Service Systems Engineering

A Field for Future Information Systems Research

Service systems are complex socio-technical systems that enable value co-creation. Service systems engineering (SSE) calls for research on evidence-based design knowledge for such systems that permeate our society. Information systems research is ideally positioned to contribute significantly to trans-disciplinary research in this area through (action) design research or the piloting of IT-enabled innovation. Better IS-based design knowledge could particularly advance the architecture, the interactions, and the resource base of service systems, helping value creation to become better adapted to the context of need and opportunities for collaboration between customers and service providers.

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1 Relevance and Timeliness of the Topic for Business and Information Systems Engineering

Service has evolved into a key concept for research in information systems (Rai and Sambamurthy 2006; Buhl et al. 2008; Satzger et al. 2010; Leimeister 2012). The diversity and number of publications focusing on service in information systems has risen markedly in recent years (Fielt et al. 2013).[1] Private and public organizations alike increasingly use a service logic to develop and manage their activities, creating new opportunities for innovation (Chesbrough and Spohrer 2006; Chesbrough 2011).

The service logic marks a paradigm shift in practice as well as in theory. Service logic posits that value is created through collaboration and contextualization. According to service-dominant logic, service is a collaborative process creating context-specific value (Vargo and Lusch 2004; Edvardsson et al. 2011). Collaboration implies that different actors interactively engage in the co-creation of value, moving away from a strict distinction between producer and consumer (Lusch et al. 2007; Möslein and Kölling 2007). The notion of value-in-use or, more recently, value-in-context emphasizes that value is often bound to a specific context, e.g., a unique situation in the life of an individual or a distinct set of organizational goals and challenges (Edvardsson et al. 2011). Through contextualization, service achieves mutual economic and emotional benefits.

Contextualization and collaboration are both information-intensive aspects of value creation (Karmarkar 2004; Lusch et al. 2007). The realization of these aspects thus rests critically on information

[1] The growing academic interest becomes evident in the foundation of a special interest group on services within AIS (SIGSVC), a dedicated track at ICIS 2011, related tracks at Wirtschaftsinformatik, ICIS, ECIS, HICSS, MKWI and AMCIS conferences, and a number of high-profile journal special issues, such as in MISQ, JMIS, and JSIS. Larger research groups around service engineering and management can be found (amongst others) in Augsburg, Frankfurt, Hamburg, Karlsruhe, Kassel, Leipzig, München, Münster, Nürnberg-Erlangen, Osnabrück, Stuttgart, St. Gallen and Zürich.

systems and information-based mechanisms. As a consequence, it is often through advances in information systems that innovative service business models become possible and are able to transform business with collaboration and contextualization.

Maglio et al. (2009) and Alter (2011, 2012) propose that research on service should adopt a systems perspective. Guided by a value proposition, service systems enable value co-creation through configuration of actors and resources (Vargo and Lusch 2004). Actors refer to human agents with their knowledge and skills that participate in co-creation (Maglio et al. 2009; Alter 2012). Resources include, among others, technology, information, and physical artifacts (Alter 2012). The systems perspective allows addressing the architecture of service systems by recognizing the connectedness and complementarity of these elements in enabling value co-creation (Voss and Hsuan 2009; Alter 2012). Given the key role of actors and information as a resource in service systems, we conceptualize a service system as a socio-technical system that enables value co-creation guided by a value proposition.

Service systems engineering (SSE) focuses on the systematic design and development of service systems. This conceptualization is a departure from traditional service engineering research. Traditional service engineering (SE) proposes models, methods and principles to engineer individual services (Leimeister 2012), often adapting approaches from product and software engineering for this purpose (Bullinger et al. 2003; Thomas and Nüttgens 2010). Traditional service engineering has advanced the industrialization of services (Karmarkar 2004; Walter et al. 2007). Yet, its inherited product-centric thinking does not reflect service-centric business models and strategy (Ostrom et al. 2010) nor does extant service engineering research take full advantage of the opportunities for systemic, interactive, and collaborative service innovation based on advances in IT (Spohrer and Kwan 2009).

More fundamentally, a number of service researchers have promoted the vision of establishing a service science as a new academic discipline (Chesbrough and Spohrer 2006). While such a discipline has not emerged, these developments emphasize the systemic and trans-disciplinary nature of service-related research challenges and prompted a markedly higher research activity in many disciplines, including IS (e.g., Fielt et al. 2013). Service science in general and service engineering research in particular have achieved important conceptual advances. What is missing, however, is evidence-based design knowledge rooted in the design, implementation, and evaluation of real-world service systems (Satzger et al. 2010).

