Expanding Impacts of Technology-Assisted Service Systems through Generalization – Case Study of the Japanese Service Engineering Research Project

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This is an accepted manuscript by Service Science.

Watanabe, K. and Mochimaru, M., 2017, "Expanding Impacts of Technology-Assisted Service Systems Through Generalization: Case Study of the Japanese Service Engineering Research Project," Service Science, Vol. 9, Issue 3, pp. 250-262.

The published version is found at: https://doi.org/10.1287/serv.2017.0183

Abstract

The importance of technologies for services has been remarkably emphasized recently with the terms digitalization and smart service systems. Technologies, especially ICT have been regarded as an important driver to innovate services, and various researchers on services and service systems have investigated the development of technology-assisted service systems and its methods. However, few studies report how to generalize and disseminate developed service systems and technologies for other service systems. This type of study is essential to expand the impact of the study on technology-assisted service systems in the industrial and societal level.

As our research question, we examined the necessary processes and deliverables to develop and disseminate technology-assisted service systems. We analyzed five cases of a service engineering research project in Japan, which aimed at improving service industry productivity through disseminating developed technologies. We conducted the semi-structured interviews with the researchers responsible in each case. As a result, we clarified the generalization process through continuous co-development with stakeholders in the same or different service systems. We also specified a set of research outputs: technology, activity guideline and application process, designated as a technological support model for service system. The features of these outputs can be emphasized by categorizing them into three types: knowledge-worker support model, organization management support model and association management support model. These processes and outputs provide a practical guideline to develop and disseminate technology-assisted service systems effectively.

1. Introduction

The importance of technologies for services has been increasingly emphasized because of recent technological advancements in the areas of human behavior sensing technologies, Internet of Things (IoT), and data analytics (Maglio 2015). Digitalization using these new technologies is expected to transform services, making them more effective and personalized (D'Emidio et al. 2015). Under these circumstances, development of technologies for innovating services is becoming increasingly important.

In the service research domain, technology is regarded as a part of service systems in which stakeholders interact to create value (Edvardsson and Olsson 1996). Service systems include stakeholders of different kinds with diverse roles and preferences (Spohrer and Kwan 2009), which makes it difficult to implement technologies for them effectively. To overcome this difficulty, several recent studies have already provided meaningful insights for development of technology-assisted service systems (Tuunanen et al. 2011, Dominguez-Péry et al. 2013, Wallin et al. 2015). However, these studies discuss mainly adaptation and integration of specific types of technologies and service systems. Few studies have revealed means of making some or all of developed service systems and technologies applicable to different service systems. Without such studies, it is difficult to expand the impact of developed service systems and technologies to the industrial or societal level.

This study investigated how to generalize technology-assisted service systems for multiple service systems. The deliverables for other service systems can include not only technologies but also deliverables of other types such as methods and processes. We still accept existing thought on the matter, which takes technology as a part of a service system, but we further explore the possibility of making a developed service system and technology in a more generalized form. This study especially focuses on regional services, including public, private and non-profit organizations, which contribute to local economies and societies. Polarization of economic growth among regions has been recognized as a global challenge from economic and social development perspectives (OECD 2009). Considering growing impacts of services under the service economy, innovating management and operation of regional services by means of technologies, especially ICT is meaningful for regional development, which also leads to national-level economic growth (OECD 2009). However, most of service providers are small- and medium-sized organizations and tend to receive insufficient benefit from ICT due to lack of resources and knowledge (Consoli 2012). Generalized technology-assisted service systems is required especially for these regional services, and also for following regional and national-level development.

For this purpose, we analyze five cases from a service engineering research project conducted in Japan during 2009–2012. This project was undertaken to develop technologies that can promote the productivity of services. As our research question, we examine what the necessary processes and deliverables are to develop and disseminate technology-assisted service systems.

The remainder of this paper proceeds from a theoretical background on development of service systems and technologies in Section 2. Section 3 explains the research method and target cases. Findings related to the case study are presented in Section 4. Research discussions related to these findings are presented in Section 5. Finally, we conclude this paper by summarizing research results in Section 6.

2. Theoretical Background

2.1 Role of technologies in service research

First, we introduce how the role of technology has been discussed in service research. In the early age of service research, industrial technology that had been nurtured in manufacturing industries was applied to service sectors to improve service productivity and quality through standardization of processes and deliverables under the scheme of "industrialization of services" (Levitt 1976, Sundbo 2002). On the contrary, service innovation research later emphasized the importance of non-technological aspects for innovating services, such as process, organizational and business model changes (Gallouj and Weinstein, 1997, Sundbo 1997, 1999). Especially, customer participation in developing services (Edvardsson and Olsson 1996, Sundbo 1997) and a learning process in organizations (Sundbo 1997) are more emphasized in service innovation.

