Joining Forces: Understanding Organizational Roles in Inter-organizational Smart Service Systems Engineering

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Abstract. The combination of technologies like the Internet of Things, big data analytics, and cloud computing allow service systems to become "smart". To design and operate smart service systems, a multitude of skills, knowledge, services, and components are required. These are unlikely to be found within a single organization, and, hence, inter-organizational projects are formed for smart service systems engineering. In our study, we explored the inter-organizational setups of 14 projects by interviewing experts who were involved in smart service systems engineering. Our analysis resulted in a conceptualization of 13 roles that we further clustered into three main groups. With this systematization of roles, we contribute to academia by advancing our understanding of the inter-organizational dimension of smart service systems engineering. Our insights are helpful for practitioners in setting up and managing inter-organizational projects for their digital service innovation initiatives.

Keywords: Smart service, smart service systems, service engineering, inter-organizational projects, stakeholder integration

1 Introduction

The proliferation of connected devices and assets drives the emergence of the Internet of Things (IoT) and enables the provision of smart services [1, 2]. In a business-to-business (B2B) context, for instance, digitally connected aircraft engines report status data in real-time, thereby enabling pay-per-use business models. Industrial products such as compressors, ventilation systems, and elevators are being upgraded with digital services for remote control, monitoring, usage-based billing and other services [3]. In a business-to-consumer (B2C) context, cars may analyze driving behavior based on sensor data, schedule workshop appointments, or provide optimized eco-feedback.

There has been much academic discussion on smart services since the term was first coined in 2005 [2]. A recent literature review [4] found a growing academic interest in

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this topic but also identified customer involvement in the design, operation, and improvement of smart services as an under-researched area. Furthermore, involving additional stakeholder groups other than the customer (like suppliers and partners) was not covered in the analyzed literature at all. This is surprising as smart service systems engineering (SSSE) projects tend to be inter-organizational projects for at least two reasons. First, they utilize digital technologies as key parts of their outcomes [5], e.g., smart products or cloud computing [6]. Utilizing such novel digital technologies usually requires knowledge and expertise (e.g., on digital networks, user experience design, and data security) that is often not fully available in a single organization. Second, there is a need for specific expertise on business model innovation and service engineering to design new value propositions [7, 8]. Hence, service providers need to engage in inter-organizational relationships – beyond customer involvement – in order to develop and provide smart services [9, 10]. However, looking at existing academic works, there is obviously a limited understanding of how SSSE projects are managed across organizational borders in order to integrate heterogeneous resources and competencies. Therefore, we pose the following research question: *Which roles of project participants can be identified that contribute to inter-organizational SSSE projects?*

The units of analysis of our study are SSSE projects, which are projects that target the development of new value propositions through the provision of smart service. Our objective is to propose a *set of project participants' organizational roles* to make the structural setup of inter-organizational SSSE projects transparent. At this stage, we explicitly do not cover how the actual collaboration between project participants takes place, i.e., how partners in a project communicate, which methods, tools, or project methodologies are employed; or which information is shared (reflecting the dynamics of SSSE projects). Furthermore, the formation process of the inter-organizational partnerships is also out of the scope, as we consider these to be highly path-dependent with determining factors that go beyond the single projects that we analyze [11, 12].

The remainder of this paper is organized as follows: In Section 2, we introduce the key concepts of smart service systems and inter-organizational collaboration in SSSE. Afterward, we present details of our research method that makes use of explorative expert interviews (Section 3). Section 4 contains the results of the interviews, as well as the proposed conceptualization of organizational roles in SSSE projects. The paper closes with a discussion and a conclusion (Section 5).