Service systems engineering seeks to fill this gap. It takes the service system as the basic unit of analysis. IS as an integrative discipline is well equipped with mental models, tools, methods and approaches to engineer these complex intangible systems. This mindset drives our understanding of service systems towards more precise models of service systems that are attuned to design and operations (e.g., Alter 2012). Information systems research is also well equipped to enhance the opportunities for interactive and collaborative engineering of the service systems of the future. Moreover, IS can contribute to the architecture of multi-sided service systems that provide the platform for novel forms of service innovation.

In recent years, service logic has diffused increasingly into academic theory and business models. What is needed are systems that realize this service thinking by leveraging people and technology. The IS discipline is therefore in a unique position to spearhead the efforts in advancing the architecture, interaction, and resource base of these service systems with evidence-based design knowledge.

2 Problem Statement and Research Challenges

2.1 Designing the Foundation for Value Co-creation

Research on service systems engineering responds to the paradigm shift associated with service logic. Service systems engineering seeks to advance evidence-based design knowledge on service systems that enhance collaborative and contextualized value creation. To date, there is a lack of such design and engineering knowledge. This lack of design knowledge inhibits innovating with service systems in many different contexts, ranging from manufacturing to health care.

Service systems engineering thus calls for research leading to actionable knowledge for systematically designing, developing and piloting service systems, based upon understanding the underlying principles of service systems. However, service systems are hard to delineate, complex by nature and include not only data and physical components, but also layers of knowledge, communication channels and networked actors. This equally applies to service systems in manufacturing, healthcare, energy, or security. It might be appealing and promising to research these systems from a domain-specific perspective. However, from a theoretical and methodological viewpoint it is far more promising to focus on the underlying principles that unite these systems and help us to understand their systematic engineering under conditions of instability and change (e.g., Bullinger and Scheer 2006; Luczak 2004).

Against this background, we see three key challenges for SSE:

- Engineering service architectures,
- Engineering service systems interactions, and
- Engineering resource mobilization.

Each of the challenges addresses a key characteristic of service systems. We posit that service systems engineering should focus on the research challenges of service systems that enable novel value propositions, i.e. service architecture, enhancing interactions within processes of co-creation, and mobilizing resources (**Fig. 1**).

2.2 Engineering Service Architectures

Architecture is a concept that is used in many disciplines to describe the decomposition of a system into functional components as well as the interactions of these components in delivering overall system outputs (Baldwin and Clark 2000). It is applied equally to service systems (Böhmann 2004; Voss and Hsuan 2009). Service architecture transforms the value proposition of a service system into a configuration of actors, resources, and activities of value co-creation (Böhmann 2004; Alter 2011). Service architectures also determine system-wide properties of service systems such as speed (Alter 2008; Becker et al. 2012). Research challenges on the architectural level need to address the architectural innovation for realizing novel value propositions and system-wide properties, the alignment of technical architecture and service architecture in technology-based service as well as advanced models, methods, and tools for service architecture development.

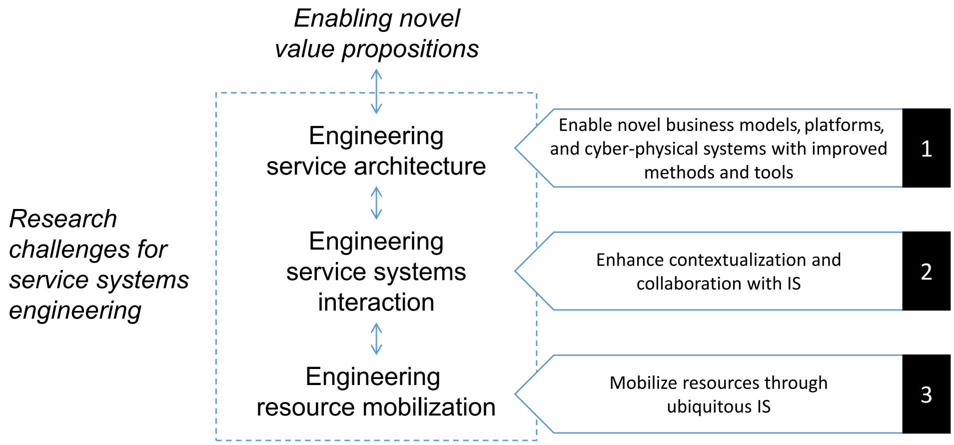

Fig. 1 Research challenges for service systems engineering

Architectural Innovation Innovation in the value proposition of a service system or system-wide properties has a significant impact on service architecture. A key challenge is to enable collaborative and contextualized value creation on an architectural level. In a multi-sided value logic, for example, value is not only created in a simple dichotomy of customer and provider, but involves parallel processes of collaborative value creation with multiple stakeholders (Benkler 2006; Blau et al. 2009). The realization of a multi-sided value logic requires advancing design knowledge on service architecture that allows fusing service by multiple stakeholders into coherent processes of value co-creation. Moreover, system-wide properties call for architectural innovation. The need to make service systems adaptive to specific contexts creates additional complexity and risks. Thus, next to well-known properties such as flexibility service architectures of the future also need to address resilience (Riolli and Savicki 2003). Resilient service systems maintain performance under adverse conditions and quickly recover from failure. This is a critical architectural property of service systems in the context of increasing environmental risks and security threats.