Meanwhile, technologies, especially information and communications technologies (ICT) have been regarded as an important element to promote innovation in organizations (Sundbo 1999, Maglio et al. 2009, Randhawa and Scerri 2015). Especially, recent technological evolution in ICT domains accelerates studies of new technology utilization in services. Digitalization is regarded as an effective strategy to create new services and to adapt to individual differences of customers (D'Emidio et al. 2015, McPhee et al. 2015). The dissemination of ICT devices such as smartphones has enabled new types of business models such as sharing businesses (D'Emidio et al. 2015). In the manufacturing sector, data collection through sensors in products realized new types of services such as asset monitoring and remote maintenance (Baines and Lightfoot 2013). Data analysis methods can help better operation in service systems, for example through rule changes to decrease parity in opportunity and competition among stakeholders (Spohrer and Kwan, 2013). Under these circumstances, the development and utilization of technologies for services are becoming more important with linkage to the previously described non-technological approaches for innovation in services. Further integration of technologies in service systems is being anticipated, which is represented in the recent terms “smart service systems” (Medina-Borja 2015).

2.2 Development of technology-assisted service systems

In this section, we introduce several research activities related to development of service systems assisted by technologies.

2.2.1 New Service Development

The study of New Service Development (NSD) is intended to provide a comprehensive approach to develop new service including resources and values. Technology is regarded as a part of the service system (Edvardsson and Olsson 1996, Fitzsimmons and Fitzsimmons 2000). In other words, technologies should be developed to be well-suited to the overall service systems. This idea is commonly encountered in reports of other studies, as explained later.

The development processes in the NSD studies generate service offerings suitable for customers. Edvardsson and Gustafson (2003) reported a new service development process having three phases: (1) the idea and project formation phase, (2) the design phase, and (3) the implementation and integration phase. Johnson et al. (2000) described a development cycle including design, analysis, development, and full launch. Technologies are specified as a resource of service systems in the design and development phases.

In these processes, the participation of stakeholders has been regarded as particularly important. Customer involvement has persisted as an especially important concept (Edvardsson 1996, Matthing et al. 2004). Wallin et al. (2015) studied specific challenges in NSD of ICT-enhanced services. In their study, the integration of stakeholders in the development process and co-creation with them, based on the viewpoint of Service-Dominant Logic (Vargo et al. 2004, 2010) were regarded as a key challenge.

2.2.2 Service Engineering

The term "service engineering" was coined in the 1990s as a new type of engineering research to design and develop services. This new research movement progressed simultaneously from several places. The best-known research has been German research of service engineering (Bullinger et al. 1995, 2003). The problem setting of this body of service engineering research is the lack of systematic approaches in design and development of services. Bullinger et al. (2003) define service engineering as "a technical discipline concerned with the systematic development and design of services using suitable procedures, methods and tools." Systems engineering provides a foundation for these methods and tools. Humans, such as service employees, are also represented as design objects in this research scheme.

Another research movement of service engineering emerged in Japan. Japanese service engineering research also originated from the systematic modelling approach, although it came from a different research background (Watanabe et al. 2016). The modeling scheme, which describes a service structure consisting of humans and products, service processes and stakeholder relations, was developed (Shimomura et al. 2005, Sakao et al. 2007). This modeling scheme was implemented in a computer-aided design tool for service, designated as Service CAD (Arai et al. 2005). In this research scheme, products as technological artifacts are designed in parallel to service activities. From a methodological perspective, Hara et al. (2009) reported the necessity of concurrent design and development of products and services to develop effective solutions for customers.

The concept of service engineering in Japan was further extended to analysis and enhancement of service systems with technologies (Watanabe et al. 2016). In this study, we examine one major project in a case study.

2.2.3 Product-Service Systems

Product-Service System (PSS) is another concept to integrate products and services as a solution for customers. The PSS concept was proposed based on discussion of servitization of manufacturing to tackle environmental concerns and to realize sustainable business models

(Goedkoop et al. 1999). PSS is defined as “a marketable set of products and services, jointly capable of fulfilling a client's needs” (Goedkoop et al. 1999).

Many PSS development processes include integrated procedures related to product and service design and development starting from understanding of customer value or value proposition to testing and implementation (Aurich et al. 2006, Maussang et al. 2009, Marques et al. 2013). The previously described Japanese service engineering research such as Service CAD is also regarded as a method of PSS design and development (Vasantha et al. 2012). The features of PSS design outputs are life cycle analysis and business model development, which derive from the original objectives of PSS research. For example, Komoto and Tomiyama (2008) proposed Integrated Service CAD with a Life cycle simulator (ISCL) in which a life cycle simulation function based on developed service models was included. Alonso-Rasgado et al. (2004) emphasized business model development in PSS and developed its process. Sustainability in business and environmental aspects is more emphasized in PSS design and development. Müller and Sakao (2010) represented such diverse aspects of PSS design outputs as nine mutually related dimensions.