2 Research Background

2.1 Smart Services and Smart Service Systems

Beverungen et al. [13, p.12] define *smart service* as "the application of specialized competences, through deeds, processes, and performances that are enabled by smart products." *Smart products* refer to physical objects with embedded systems and networking capability that enable the intelligent adaptation to customer needs and changes in usage situations [2]. Smart products allow transforming service systems, which are understood as "sociotechnical configurations of people, technologies, organizations, and information designed to deliver services that create and produce value" [14, p. 2], into *smart service systems* [14]. They are "service systems in which smart products are boundary-objects that integrate resources and activities of the involved actors for mutual benefit" [13, p. 12]. Smart service systems control "things for the users based on the technology resources for sensing, connected network, context-aware computing, and wireless communications" [15, p. 166]. The previous definitions of smart service systems also show similarities to existing conceptualizations of *product-service systems (PSS)*. Generally, PSS are understood as integrated combinations of products and services as "a competitive proposal intended to satisfy consumer demand." [16, p. 223] Chowdhury et al. [7] further describe *smart PSS* as "combinations and interactions between smart technologies, physical products, services, and business models." While the discussion on PSS mainly focuses on the integrated offering of goods and services [16], works on smart service systems rather look at the socio-technical configurations for service provision [13, 17], which become increasingly complex through the use of information technology [17, 18]. Hence, smart service systems are characterized by high complexity as they integrate a large variety of resources. Therefore, a spectrum of different contributions must be provided to design such systems, which are unlikely to be available in a single organization but requires inter-organizational collaboration.

2.2 Inter-organizational Collaboration and Stakeholder Integration in SSSE

The engineering of smart service systems has been discussed under several terms, including service engineering [19], service systems engineering [20, 21], digital innovation [6, 22], design of informatics-based services [23], and PSS engineering [24]. Several process models have been suggested to guide the corresponding service engineering processes [e.g., 8, 21, 25]. Generally, these models and methods do not discuss the inter-organizational setup of SSSE projects in much detail. Similarly, Hagen et al. [24] identify a lack of appropriate methods to support the collaborative work of a growing number of stakeholders. Beverungen et al. [21] point to the potential of integrating external resources from customers, suppliers and other stakeholders as part of their basic mechanisms of recombinant innovation. However, they do not describe stakeholder involvement in the actual service system engineering process but refer to external resources as part of the engineering outcome, i.e., the resulting service system. With a similar focus on the outcome, Blaschke et al. [26] derive design principles for digital value co-creation networks from a service-dominant logic perspective.

Besides service engineering approaches, Jonas and Roth [27] conceptualize a continuum of four *modes of stakeholder integration* in service innovation. It ranges from low to high stakeholder integration with the four modes of (1) passive integration, (2) reactive integration, (3) mutual integration, and (4) proactive initiative. In another article, they identify customers and users as the main external stakeholders who are passively or reactively integrated into service innovation. There is limited empirical evidence for the integration of other external stakeholders, including suppliers, external service providers, and universities [28]. Looking at the actors that are part of the resulting service systems, Ekman et al. [29] suggest a typology of different roles generic actors can assume. They distinguish between either active, passive or inactive roles, as well as either provider or beneficiary roles. Regarding different *types of stakeholders* in industrial product service systems (IPS²) network organizations, Meier et al. [30, p. 619] distinguish between the customer, the IPS² provider and three different suppliers types, including component suppliers that provide technical artefacts, service suppliers, and IPS² module suppliers that provide integrated sub-systems.

While stakeholder integration and collaboration have hardly been researched in the context of SSSE, there is some further relevant research in the fields of business networks (BN), information systems development (ISD) and software engineering (SE) [e.g., 31], as well as project management in general [32, 33]. To describe the actors and their relations in BN, a role-linkage model was proposed by Kambil and Short [34]. They define roles as "distinct technologically separable, value added activities undertaken by firms or individuals" [34, p. 10]. As for ISD and SE, stakeholder integration has long focused on customer and/or user involvement. The emerging approach of platform-based development of software applications further introduces the platform provider as an external party [35].