Cyber-Physical Systems Contexts Service systems are increasingly based on technology. In the wake of this development, physical goods and service increasingly fuse into product-service-systems or hybrid products (Leimeister and Glauner 2008). Information systems research addressed this challenge early on[2] but now the next level of this development emerges in the form of cyber-physical systems where physical and virtual worlds merge (Broy 2010), service systems engineering has to bridge the boundaries of tangible and intangible resources. The ubiquitous availability of data and vast opportunities for automation extend the playground for service systems innovation significantly. Machine intelligence in conjunction with human intelligence allows for new forms of resource bundling and service provision. Service systems emerge into an inherent component of industrial production systems and new business models in manufacturing (Kempf 2013; Zolnowski et al. 2011). To date, however, the lack of design knowledge on such architectures limits the opportunities for taking advantage of cyber-physical systems to engineer innovative service systems.

Advanced Models, Methods, and Tools for Service Architecture Development Across all research challenges, service engineering models, methods, and tools rarely focus on the development of service architectures. While there is already a solid knowledge base on service engineering (e.g., Bullinger and Scheer 2006; Luczak 2004), novel work should seek to enhance the possibilities for modularization, standardization, contextualization and re-configuration of service components and resources, as well as for modeling and simulation of the behavior of service systems and their key actors.

2.3 Engineering Service Systems Interactions

Maglio et al. (2009) emphasize interactions with service systems as a key focus for service research with a systems lens. Advances in information and communication technology provide the opportunity to innovate with regard to these interactions. The diffusion of stationary and mobile internet access as well as smart sensors allow the design and engineering of novel forms of information-intensive interactions with and in service systems. For example, these novel interactions make use of information of the location and the audio-visual environment of individuals, or the state of devices connected to a network. These novel forms of interaction significantly expand the opportunities for contextualization and collaboration (Kieliszewski et al. 2011). Service systems engineering should be able to draw on reliable design knowledge on information-intensive service systems interactions. This calls for a much deeper understanding of the underlying principles of service systems interaction thus also enabling new ways of to theory-inspired design. Moreover, service systems engineering should be able to draw on rigorous evaluation of patterns and components for information-intensive interactions. In addition, rigorous design research is required on the impact of specific interactions on the perceptions of service systems. Examples of such work are interaction components that refine our notions of intensity and variability (Glushko and Tabas 2009) or stimulate trust (Leimeister et al. 2005). Future work could focus on critical interactions with service systems, in particular the initiation of service as well as the recovery from service failure and ensuring conflict resolution.

Moreover, there is a need to better understand and improve design meth-

[2]Cf. the special focus of WIRTSCHAFTSINFORMATIK 3/2008.

ods for service systems interactions. A key question pertains to embedding IT-enabled interactions into a choice of channels through which interactions can be conducted (Patrício et al. 2008). Service systems engineering can benefit from a close exchange with researchers in human-computer interaction. Moreover, this is a field that could benefit from simulation of interactions in laboratory settings, e.g., through the use of virtual reality (Meiren and Karni 2005) and robust usability testing.

2.4 Engineering Resource Mobilization

One of the key effects of ubiquitous information systems is the mobilization of resources for value co-creation in service systems beyond what was possible until recently. We understand mobilization as extending the access to and the use of resources. In this context, IT helps to:

- mobilize human resources, e.g., through micro-tasking (Kern et al. 2010) or service portals that connect the knowledge and skill of actors in seeking and providing service,
- mobilize physical resources, e.g., through resource sharing portals improving access to and utilization of privately-owned fixed assets such as cars, housing, etc.,
- mobilize information resources, e.g., through user generated content (Leimeister et al. 2009) or open data (Lindman et al. 2013).