2.2.4 Service Science

Service science aims at elucidating and innovating service systems (Spohrer et al. 2009). According to Spohrer (2008), a service system is a “configuration of people, technologies, and other resources that interact with other service systems to create mutual value.” Compared to the other research domain, service science emphasizes ICT application to services more.

Related to development of service systems including technology, service science provides several approaches. Systematic modeling such as BPMN (White 2004) and SysML (Friedenthal 2014) is used to analyze, design, and develop not only information technologies for services but also a service itself. Agent-based modeling is another approach to describe dynamic interactions in a service system with a simulation (Mizuta 2016). In addition, service science studies examine data collection and analysis of service systems using sensing devices such as RFID (Dominguez-Péry et al. 2013) to improve and refine service system operations. Related approaches are apparent in several relevant projects such as Active (or Ambient) Assisted Living (Sun 2009, Wood 2008) and Hub-of-All-Things, which is intended to gather data related to everyday life (Ng 2013).

While technology is a key element in service science research, value co-creation among stakeholders is regarded as a fundamental concept in service systems (Vargo et al. 2004, Spohrer and Kwan 2009). Recently, human-centeredness is emphasized more with the term "Human-Centered Service System (HCSS)" (Maglio et al. 2015). How to integrate human activities and technology in service systems has become an important research topic in service science research (Maglio 2015).

2.2.5 Summary

In these studies, we were able to identify the following common characteristics in their respective development processes.

- Technology development and integration as a part of service systems

Every research area described above integrates technology as a part of service systems, although the degree of emphasis on technology is slightly different. Some design and development methodologies in service engineering, PSS, and service science include a product development process as a component of the whole service system development. For the effective operation of technologies in services, the integration of product and service development is regarded as fundamentally important (Aurich et al. 2006, Hara et al. 2009)

- Understanding and participation of stakeholders in development

In every research area, understanding and participation of stakeholder in development are emphasized, although the degree of participation is also different. Qiu (2009) stated the importance of socio-technical aspects of service systems. Socio-technical systems (STS) explain a status of combined social and technical components to accomplish tasks (or value) in a system (Appelbaum 1997). The concept of HCSS also emphasize coordination between human and technology (Maglio 2015). The cooperative relationship between human and technology can be established through participation of stakeholders in development of service systems.

2.3 Challenges for increasing impacts of service system development

Existing studies of service system design and development have revealed design and development methods or methodologies of various kinds, support tools, and meaningful implications in developing service systems. However, the developed service systems and the technologies integrated into them tend to be considered merely as cases of the studies. Few reports of the relevant literature describe a concrete study of dissemination of a part or whole service systems to other services.

We describe our research emphasis in Figure 1. Most studies of service systems have specifically examined their design and development, but not dissemination of their results. The dissemination of the results is essential for expanding the impact to similar services. As was mentioned, we focus on regional services as primary targets of this study. Considering the limitation of their resources and knowledge (Consoli 2012), it is required that generalized deliverables are easy to apply to each service case. Means of dissemination could also provide future business opportunities especially for technology providers and integrators.

3. Case Studies

3.1 Overview

This study analyzed five cases of a service engineering research project in Japan related to government-funded efforts during 2009–2012. This project aimed at improving service industry productivity using engineering methods and technologies.

The concept of this project is characterized in two points. First, this project took a bottom-up, practice-oriented approach. The researchers were required to analyze service fields to clarify difficulties and then to intervene in practical service situations by developing technologies through deep collaboration with stakeholders such as service field managers and employees. Secondly, it was necessary that research results in the cases be disseminated in multiple service fields to increase the service sector productivity. The researchers needed to consider how to generalize their research results.

We selected the major cases of this project which took considerable periods (more than 2-3 years) for development and succeeded at providing deliverables. The analysis of this project is expected to provide meaningful implications applicable to other service systems to increase the impact of technology-assisted service systems.

3.2 Methods

From March 2015 through April 2015, we conducted interviews of eight researchers who participated in the research project. The number of interviewees in each case is presented in Table 1. We selected the interviewees who served in responsible roles and who knew the contents of the respective projects. As a data collection method, we conducted semi-structured interviews to clarify our research questions about the research processes and outputs, to some extent in an exploratory manner. We asked about the research processes (including activities, events and important decision-making in the processes), the stakeholders (including their concerns, roles, characteristics and any changes), and how and in which form the research results were generalized in the project period and later. As a supplement to these interview results, we also analyzed internal research records and public project reports (AIST 2010, 2011, 2012).

The results of each case and a preliminary study of research processes of extracted cases have already been reported (AIST 2010, 2011, 2012, Watanabe and Mochimaru, 2015, Motomura et al. 2016). The present study analyzed the overall project to clarify generalizable research processes and outputs.

3.3 Case description

Table 1 presents features of the five cases. We included a brief explanation with each case as follows.