As for projects in general, Sydow and Braun [32] use the term inter-organizational projects (IOPs) to reflect that an increasing number of projects is carried out in inter-organizational teams of individuals. They distinguish between individual and organizational levels of project membership but mainly discuss IOPs from the perspective of the individual team member. Manning refers to the term of project network organizations (PNOs) in case that "legally independent, yet operationally interdependent individuals and organizations [..] maintain longer-term collaborative relationships beyond the time limitations of particular projects." [33, p. 1399] A PNO typically involves multiple of such project participants with different and partly overlapping roles, including the strategic coordination by a project entrepreneur, a core project team, and a flexible pool of partners with, e.g., software providers and IT service firms [33]. In this regard, roles can be seen as "clusters of behaviors expected of parties in particular statuses or positions" [36, p. 282]. While roles are typically assigned to individuals and, hence, reflect human behavior [37, 38], they can also refer to teams [36] or actors such as organizations, social entities, groups, or networks [39].

In service research, all these kinds of actors can be understood as service system entities [40]. In SSSE projects, these entities form networks (equivalent to BNs, IOPs, and PNOs) "that aggregate a variety of actors with different aims, interests, and values" [40, p. 656]. Understanding the collaboration with customers and partners in service innovation processes has been identified as a research priority by Ostrom et al. [41]. They write: „Research should also address service innovation that involves new or changed roles of service firms, customers, and employees, such as when conventional employee roles are delegated to customers" [41, p. 131]. We address this research priority by identifying the roles of actors in inter-organizational SSSE projects.

3 Research Method

We studied cases of real-world SSSE projects regarding their inter-organizational setup by interviewing experts who were involved in these projects. The unit of analysis in our study is the SSSE project. Each case of our multiple case study reflects a single SSSE project in which multiple organizations engage with each other to build a smart service system. To select suitable cases, we followed a purposive, theoretical sampling approach [42, 43]. Our goal was to identify information-rich cases from which we expected relevant and plentiful data as well as a broad range of perspectives about our study [43]. We sought for a variety in our sample, including SSSE projects in both B2C and B2B settings, different technical and organizational complexity of SSSE projects, as well as different actor perspectives.

Table 1. Overview of Expert Interviews

Case ID	*Organization Pseudonym*	*Organization Description*	*Expert Position in Organization*	*Interview Duration*
1	ENERGYPLAT	Digital platform provider for energy management	Head of Product Management	1:30 h
2	INSURANCE	Insurance company	Project Manager	1:04 h
3	CITYMOBIL	Utilities and public transport	Project Manager	1:29 h
4	GLOBALSYS	Global IT solution provider	IT Architect and Consultant	1:17 h
5	GLOBALSYS	Global IT solution provider	Program Manager	1:27 h
6	ENERGYTRADE	Digital platform provider for energy trading	Project Manager	1:11 h
7	ITSOLUTION	IT solution provider, consul-ting, software development	Lead Architect	1:13 h
8	ITCONSULT	IT consulting	Program Manager	0:41 h
9	DIGIBUSINESS	IT and digital solution provider	Project Steering	1:06 h
10	UTILCONSULT	Management consulting for utilities	Team Lead for Digitalization & IT	1:14 h
11	PHARMACHINES	Machinery construction for the pharmaceutical industry	Product Manager for Service/Support	0:48 h
12	PACKMACHINES	Plant construction for packing food/non-food items	Head of After Sales Service	0:41 h
13	INTERNALIT	Internal IT provider of a machinery manufacturer	IT Solution Consultant	1:00 h
14	FIELDSERVICE	Provider of field service management software	CEO	1:04 h

We collected qualitative interview data through semi-structured interviews with 14 experts from 13 organizations via phone between October 2018 to January 2019 (Table 1). The experts include, for instance, Project Managers and Program Managers from both manufacturing and service organizations as well as IT solution providers. The heterogeneous set of informants helped us in gathering a large variety of perspectives and roles of SSSE projects. The in-depth interviews lasted between 41 and 90 minutes. As we guaranteed anonymity to all interviewees, we only provide organization pseudonyms and the expert's position. We followed a semi-structured interview guideline that also left room for additional ideas and thoughts of the informants. Our main goal was to stimulate the experts to report on their SSSE projects and their context. Our interview guideline comprised the following sections with multiple questions each:

1. Introduction of interviewer and expert, description of the expert's organization, expert's background, and his/her role in the organization.
2. Identification of SSSE projects, in which the expert was involved, and a general description of the specific project selected for closer analysis in the following.
3. Project initiation, including the trigger for starting the project.
4. Project organization, including internal and external team structure, the chosen project management approach, employed methods, and specifications made.
5. Project outcome, including the value proposition and resource configuration of the smart service system.