To leverage these opportunities, service systems engineering can be advanced through research on IT-based mechanisms and components that facilitate the mobilization of resources. Also, the multitude of service system interactions spurs the emergence of new resources, especially information resources that users collect and share. Yet, the use of such resources also exacerbates one of the main challenges in modern service systems: the interplay of people-bound activities, IT components, and community functions. This calls for interdisciplinary research to realize the potential for service system innovation in this area (Menschner et al. 2011). Engineering the resource mobilization of service systems is therefore a key prerequisite for the systems' successful implementation and adoption in future organizations and markets.

3 Towards Evidence-Based Engineering: Scientific Methods Relevant to Solve the Problem

Service systems engineering emphasizes the importance of design knowledge on service systems. Three arguments support this focus. The first argument rests on the conceptualization of service as being contextual and collaborative. The complex socio-technical context of service systems and their rich scope for collaboration restrict the opportunities for meaningful laboratory-style research. Obtaining design knowledge with strong external validity thus requires research to be embedded within a service system or calls researchers to design novel service systems. In order to develop an understanding of the interaction of such complex social-technical entities, approaches that embed research in a real-world context are likely to generate superior design knowledge.

The second argument acknowledges that new information technologies have the potential to enable new and unknown service systems. However, such novel service systems only emerge if actors accept both the technology and the service. Recent studies underline the potential of involving customers, as this can result in more innovative service that has greater user value (Magnusson 2003). Additionally, as requirements of actors in a service system are often "sticky" information, significant costs are involved in eliciting these requirements in non-participatory design settings (Oliveira and von Hippel 2009). Hence, participatory design and prototyping approaches are also paramount for understanding successful engineering of highly accepted service systems.

The third argument is that service systems engineering seeks to advance knowledge on models, methods, and artifacts that enable or support the engineering of service systems. Such knowledge types per se favor design-oriented research approaches.

Thus, the most prominent research approaches for service systems engineering are design science research (Peffers et al. 2007; Gregor and Hevner 2013), action research (Susman 1983) or piloting of innovations (Schwabe and Krcmar 2000). Design science aims to develop solutions to organizational and business problems through design and evaluation of novel artifacts. The design process is informed by existing theories which are applied and extended through problem-solving. The iterative design process generally consists of analyses, design, implementation and evaluation of an artifact (Simon 1996; Hevner et al. 2004). Yet, research service systems engineering with doctrinal design research faces critical challenges. The complexity of service systems can limit opportunities for iteration and evaluation. Furthermore, many real world settings do not allow for applying a refined version of the design to the identical problem in the same context and compare and evaluate its differences, as contexts and problems evolve.

Recent approaches try to overcome these issues by combining design research with action research (Sein et al. 2011), leading to action design research. Action research combines theory development with researcher intervention to solve immediate organizational or real-world problems in general (Baskerville and Wood-Harper 1998). It also requires reflection, learning, and formalization of the learning (Sein et al. 2011). Following these ideas, typical research initiatives contain several design science projects, which are used to reflect and learn about the design and redesign and to formalize this knowledge into principles and methods suitable to a class of field problems (Sein et al. 2011).

The most demanding but most promising way to realize action design research is the piloting of novel service systems. Piloting involves considerable complexity but allows for the robust evaluation of the feasibility of complex service systems innovations and their real-world effects (Schwabe and Krcmar 2000). By focusing on economic and societal needs, service systems innovation can improve the impact of research on business and society, e.g., by improving health care systems (http://www.psychenet.de), civic life (www.il.iwi.unisg.ch), or sustainable mobility (Acatech 2011). In particular, field-based pilot studies on novel service systems in medical research point the way to rigorous evaluation in order to provide evidence-based design knowledge on service systems.

This is not to argue that other research approaches cannot or should not contribute to service systems engineering. Methods of qualitative and quantitative empirical research provide the foundation for rigorous evaluation. Moreover, empirical research that strives to advance theory on service, specific aspects of service systems, or processes of developing service systems provides valuable insights for better informed service systems engineering. At the same time, we argue that information system research can develop a distinct advantage in design-oriented research compared to some reference disciplines, such as service marketing.

Despite this call for field-based, participatory and design-oriented research, extant research in the field of services and service systems is to date often phenomenological or descriptive or highly selective or reductionist in nature (e.g., only on technical or managerial aspects). Following Gregor's (2006) categorization of theories, most theoretical approaches in service systems research address either theories for explanation, with a minimal amount of kernel theories or components and limited empirically robust theory testing. Little research exists on service systems engineering that develops or tests theories for prediction, theories for prediction and explanation or even theories for design and action. Service systems engineering thus offers vast opportunities for theory development and testing on all levels.