- Case 1: Development of analysis and visualization technologies of employee movement

The first case is development of human sensing technologies to analyze employee movement. This sensing technology, called Pedestrian Dead Reckoning (PDR), is effective for precise position sensing in indoor situations (Kourogi et al. 2010). This technology was first applied to measure and visualize human movement to several service fields such as restaurants and elderly care facilities. After attempts in several fields, this technology was accepted mainly for restaurant service, which originally used a bottom-up improvement activity known as Quality Control (QC) Circles (Watanabe 1991). While applying the basic technology, the research team continued development of new technologies such as service operation estimation and a new smaller measurement device. Then the team applied them to the service fields. During the last project year, the research team combined financial data with measurement data to evaluate the technology from a management perspective. In this phase, the technologies and their application process were almost established. In 2014, the research team developed a new business to adapt technologies to service fields as business. Workplaces of various kinds, not only other service fields but also manufacturing workplaces, became targets of technology application.

- Case 2: Development of consumer behavior analysis methods to manage service operations

The second case includes development of consumer behavior analysis methods mainly for the management of service operations. The research team emphasized point-of-sale (POS) data, which represent the usage situation of services. More precisely, ID-POS data that correlate purchase data with each customer were used (Ishigaki et al. 2010). Although the ID-POS data analysis was a well-known approach, they considered that the diversity of consumer preferences was not examined sufficiently. They started analyzing retail services and a restaurant service and developed a new method of classifying customers using numerical analysis. Then, the research team specifically examined demand forecasting to support store managers in producing work shifts and doing procurement work. The demand forecasting method was developed through interviews with store managers. A customer segmentation method using analysis of ID-POS data was also developed and combined with the demand forecasting method. They applied these developed methods to both retail and restaurant services and achieved important results. The researchers developed also a customer contact point support system to collect customers' requirement and satisfaction. These technologies were integrated as a software package, which was then licensed to several companies.

- Case 3: Development of consumer behavior measurement technology for regional development

The third case is about development of a technology for measuring consumer behavior for regional development. The research field was a district in Japan that is well-known for its hot springs. For tourist convenience and to elucidate their behavior, a digital payment system was developed and installed for public baths, souvenirs, and restaurants. This concept was based on a traditional payment charge system for tourists in this region. Through collaboration with hotel owners, store owners, restaurant owners, the municipality and local residents, this system was installed in all public baths and in many stores and restaurants. An NPO was also launched to operate this system. Currently, to energize the region, this NPO is operating this payment system using information related to tourist behavior for organizing events. The developed payment system is now being applied to other purposes and areas to elucidate consumer and tourist behavior.

- Case 4: Development of crowd movement simulation technology

The fourth case is one of a technology to simulate crowd movement, mainly to support public services. The research team developed and used two technologies to simulate crowd movement. One technology is a multi-agent simulation to simulate the behaviors of numerous agents (Ferber 1999). The other is video monitoring, which can analyze the movement of pedestrians to gather information for simulation and evaluation. These technologies were modified and applied to three specific issues in public services. The first issue is how to lead a crowd from one place to another after a disaster. The second issue was to manage a crowd at a fireworks event. The third issue was to develop a community bus that can change its route on demand. The simulation technology was used for route planning and feasibility testing. All these studies were conducted through collaboration with municipalities. The simulation results were later used to support decision-making by personnel in charge of public services.

- Case 5: Development to support technology to share information among employees

The final case is one that includes development of a mobile application to support employees through information sharing. The research team clarified inefficiency of information sharing at elderly care facilities through field observations and time-and-motion studies. To improve elderly care service efficiency, a mobile application for information sharing was developed through co-design with employees. The developed application has been licensed and used not only at elderly care facilities, but also for university education and manufacturing services.

4. Findings

4.1 Research process

Based on interview results, we ascertained that the researchers and the service providers in each case had gradually established mutual understanding and co-developed new technologies and service systems including them. In addition, the researchers generalized their outputs through experience with multiple attempts as a continuous co-development process.

- Mutual understanding and co-development

In the earlier phase of each case, researchers and stakeholders in the service fields strove for mutual understanding and exploration of meaningful collaboration. The researchers started with preliminary field study methods such as observation and interviews. Subsequently, they applied their existing technologies or methods to service fields according to the initial problem setting based on the preliminary study. For example, PDR was applied to elucidate employee behavior in service fields in case 1.

However, a certain amount of time was necessary to establish collaborative relations between the service field side and the researcher side. Stakeholders in service firms such as employees and managers misunderstood or overestimated the potential of technologies. For example, an interviewee of case 1 said “First, the employees considered that our technology was much more precise than actual performance.” The researcher side also did not understand the stakeholders, their services, and problems sufficiently at first, which caused a mismatch of technologies and service systems.