Our data analysis followed the steps of compiling, disassembling, reassembling, and interpreting according to Yin [44]. Compiling involved organizing and sorting the interview recordings and interview metadata on a cloud-based data storage that was accessible by all authors. In the disassembling phase, we broke down the interview data of each case into smaller fragments and specifically tried to identify the text passages in which the informants reported on the collaboration of multiple organizations. We used descriptive codes to label the work contributions (e.g. "UI/UX design") of the organizations that participated in the projects as well as codes that describe the way and intensity of collaboration within the SSSE project under study. We summarized our findings in detailed case memos that gave descriptions of the inter-organizational setup as well as relevant context information for each of the SSSE projects. We also created graphical sketches of the cases' inter-organizational setups. Then, in the reassembling phase, we searched for patterns across cases in the way that the multiple actors contributed to the inter-organizational SSSE projects. We did this by comparing and discussing our codes from the previous within-case analysis (in the disassembling phase) and bringing them to the more abstract level of organizational roles. As recommended by Yin [44], we constantly compared the codes from the different cases and structured our data with one consolidated matrix of cases, organizations involved, and roles. In the interpreting phase of our data analysis, we then further condensed our findings by searching for possible explanations of the different inter-organizational setups we observed. Here, we clustered the set of organizational roles into three main groups of roles that differ in the way they are involved in SSSE projects.

4 Results

4.1 Overview of SSSE Projects

The experts in our sample reported on a broad range of SSSE projects, ranging from mobility and vehicle charging services for citizens, remote support services for industrial equipment, to vehicle delivery tracking and energy management (Table 2). The target customer groups of the new offerings were anonymous markets (e.g., case 10), specific customer segments (e.g., users of electric vehicles in case 3) or even specific customers (e.g., case 8 about the customer-specific development of a digital monitoring service by ITCONSULT). All SSSE projects exhibit an inter-organizational setup, which partly comes naturally as several interviewees work for IT solution and consulting companies that were contracted by service providers for the SSSE projects.

Table 2. Selected SSSE Projects

Case ID	*Project Result (Smart Service)*	*Project Description*
1	Energy distribution network control service	Development of a digital service by ENERGYPLAT that stabilizes the energy distribution grid by predicting instabilities and incentivizing individual households to change their energy consumption behavior.
2	Diabetes prevention app	Customization of an app that uses blood sugar measurements, activity tracking and reporting for people to influence their behavior. To create this app INSURANCE relies on a 3rd party white-label solution.
3	Electric vehicle charging	Development of a billing and access service to allow for a simple and cost-efficient charging of e-vehicles in the city of CITYMOBIL.
4	Fleet and maintenance management	Development of a system for a manufacturer of commercial vehicles that enables the sharing of data between manufacturer and customers for fleet management and maintenance planning.
5	Smart parking service	Development of a service by GLOBALSYS for a large German city that combines multiple data sources to identify areas with a high probability of free parking space. Service also includes reservations.
6	Energy trading platform	Development of a tendering service as an alternative to expensive energy exchanges to improve own margin. It supports placing tenders in the marketplaces, showing current tenders, and market pricing.
7	Customer service for public transport	Development of a platform by ITSOLUTION for a municipal public transport organization, including services for end-users, e.g., master data management, ticket purchasing, subscriptions, etc.
8	Car delivery tracking	Customer-individual development of a digital monitoring service by ITCONSULT for the real-time tracking of car delivery.
9	Industrial doors remote support	Development of a remote support service for industrial doors by DIGIBUSINESS for the door manufacturer.
10	Intermodal public transport service	Development of a digital service (incl. app and information terminals) by UTILCONSULT for citizens that integrates multiple modes of transport for planning a journey.
11	Virtual reality-based user training service	Development of a virtual reality training service using maintenance simulations of PHARMACHINES' products, which one of its customers triggered.
12	Remote support via video chat	Development of a video-chat-based remote support app to support customers in resolving incidents with PACKMACHINES' products.
13	Predictive maintenance	Development of a showcase of an availability-based business model as part of a governmentally funded consortium project, in which INTERNALIT participated.
14	Digital customer portal	Development and customization of software that FIELDSERVICE's customer in facility management can use to provide its customers with a customer portal (instead of paper-based documentation).