4 Relevant Academic Disciplines and Examples of Initial Results

The adoption of the service systems concept in information systems research has been stimulated through conceptual advances in reference disciplines, such as, marketing (Grönroos 2008; Vargo and Lusch 2004), innovation (Tidd and Hull 2003), operations (Pullman and Thompson 2003), engineering (Bullinger et al. 2003), service computing (Papazoglou 2003), as well as organizational (Edvardsson et al. 2011) or people issues (Oliva and Sterman 2001). Rust (2004) already called "for a wider range of service research". While information systems research can and should contribute substantially to addressing the above listed three research challenges, each of the challenges affords or even requires interdisciplinary approaches (Satzger et al. 2010). Although such interdisciplinary work is still inhibited by disciplinary boundaries and the emergence of a separate discipline of service science is not to be expected in the near future, we see growing awareness of the service-related contributions across disciplinary boundaries (Fielt et al. 2013) as well as an increased openness for the publication of interdisciplinary work related to service research.[3]

Service systems engineering opens up manifold opportunities to advance research and innovation. We argue that many of the grand challenges that dominate the innovation policy in Europe and Germany would benefit from the integrative approach to designing systems of value co-creation as the process of servitization transforms these areas. The relevance of the service systems engineering becomes especially visible and tangible at leading IT trade shows such as Cebit, where the trend towards a service logic and the intersection with IS can be grasped immediately even by the relevant public through exemplary initiatives as "Trusted Cloud", "Smart Factory", or "E-Energy". We also argue that these initiatives not only illustrate achievements in the field but highlight the role of our discipline and the need for future research within IS.

One exemplary emerging area of research for service systems engineering is hybrid value creation. The integration of products and service inspired research from multiple disciplines, including IS (Becker and Krcmar 2008). This area of research clearly advances early work on service engineering. Over the years, researchers in this field have particularly contributed to our understanding of the architecture and interactions of service systems. IS researchers have constructed methods for developing modular architectures for integrated solutions (Böhmann et al. 2008) or product-service-systems (Thomas et al. 2008). Others enable the organizational integration of products and service through mobile information systems (Fellmann et al. 2011), IT-based boundary objects (Becker et al. 2012) or contracting and pricing processes (Bonnemeier et al. 2010). Finally, IS researchers have used IT to develop novel modes of interacting with service systems that integrate products and service in particular domains, such as healthcare and well-being (Knebel et al. 2007). Future developments in manufacturing can leverage the design knowledge generated in research on hybrid value creation, but more research is needed to architect service platforms for the next generation of industrial manufacturing based on cyber-physical systems (Industry 4.0).

Another promising area for applying service systems engineering are novel approaches to sustainable mobility. Innovation in this area can leverage the opportunities for mobilizing resources (e.g., sharing private vehicles), novel forms of service system interactions (e.g., mobility apps), and new architectures that integrate seamlessly previously separate service systems (e.g., public transport and car sharing). Similar arguments hold for patient-centered healthcare, independent living well into old age, or the restructuring of energy supply and consumption.

To date, all too often research and innovation in these fields focus on new technology. By leveraging these technological advances for enhancing or creating service systems, technology becomes embedded into value co-creation for the benefit of customers, service providers, and often society at large. All major forward-looking projects of the German high-tech strategy cannot realize their full potential without the ability to systematically and reliably engineer complex interactive service systems. The strategies and practicalities for achieving these goals will be developed and implemented in the next 10 to 15 years. Our discipline can take the driving seat in making it happen.

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[3] Cf. recent special issues on "Service innovation in the digital age" in MIS Quarterly and on "IT-related service: a multidisciplinary perspective" in the Journal of Service Research, both with an interdiscplinary board of editors.

Abstract

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A Field for Future Information Systems Research

Service systems engineering (SSE) focuses on the systematic design and development of service systems. Guided by a value proposition, service systems enable value co-creation through a configuration of actors and resources (often including a service architecture, technology, information, and physical artifacts), therefore constituting complex socio-technical systems. IS research can play a leading role in understanding and developing service systems. SSE calls for research leading to actionable design theories, methods and approaches for systematically designing, developing and piloting service systems, based upon understanding the underlying principles of service systems. Three major challenges have been identified: engineering service architectures, engineering service systems interactions, and engineering resource mobilization, i.e. extending the access to and use of resources by means of IT. Researching SSE is challenging. Assessing the models, methods, or artifacts of SSE often requires embedded research within existing or even novel service systems. Consequently, approaches such as piloting IT-based innovations, design research or action research are the most promising for SSE research. As an integrative discipline, IS is in a unique position to spearhead the efforts in advancing the architecture, interaction, and resource base of service systems with evidence-based design.

Keywords: Service, Service systems, Service science, Design, Piloting, Research agenda, Value co-creation, Service-dominant logic, Service architecture

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