These gaps were filled gradually in each project. In case 1, the interviewee described, “it was necessary to explain the limitations of our technology in a way that they did not lose their trust in us completely.” According to the interviewee, the manager and employees also changed the manner of using the technologies by understanding them. The research team also came to understand the service systems more precisely. The interviewee of case 2 described that the research team gradually expanded the range of their understanding. After the attempt at ID-POS analysis, the interviewee conducted an interview of store managers to clarify their needs in technologies in the second year. Then the research team developed a demand forecasting method to support store managers to determine work shifts and procurement. The external variables used to determine demand were obtained through the interviews and discussion with shop owners. In this case, the research team and stakeholders in the service field co-developed technologies through a process of mutual understanding.

- Generalization through co-development

In each case, the technologies developed with at least one partner were applied and tested several times in collaboration with the same partner and also with other partners. In case 1, the developed sensing technology was applied in parallel to services of different kinds such as a restaurant, an elderly care facility, and a hotel. Finally, the technology target was expanded to manufacturing workplaces. The same approach was taken in cases 2, 4, and 5.

In every case, especially case 1, 2 and 4, the technologies were also applied repetitively to the same partners through their further development. In case 2, the target and functions of technologies were updated and applied every year. They started with customer categorization, then realized demand forecasting and finally packaged a total management support software. In case 1, the mobility and maintainability of sensor modules were improved through repetitive applications. The visualization system of collected data was also improved through the development process, which will be discussed later. The co-development and generalization were conducted not in a sequential process, but rather in an in-parallel process.

The outputs obtained through the generalization process varied among cases. The outputs are described further in the next section.

4.2 Research outputs

The interview results revealed outputs of three kinds from research activities with stakeholders in service systems: technology, activity guidelines, and application processes.

- Technology

In every case, technologies of some kinds were developed as the main deliverables. Technology was used as a part of a service system to enhance stakeholder capabilities and their values. For example, sensing devices used in cases 1 expanded the perception of employees concerning their behavior in the service system. Simulation and forecasting technologies in cases 2 and 4 provide additional insight into dynamics of service systems.

Interview results clarified that the interface between technologies and stakeholders in service systems took an important role in service systems. In case 1, the original core technology of the research team was the sensing devices used to realize PDR. However, the visualization system of measurement results became their competence as the research team conducted research with service employees several times. Visualization of collected data provided insights for those who analyze services also in case 3 and 5.

Meanwhile, technologies used in daily life or ordinary work settings were required to be as simple as possible. In case 3, the payment system used by store owner or staff was required to have fewer operations for use. In case 5, the information sharing system was designed to input information with fewer taps by utilizing a recommendation function.

As other interesting comments in the interview, the interviewee of case 3 acknowledged through the first approach to apply mobile phones for behavior measurement, that "something for measuring cannot be used continuously in the service field." The interviewee continued "the tool used in the service system should be beneficial for daily activities," so that the payment system in case 3 was designed to make the shopping experience of tourists easier while it worked for better understanding of tourist behaviors.

- Activity guideline

The research outputs in this project were not only technologies. Activities of stakeholders in a service system should be well-arranged to utilize technologies. The interview results depicted the expected activities for stakeholders in service systems. They were expressed in different forms of guidelines.

Many of the interviewees stated the importance of interpretation of collected data and decision-making by stakeholders themselves. For example, the interviewee in case 4 considered their simulation system "not to provide an answer but to provide information to have users determine their solutions by themselves." The interviewee mentioned that he actually requested their partners to use them in this manner. This principle was emphasized also in case 1 and 5.

As a means to let stakeholders utilize technologies, small group activity was applied in case 1 and 5. In case 1, the sensing device and visualization system were used by employees for quality control activities. It was expected that the sensing device would be used for continuous improvement, but actual changes in service processes depend on the agency of employees. In case 5, the data of time-and-motion study conducted by the research team were visualized and shared with employees. Through the workshop with the employees, a research aim of developing an information sharing system was set. Activities in service systems were not necessarily developed independently from their associated technologies. In case 5, the usage of the information-sharing application became diversified: from merely sharing information in daily work to sharing new processes and know-how in work. The collected data from the information sharing system were also used for the workshops reflecting their services by employees. By combining the knowledge of stakeholders in service fields and capabilities of technologies, service systems can react and adapt to new issues and situations.

The activity guideline might also originate from traditional customs. In case 3, mobile phones that the research team first applied to a hot spring area did not conform to the stakeholder activities. After receiving some ideas from a municipal officer, the researchers digitalized the public bath tickets. This public bath ticket was the existing part of the public bath service system. It was also a good interface to elucidate customer behaviors. The old business custom of sending tourist bills to their hotels was also refurbished with an ICT-based approach.

- Application process

As was explained about the research process, application of new technologies and activities to existing service fields was not an easy process. In the cases, this application process had also become sophisticated through repetitive trials.

There were some common methods and techniques across the cases. First, the analysis of service practices and stakeholders were common practices in every case. As another common technique, the demonstration of technologies is used to let stakeholders know the effectiveness of technologies.

Team development to use technologies in the service system was also conducted in several cases. In case 1 and 5, a group activity by employees was emphasized in the interview. In case 3, the researcher and stakeholders in the service field developed an NPO to use data from the payment system. The interviewee emphasized the importance of teaming up with key persons in the district.