4.2 Organizational Roles of Project Participants

Our analysis of the 14 cases led to the conceptualization of 13 roles that we further clustered into three main groups of roles. The three main groups are *Focal Roles*, *Project Partner Roles* and *Supplier Partner Roles* (Figure 1). We further distinguish two key phases, including the actual SSSE Project (i.e., build-time of the system) and the Smart Service System Operations (i.e., run-time of the system). Some of the identified roles are relevant in both phases and, therefore, we placed them on the edge between. Table 3 provides an overview of all roles that we identified from our interview data. The column "cases" indicates in which project the respective role was identified as being actively involved in the SSSE project.

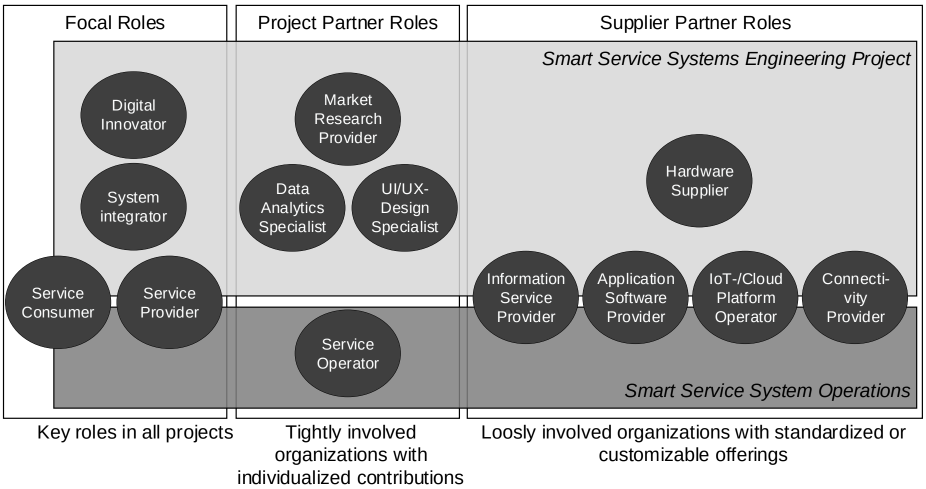

Figure 1. Proposed Set of Organizational Roles in SSSE Projects

The four **Focal Roles** that were relevant to all SSSE projects are Service Provider, Service Consumer, Digital Innovator and System Integrator. The organization assuming the *Service Provider* role is usually the initiator of the SSSE project as it intends to develop a new smart service offering. The *Digital Innovator* role is responsible for developing new service ideas and business models utilizing the capabilities of digital technologies. Finally, the *System Integrator* role oversees the design and implementation of the technical parts of the service system. The *Service Consumer* role represents the target user of the new service, who is, therefore, a major stakeholder in any SSSE project. However, the degree of consumer integration we were able to observe varies. For example, the e-vehicle charging service (case 3) was first designed and implemented without end-user involvement. Only in later project stages, paid testers were involved to gather feedback. Similarly, PACKMACHINES (case 12) developed the video-chat service together with a software firm without involving their customers and only started gathering feedback when they presented the first version of the service in sales appointments. In contrast, INTERNALIT (case 13) invited potential consumers to take part in focus group discussions already during service development.

