates opportunities. Most innovations can be viewed as breaking a rule or violating a policy. How can we tell the difference between cheating and innovation in a service system, where people informally and formally change rules and policies?

Service systems are complex adaptive systems made up of people, and people are complex and adaptive themselves. Service systems are not simple and optimized. They are dynamic and open. And there are any different kinds of value. Financial value is only one type – others include relationship and reputation value. Mechanism design theory, a new branch of theoretical computer science integrated with game theory and economics, introduces the notion of a social utility function in the context of computational systems. A fundamental problem in economics (principle-agent) and game theory (prisoners dilemma) hinges on the fact that sometimes individual and collective goals are not aligned – and therefore all value that a system could capture may not be captured if decisions and behavior are not coordinated properly (e.g., Beinhocker, 2006; Roughgarden, 2005). The emerging field of incentive engineering, which is increasingly studied by human capital management students in business schools, addresses the problem of incentive alignment of individuals and larger groups. The emerging field of service science seeks to tap into these and other relevant bodies of knowledge, integrate them, and advance three goals – aiming ultimately to understand service systems, how they improve, and how they scale.

SUMMARY

We have argued that service and service systems are appropriate objects of study, and that a science of service can provide a foundation for creating lasting improvements to service systems. Nevertheless, we are only at the beginning of this effort. Here, we have begun the discussion by sketching answers to a few basic questions about service and service systems.

> **What is service?** Service is the application of competences (by the provider) for the benefit of another (the client). Self-service is one of its main competitors, as it eliminates the need for the provider in service provisioning. The degree to which an exchange is a service exchange is related to the degree that unique client input and unique provider competences are essential to realize mutual benefit. If all entities have the competence to provide a service, and all entities have frequent, standardized need of the service, then situational factors determine whether service or self-service is used, and the service would have relatively low knowledge value.

> **What is a service system?** We introduced the abstract notion of a service system to refer to entities that exchange service for mutual benefit. The complex internal structure of service systems includes value coproduction configurations of people, technology, internal and external service systems, and shared information (such as language and

laws). The complex external structure of service systems (service system ecologies) is sustained through the maintenance of win-win value propositions. Competition and innovation act as disequilibrium-provoking forces. Business firms and nations can be viewed as service systems. Families and cities can also be viewed as service systems. Individual people are a special type of service systems, as they do not have internal service system structure. The complete global economy is a special type of service system, as it does not have external service system structure.

Service science or SSME aims to understand and catalog service systems, and apply that understanding to advancing our ability to design, improve, and scale service systems for practical business and societal purposes (efficiency, effectiveness, and sustainability). The study of services systems is an integrative, multidisciplinary undertaking and many disciplines have knowledge and methods to contribute. In this paper, we have set out the context and background, and pointed toward one possible direction for SSME, namely a focus on service systems and on computational approaches to understanding sociotechnical systems. But nothing is settled. And much work remains to be done.

ACKNOWLEDGMENTS

We thank Michael Maximilien for helpful comments on an early draft.

REFERENCES

Argyris, Chris (1999) On Organizational Learning. Blackwell Publishers. Oxford, England.

Baldwin, C.Y. and Clark, K.B. (2000) Design rules: The power of modularity. MIT Press. Cambridge, MA.

Beinhocker, E.D. (2006) The origin of wealth: Evolution, complexity, and the radical remaking of economics. Harvard Business School Press. Cambridge, MA.

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

Collins, Harry and Marin Kusch (1999) The Shape of Actions: What Humans and Machines Can Do. MIT Press. Cambridge, MA.

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.

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.

Hunt, Shelby (2000) A general theory of competition: Resources, competences, productivity, and economic growth. Sage. Thousand Oaks, CA.

Johnson, S. (2002). Emergence: The connected lives of ants, brains, cities, and software. Scribner.

Lusch, R.F. and S.L. Vargo (2006) The Service-Dominant Logic of Marketing: Dialog, Debate, and Directions. Editors. M.E. Sharpe. Armonk, NY.

Maglio, P.M. and J. Spohrer (2006) SSME. Production and Operations Management. In Press.

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

March, James G. (1999) The Pursuit of Organizational Intelligence. Blackwell Publishers. Oxford, England.

Nelson, R.R. and S.G. Winter (1982) An evolutionary theory of economic change. Belknap/Harvard University. Cambridge, MA.

Paton, B. (2004) Two pathways to energy efficiency: An energy star case study. Human Ecology Review. 11(3). 247-259.

Roughgarden, Tim (2005) Selfish Routing and the Price of Anarchy. MIT Press. Cambridge, MA.

Sanford, L.S. (2006) Let go to grow: Escaping the commodity trap. Prentice Hall. New York, NY.

Sampson, S.E. & C.M. Froehle (2006) Foundations and implications of a proposed unified services theory. Production and Operations Management. 15(2).

Spohrer, J. & D. Riecken (2006), Special Issue: Services science. Communications of the ACM. 49(7). July. 30 – 87.

Spohrer, J., P. P. Maglio, D. McDavid, & J. Cortada (2006) Convergence and coevolution: Towards a services science. In Nanotechnology: Societal Implications: Maximising Benefits for

Humanity and Nanotechnology and Society, editors Mihail C. Roco and William S. Bainbridge. Springer. New York, NY.

Sterman, John D. (2000) Business Dynamics: Systems Thinking and Modeling for a Complex World. McGraw-Hill. New York, NY.

Tien, J. M., & D. Berg. (2003). A case for service systems engineering. The Journal of Systems Science and Systems Engineering. 12 (1), 113-28.

U.S. National Academy of Engineering (2003) Report on "The Impact of Academic Research on Industrial Performance”