Each research team combined these techniques and practices to apply technologies and activity guidelines to service systems. In case 1, 2 and 5, the interviewees were able to state this application process. In case 5, the methodology to use a licensable application in service fields was also studied.

In some cases, these outputs were packaged as generalized forms. In case 1, a new start-up company was launched to provide measurement and consultation services as a deliverable. The researchers have a procedure to apply their technology to clients. In case 2, the research team developed a software package to provide total solutions for each stakeholder in retail and restaurant companies. In the other cases, the technologies themselves were refined and were applied to other cases with the support of the researchers.

Table 2 represents the result of dissemination after the project (until April, 2017). In case 1, the research result was disseminated to more than 20 cases, from the research group and the start-up company. Not only service sectors, but also manufacturers and logistics companies also adopted their technology and method. In case 2, 48 technology packages were licensed, mostly to ICT consulting companies. In addition to the number shown in Table 2, it can be assumed that these consulting companies have applied to more cases. The result of case 3 was applied to various types of service, from more public services such as museums to more private services such as bundle promotion for different services. The application targets in case 4 were mostly public services. The number of applications was rather small compared to the others. The mobile system in case 5 was also licensed to two companies. Their research result was applied to other kinds of services such as education and health promotion.

5. Discussion

5.1 Implications on research process

Co-development is a fundamental process that has been examined in numerous existing studies of service development (Edvardsson and Olsson 1996, Matthing et al. 2004, Prahalad et al. 2004, Watanabe and Mochimaru, 2015). As demonstrated by the findings, stakeholder participation was effective in this project, not only to develop effective technologies but also to understand and reorganize the service systems to raise stakeholder satisfaction. An important aspect of the analysis of co-development is the importance of mutual understanding between researchers and service providers. Researchers must ascertain service field processes and stakeholders to develop effective technologies there. Service providers, including managers and employees, must also ascertain features of technologies from the aspect of services. Through this mutual learning process, technologies and services become more integrated. For HCSS development, this process would be essential.

An ideal situation of an ordinary service system development is that, after the co-development process, technologies and service systems become mutually integrated. In this project, a further step was taken to extract and generalize research outputs to make them transferrable to other services. The findings also suggested that generalization is conducted in a series of co-development with stakeholders in the same or different service fields. This process brought better adaptability to different systems and efficiency for adaptation. The elimination of applicable service systems was also conducted through this process.

This study expands the development of service systems which has been studied in new service development, service engineering and service science to generalization and dissemination of developed service systems and technologies for other service systems. This study is also different from the existing STS studies which specifically examines technology development for certain workplaces.

5.2 Implications from research outputs

For this study, we extracted research outputs of three types obtained through case studies. This set of technology, activity guidelines, and application processes, designated as a *technological support model for service system* is generated through the previously described research process in Figure 2. Our inference drawn from this study is that the application and dissemination of technologies should be conducted by integrating activity guideline for stakeholders in service systems and the application process. This result would be meaningful for realizing smart service systems (Medina-Borja 2015).

The composition of this model could differ in response to the types of service systems. Table 3 presents categorization of the cases in this study into three types according to the composition of stakeholders and main support target in service systems. We present the features of respective models and implications for their development.

- Type 1: Knowledge-worker support model

The type 1 is a knowledge-worker support model corresponding to cases 1 and 5. Both cases specifically examine employees in service fields. In these cases, employees are considered not as workers of routine tasks but as knowledge workers who change their work through reflection. The technological support model developed for them worked to expand their view on service systems.

The technologies presented in this model provide functions to collect data on work and to represent the service system status. Technologies to collect data are used in ordinary work settings. Therefore, technologies should be easy to access and be well-adjusted in work processes. In addition, reflective activity by workers is the most important in a model of this type. Each service system has its own characteristics and requirements for activities. Workers need specific occasions to reflect on their own work and service systems, being away from an ordinary work setting. For this purpose, reflective activities in organizations should be implemented as a part of activity guidelines. For example, community-driven activities such as QC circles (Watanabe 1991) in case 1 are effective. As another approach, a methodology for employees to redesign service practices was studied in case 5 (Watanabe et al. 2015). By integrating the technologies with these activities or methodologies, workers can improve or redesign service systems. In addition, an application process to introduce both technologies and activity guidelines can be developed. In both cases, the researchers were able to present their application process or know-how with concrete steps.

- Type 2: Organization management support model

Type 2 is an organization management support model corresponding to cases 2 and 4. This model helps organizational management conducted by a manager of an organization. For example, case 2 represents how the model of this type might support store managers to operate their own store operations. In case 4, management support of municipality events and activity was exemplified.