Table 3. Project Partner Roles

Focal Roles		
Service Consumer	• Uses service • May be involved at various stages of the project, e.g., to provide feedback during development	1-9, 11, 13
Service Provider	• Initiates and manages the overall project as a project sponsor • Operates and offers the service towards the service consumer	1-14
Digital Innovator	• Facilitates the creation of service ideas • Designs business model	1-14
System Integrator	• Develops technical concept, e.g., system architecture • Develops front-end interfaces, e.g., apps, and backend services, e.g., cloud analytics and other software components • Integrates existing systems, services, and devices	1-14
Project Partner Roles		
UI/UX Specialist	• Designs customer journey, user interactions, and wireframes • Supports implementation of front-ends	1, 2, 4, 6, 7, 13
Data Analytics Specialist	• Designs and implements big data solutions • Expert for data analysis, machine learning, forecasting, etc.	8
Market Research Provider	• Provides insight into customer demands • Provides support in gathering feedback on service prototypes	2, 5
Service Operator	• Operates the technical part of the smart service system • Performs application management, e.g., ensures availability and compliant operation of the system	1-9, 13
Supplier Partner Roles		
Hardware supplier	• Supplies sensors, communication modules, and other hardware components	3-5, 9, 10, 13
IoT-/Cloud Platform Operator	• Provides cloud services, in a Platform-as-a-Service (PaaS) or Infrastructure-as-a-Service (IaaS) model to serve as the runtime environment for software components	1, 5, 6, 9, 13
Information Service Provider	• Provides information for the data-driven value creation, e.g., weather forecasts, energy prices, traffic information	1
Connectivity Provider	• Provides services for connecting smart products in the field, e.g., cellular networks	5, 8, 9
Application Software Provider	• Develops and/or runs existing application software systems that must be integrated	2-7, 10

The **Project Partner Roles** are characterized by contributions that are specific to the smart service system to be engineered. Organizations with these roles offer individual, knowledge-intensive services, which are relevant in SSSE projects. The organizations assuming Project Partner Roles were perceived as active participants, who were integrated closely into the collaborative project work. However, these roles might also be taken by organizations that have a Focal Role, if the required capabilities are available there. For example, in case 13, INTERNALIT also acted as the UI/UX-Design Specialist when they prepared screen designs for digital user interfaces.

Organizations with **Supplier Partner Roles** provide technical artifacts including hardware (e.g., sensors) and digital services (e.g., cloud storage). As such, they provide relevant parts of the smart service system, but they usually do not participate actively in project work. These contributions typically comprise mature, well-defined products and services, for which effortful adaptations are either not possible or not required. The integration of these contributions takes place by buying the products or services through standard market-based transactions. Another characteristic of Supplier Partner Roles is that they can become part of the run-time smart service system, i.e., they are not only relevant during the SSSE project, but also in the later operations of the service. This might apply to all mentioned roles except for *Hardware Suppliers*, for which the experts from our sample did not report on such an ongoing involvement.

4.3 Assignment and Occurrence of Roles

In our sample of SSSE projects, we observed that a specific organization can have multiple roles in a project and that the contributions of a certain role can be provided by more than one organization. Furthermore, we did not find all the 13 roles that we conceptualized to be present in all 14 projects. To illustrate the different configurations of roles, we distinguish between three types of project participants in the following: *customer organizations* or single consumers (type C), *provider organizations* (type P), and *external supplier organizations* (including single persons, e.g., freelancers; type E).

Table 4. Assignment of Roles to Project Participant Types per Case

Roles	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
Service Consumer	C	C	P,C	P,C	C	C	C	P	P,C	-	C	-	C	C
Service Provider	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Digital Innovator	P,E	P,E	P	P	P,E	P,E	P,E	P,E	P,E	P	C	P	P,E	P,E
System Integrator	E	P	E	E*	E	P	E	E	E	E	E	E	P.E	E
UI/UX Design Spec.	E	P	-	E	-	P	E	-	-	-	-	-	P	-
Data Analytics Spec.	-	-	-	-	-	-	-	E	-	-	-	-	-	-
Service Operator	E	P	E	E,P	E	P	E	P	E	-	-	E	-	-
Market Research Prov.	-	E	-	-	E	-	-	-	-	-	-	-	-	-
Inform. Service Prov.	E	-	-	-	-	-	-	-	-	-	-	-	-	-
Appl. Software Prov.	-	E	E	E	E*	P	E*	-	-	E*	-	-	-	-
IoT-/Cloud Platform Pr.	E	-	-	-	E	E	-	-	E	-	-	-	E	-
Connectivity Provider	-	-	-	-	E	-	-	-	E	-	-	-	-	-
Hardware Supplier	-	-	E	E	E	-	-	-	E	E	-	-	P,E	-

In the projects of our sample, we found roles that were only assigned to a single type (e.g., the role of "Service Provider" was only assigned to the type P); while others were assigned to multiple types of project participants or even multiple instances of the same type. Table 4 shows which roles we observed in which project, and to which project participant type we assigned them. An asterisk (*) indicates that multiple project participants were assigned to a role. A minus sign (-) indicates that a role was not identified in the respective case. Considering the distribution of roles across project participant types, we conclude that SSSE projects require multiple contributions from different organizations. Hence, our results support the assumption that SSSE takes place in inter-organizational settings. It becomes obvious that most provider organizations (P) must rely on external supplier organizations (E) for software development and system integration (cases 1, 3-5, 7-12).

From the multiple experts from external supplier organizations (E) within our sample we learned that they contribute a broad range of roles in SSSE projects. In this regard, case 6 is special because the provider organization (P) is an IT company itself. The UI/UX Design Specialist role was mentioned in five cases, which illustrates the awareness for the importance of usability design for smart services. The required skills for that were found at the provider organization (P; cases 2, 6, 13) or acquired from external supplier organizations (E; cases 1, 4). The Digital Innovator role is often (cases 1, 2, 5-9, 13, 14) shared between the provider organization (P) and external organizations (E). Market Research Providers were used when services were targeted at large anonymous customer groups to gather insights about demands and feedback on prototypes (cases 2, 5). Customers (C) were involved by taking the role of the Service Consumer in all cases except 10 and 12. In case 11, the customer organization was even the Digital Innovator that provided the idea for the virtual reality training service to the provider organization (P) PHARMACHINES. Our findings further illustrate that not only the customer organization (C) but also the provider organization (P) can take over the Service Consumer role (cases 3, 4, 9, 13). This occurred when a service was intended to be used by the provider organization itself, e.g., in the cases where the customer support unit used a remote diagnosis function for industrial equipment or the e-vehicle charging service was also used for the provider’s own fleet.

5 Discussion and Conclusions

Our study explored the intersection between smart service systems engineering (SSSE) and inter-organizational projects (IOPs). In all investigated cases, multiple partners worked together and, hence, we conclude that developing smart services typically requires several contributions from different organizations. External specialists are frequently hired to work on specific tasks within SSSE projects, e.g., the value proposition design for digital services, system integration, or UI/UX design. Our **contribution** is a set of 13 organizational roles that project participants can assume in inter-organizational SSSE projects. We further structured them into three groups of roles, namely Focal Roles, Project Partner Roles, and Supplier Partner Roles. We developed the set of roles and their grouping inductively based on the empirical data gathered through expert interviews. With this systematization of roles, we contribute to conceptualizing the inter-organizational dimension of IOPs in general [32] and SSSE projects in specific (cf. Section 2). Our systematization goes beyond existing frameworks of roles like the one by Meier et al. [30] who only identify a small number of basic roles. In contrast to the typology of roles by Ekman et al. [29], we identify and label the multifaceted roles that are specific to SSSE projects and, thus, go beyond their generic role descriptions (e.g., active/passive and provider/beneficiary).