The technology in this model is intended to support managers' decision-making processes related to their service systems, which includes multiple agents' behaviors. In case 2, category mining of customers provided views to determining their marketing strategy in a customized manner. In addition, the demand forecasting provided fundamental information for resource allocation and procurement, which are regarded as fundamentally important decision-making by store managers. In case 4, multi-agent simulation illustrated a holistic behavior of service systems, which incorporates numerous agents. These model-based analysis is effective to provide meaningful aspects and insights for decision-making. Although specific activities such as reflective activities of type 1 are not necessarily emphasized for the support of managers, they are also required to have specific attitudes to use the technology and data. In case 4, the interviewee emphasized that the technology users need to determine which option they should take by themselves, taking their tradeoffs into consideration. In the application process, the researchers must investigate the problems of managers and their decision-making processes. Thereafter, the analytical viewpoint should be integrated in the technology through consultation.

- Type 3: Association management support model

Type 3 is an association management support model. Compared to type 2, this type aims at supporting managers who do not necessarily have strong governance toward related stakeholders, as in case 3.

This characteristic makes the implementation of the model difficult. Technologies used by stakeholders need to be simple, intuitive and even beneficial for users. For example, a digital payment system in case 3 enabled tourists to buy souvenirs and foods without wallets. To adapt these technologies to the service system of type 3, it would be meaningful to consider visible or invisible rules among stakeholders, which Vargo and Lusch (2011) stated as institution. In case 3, a traditional payment charge system became a basis to share the usage of technologies among stakeholders. In the application process, the researchers investigate and rearrange institutions in service systems and support each type of stakeholder to adapt the model to their activities.

Although these three models cannot accommodate service systems of all types, they can provide a practical guide on how to create reusable research results for enhancing similar types of service systems. For example, type 1 is effective for services by knowledge workers who must manage their mode of tasks. Indeed, case 1 has various application cases in several kinds of services and also in manufacturing industries. Type 2 supports various managerial work in an organization related to behaviors of numerous actors. Type 3 covers more different types of stakeholders. A public or community-oriented service can be a target of type 3. The investigation of such models for different service systems will be beneficial to develop generalizable solutions for them. This is an important implication of this study.

5.3 Implications from dissemination results

The results of the case project have been applied broadly to regional services and also different kinds of sectors. The result of dissemination highlights several aspects of the aforementioned models. First, case 1 (type 1 model) was accepted by the companies which have improvement cultures originally, such as manufacturing companies. Another application case, logistics service is naturally interested in movement of employees. This implies that the prior conditions of a target service or sector would affect the acceptability of technological support models. Dissemination through consulting companies in case 2 is an effective approach for technology transfer (Bessant and Rush 1995). Type 2 model would be suitable for the application by consulting companies. Case 2 was applied to different types of regional services also, such as a shopping mall and a massage service. Case 1 and 2 demonstrated their economic value successfully, which could also accelerate dissemination of the results.

Compared to case 1 and 2, dissemination of the results from case 3, 4 and 5 may require different evaluation criteria from economic value. For example, direct implementation to public sectors seems more challenging as can be seen in case 4. Case 3 as type 3 model was applied not only for public objectives but also for more business-oriented collaboration. This flexible application could be effective to further dissemination of new service systems. Especially for innovation of public services and social innovation (Rubalcaba et al. 2013), evaluation methods have been considered as an important issue (Nieminen and Hyytinen, 2015). Evaluation criteria could be an important tool to assist the dissemination of these research results further more.

5.4 Limitation and future studies

An important limitation of this study is the limited number of case studies. Interviewees were also limited to a few researchers from each project and also not from stakeholders in the service systems. Although the researchers interviewed were in responsible positions in each project and knew their respective contents very well, the viewpoints to be analyzed were limited. In addition, technologies with physical support such as robotics were not examined.

From a theoretical perspective, the lack of analysis of co-creation with customers is an important limitation. Although the solutions were co-developed with stakeholders in service systems, the major partners were employees or other stakeholders of service providers. Direct analysis of customers and their values has not been done sufficiently. Such analysis might improve oversight of the requirements and concerns of customers. More direct analysis of customers and co-creation with them must be conducted in future studies.

The represented cases were conducted mainly by researchers with an engineering background, but further understanding of human behaviors as individuals or groups is beneficial. The research approach might be more sophisticated through collaboration with social sciences such as psychology, management science, behavioral science, and sociology.

Finally, recent ICT technologies can gather large amounts of personal data. Maintaining appropriate consideration of ethical, legal and societal issues (ELSI) while conducting studies on technology-assisted service systems is especially important.

6. Conclusion

This study was undertaken to explore new possibilities in expanding impacts of technology-assisted service systems. Among the existing studies of service systems, few have specifically addressed development of generalized solutions with high adaptability to service systems of various kinds. We studied five cases of service engineering research projects, which is a practice-oriented project aiming at generalized solutions for service industries. Results showed a co-development nature in developing, implementing and even generalizing processes of both technologies and activities in service systems through repetitive trials.