The three groups of roles can be related to the continuum of stakeholder integration as put forward by Jonas et al. [27]. As they write, "[m]utual integration is characterized by stakeholders acting on eye-level, as equitable partners for the discussion and solution of innovation tasks in a predetermined setting." We found this co-creation in SSSE projects mainly between participants having the Service Provider roles (usually a provider organization, P) and those with the Digital Innovator and System Integrator roles (often external supplier organizations, E), which represent Focal Roles. Reactive and passive stakeholder integration as put forward by Jonas and Roth [27] show similarities with our description of Project Partner Roles and Supplier Partner Roles.

Our empirical results can also be associated with the recombinant service system engineering approach [21]. One example is case 2, where INSURANCE integrated an existing app for diabetes prevention as part of their overall health insurance service portfolio. In case 5, GLOBALSYS designed the smart parking service in a way that it can be reused for other cities. ENERGYPLAT followed this approach even more consequently by being a platform provider itself (case 1). We found that several smart services were developed based on platforms, which also resulted in the role of the *IoT-/Cloud Platform Provider*. This role can be interpreted as a key driver for reducing time-to-market and technical complexity through recombination. However, it can also create dependencies and reduce competitive advantages through standardization [35].

Due to the exploratory character of our study, the following **limitations** must be considered. First, our conceptualization of organizational roles in SSSE projects is grounded in data from only 14 cases. While we covered a broad range of different SSSE projects in diverse settings, these can neither be considered comprehensive nor representative for SSSE projects in general. Investigating further cases of SSSE projects, therefore, might lead to the identification of additional roles. Second, most experts represent IT companies, which were contracted by other organizations having the Service Provider role. Thereby, we were able to ensure a high likelihood that our sample of experts can truly report on inter-organizational project settings. At the same time, this might have introduced a bias towards such settings where service providers rely on external partners. Third, we only interviewed one expert per case, which limits our available information to her/his single, personal perspective. Fourth, the proposed roles resulted from our subjective interpretation of the interview data. Although we discussed the definition of roles intensively with all three researchers involved, other researchers might have come to a different conceptualization of roles. Fifth, we were not able to assess the influence of certain organizational setups on the overall success of the project or even the smart service system operations later. Most SSSE projects in our sample were in the late stages of designing and prototyping or in the early stages of market tests. Therefore, the projects need to be investigated again to gather more data on the influence of the project setup on project success. Hence, our results should not be misinterpreted as a normative set of roles to be covered in an SSSE project.

Our study offers **theoretical implications** for advancing our understanding of smart service systems and methods for their development. First, it is necessary to analyze the roles more thoroughly in order to better understand their work contributions (e.g., skills and services) to SSSE projects as well as the value they capture from the SSSE projects and service operations later. Further research is also necessary to develop approaches for cost-benefit-analyses of multi-actor SSSE projects or even larger service ecosystems [40], e.g., by advancing modeling methods for networked value constellations like e3value or REA [45]. Second, the current static perspective of project participant roles must be complemented with an analysis of SSSE project dynamics, including the formation and termination of temporary IOPs and PNOs. Also, the clustering of typical configurations can help to identify archetypes of project setups, including the qualification of their relations in the sense of role-linkage models like the one by Kambil and Short [34]. As current service engineering methods hardly consider inter-organizational collaboration, we also see the need to advance them accordingly.

The **practical implications** of our findings relate to project management and strategic issues. Regarding *project management*, our proposed set of roles can be used to identify which contributions are possibly needed and whether these can be sourced internally or acquired externally. Furthermore, the complexity of project setups shows that efficient measures for managing the collaboration are needed. *Strategically*, the organization with the Service Provider role must decide which of the required skills, knowledge and services it wants to build up internally and which ones are to be sourced externally. In this regard, intellectual property rights also must be considered, e.g., agreements on the non-disclosure of business ideas, technical concepts and other sources of competitive advantage. Additionally, the set of roles can help to identify different strategic directions of partners that might have to be aligned, e.g., when organizations with the IoT-/Cloud Platform Provider role rely on usage fees and aim to standardize and scale their offer across multiple inter-organizational settings while the Service Provider intends to provide a customer-individual service.

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