Additionally, we designated a set of research outputs including technology, activity guidelines, and application processes as technological support model for service system. These outputs are characterized in their adaptability to service systems of various kinds. Moreover, we further categorized the cases into models of three types, knowledge-worker support model, organization management support model, and association management support model in accordance with the composition of stakeholders. This categorization is beneficial to create generalized deliverables to innovate different kinds of service systems. This research remains in its early phase. Further studies are anticipated.

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Table 1 Case description

Case	1	2	3	4	5
Number of interviewees	2	2	1	1	2
Technological solution	Analysis and visualization technologies of employee movement	Consumer behavior analysis methods to manage service operations	Consumer behavior measurement technology for regional development	Crowd movement simulation technology	Support technology to share information among employees
Main technology	Location sensing device, 3D indoor modeling, visualization system	Category mining, demand forecasting, customer contact point support system	Digital payment system (using RFID, barcode, etc.)	Multi-agent simulation, video monitoring	Knowledge representation, information sharing system
Target fields	Restaurant, elderly-care facility, Japanese-style hotel	Retail store, restaurant	Hot-spring district	Disaster prevention, event space (fireworks), community bus	Elderly-care facilities, hospitals

Table 2 Dissemination result

Case	1	2	3	4	5
Number of disseminated cases	Approx. 20 or more	Approx. 30 + 48 licensing	6	Approx. 3	Approx. 9 + 2 licensing
Original application targets	Restaurant, elderly-care facility, Japanese-style hotel	Retail store, restaurant	Hot-spring district	Disaster prevention, event space (fireworks), community bus	Elderly-care facilities, hospitals
New application targets	Factory, logistics, business office, entertainment space	Shopping mall, apparel, massage chain store, power company, automotive	Museums, bundle promotion among services, cafeteria system	-	Health promotion, education

Table 3 Types of technological support model

Type	1: Knowledge-worker support model	2: Organization management support model	3: Association management support model
Main support target	(Knowledge) worker	Manager in an organization	Manager of an association (a group of organizations)
Other stakeholders	Customer, manager in an organization	Customer, worker	Customer, worker, manager in an organization
Features in technology	- Easy-to-use technology adjusted in work processes	- Model-based analysis for decision-making support	- Simple and even beneficial (esp. for the other stakeholders above)
Features in activity guideline	- Reflective activities (e.g., small group activities)	- Decision-making by the manager themselves	- Activities aligned with customs / common behaviors
Features in application process	- Adaptation between service processes and technologies - Organizing / facilitating a group for reflective activities	- (Co-)analysis of management problems and decision-making processes	- Analysis and arrangement of institutions among stakeholders in service systems
Cases	1, 5	2, 4	3

Figure 1 Research focus

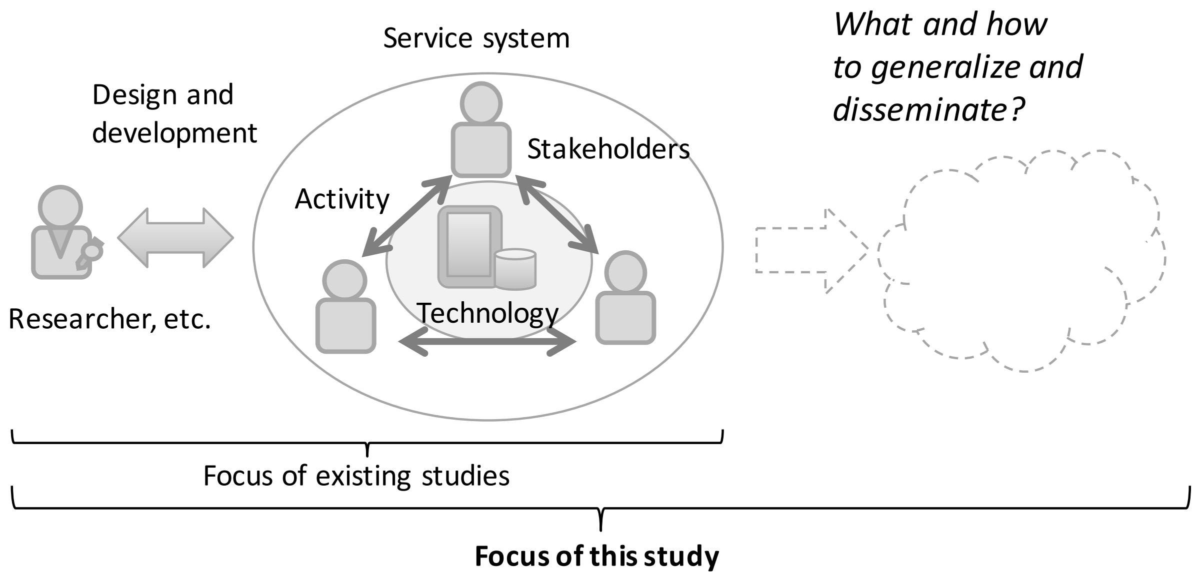

Figure 2 Generalization process