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Smart Service Management

Design Guidelines and Best Practices

Springer

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Foreword

What are the characteristics of smart service systems and offerings? How are they engineered? How should they be priced? How can a traditional manufacturing company transform its current offerings into high-value smart service systems? What role does artificial intelligence (AI) play in smart service management and engineering? Today's companies are faced with more questions than answers as they digitally transform. While there is a large amount of high-quality service research on a range of topics related to digital transformation of business, the adoption into practice, especially in traditional manufacturing companies, is still lacking. SMEs (small and medium-sized enterprises) are struggling to adopt a "smart service mindset" to keep up with the pace of change and continue their journey to become T-shaped adaptive service innovation professionals, with technical depth and business communications breadth. This task is especially difficult as businesses and governments dynamically reconfigure business models and social contracts (value propositions) interconnecting people, technology, organizations, and shared information in order to build smarter service systems that strive to meet ever-changing business and societal needs.

To become oriented quickly, practitioners and also junior researchers will need good guidance. In *Smart Service Management*, Maria Maleshkova, Niklas Kühl, and Philipp Jussen provide a map with multiple entry points for industry professionals and researchers. In a unique way, they cover the entire life cycle of smart service offerings—from business models to technology to market launch.

As the area of smart service offerings is vast, and growing rapidly, the editors first emphasize basic concepts (like service systems) to allow for a shared understanding of terms, which commonly lead to confusion if the reader is not deeply rooted in the academic community. With the nomenclature established, industrial maintenance and how an organization can enhance and adjust its management of business processes and relationships are explored with motivating examples (Part I).

With the fundamental and motivating aspects set, the editors elaborate on the design of smart service offerings and systems. They describe what constitutes a successful smart service and emphasize how to develop the right strategy for a smart service portfolio. This is especially commendable, as SMEs need early orientation to position themselves strategically. While the next step in a product-oriented business would be one or more long research and development phases, the editors stress the importance of early prototyping activities inspired by agile methods like design thinking or extreme programming. Finally, they give insights on the challenging topic of pricing smart service offerings as well as preparing smart service systems for market launch. Each step is demonstrated with real-world examples from the experience of industry projects (Part II).

While the business aspects of smart service offerings are of high importance, the authors take an interdisciplinary perspective and also focus on the technical architectures of smart service systems. Only with proven architectural concepts can smart service systems simultaneously achieve scalable and efficient performance as well as high customer satisfaction and regulatory compliance. This includes topics on the design of digital twins in cyber-physical systems, the communication between entities and sensors in the age of Industry 4.0, as well as data management and integration (Part III).

Artificial intelligence provides a wide range of possibilities for data analysis, which is a key component of data-driven service systems. AI puts the technological "smart" into smart service by providing the capability of intelligently analyzing data and learning patterns within typical service transactions, e.g., interactions between customers and providers. The authors refer to these activities as service analytics. They describe how the concept of service analytics is implemented and show examples from industry and research (Part IV).

To give the reader even more actionable content, they demonstrate the applicability of the introduced method for smart service management by presenting more real-world use cases from the related areas of IT service management, IoT (Internet of Things), and condition monitoring (Part V).

The result is a comprehensive "end-to-end" textbook that clearly and concisely introduces service-oriented ways for industry. For practitioners, this book will be a valuable reference to learn the fundamentals and repeatedly consult on their digital transformation journey to smarter service offerings and systems. Both practitioners and researchers will find that it augments their own core areas expertise, and they will appreciate the carefully selected use cases, additional readings, and extensive references that accompany each of the chapters. In sum, this book provides the most complete overview of the world of smart service that I have seen to date. I am truly delighted by the tremendous contribution of this book, as well as the great progress the community continues to make in advancing the emerging trans-discipline of service science, management, engineering, design, arts, and policy. There is more work to be done for sure, but with the help of this comprehensive book, the next generation will be better prepared to tackle the challenges of smarter service.

Cognitive Opentech Group (COG), IBM Research, San Jose, CA, USA

Jim Spohrer

Preface

Concept of the Book

This book aims to communicate the main theoretical foundations behind smart services and to give specific guidelines and practically proven methods on how to design these. Furthermore, it gives an overview of the possible implementation architectures and shows how the designed smart services can be realized with specific technologies. Finally, it provides four specific use cases that show how smart services have been realized in practice and what impact they have within the businesses.

The first part of the book defines the basic concepts and also aims to establish a shared understanding of terms, which are commonly misused or lead to confusion, such as *smart services*, *service systems*, *smart service systems*, and *cyber-physical systems*. On this basis, it also provides an analysis of existing work, especially in the field of management science, with the goal to lay the foundation for aligning state-of-the-art research, technology, and business. Furthermore, this includes insights on how organizations incorporating smart services could enhance and adjust their management and business processes with the help of smart services.

With the organizational and fundamental aspects set, the focus is shifted to the design of smart services. Here, the aim is to elaborate on what constitutes a successful smart service and to describe experiences in the area of interdisciplinary teams, strategic partnerships, the overall service systems, as well as the common, broad data basis. The necessity of rapid prototyping is emphasized, which goes hand in hand with recent procedure models such as design thinking or Scrum. After the design phase, a methodology is presented on how to realize smart services within an organization and how to successfully introduce a smart service to market. This step covers multiple aspects, including the customer targeting and acquisition, the different phases with its individual challenges, as well as communication and service pricing.

While the business and service development sides of smart service are of high importance, the technical architectures need to be handled with the same level of detail, as they ensure a scalable and efficient realization. This includes topics on the design of digital twins in cyber-physical systems, the communication between entities and sensors in the age of Industry 4.0, as well as data management and integration. On this basis, there are a number of analytical possibilities that can be realized and that can constitute—or be included into other—smart services. This includes machine learning and artificial intelligence methods, which can lead to value added for customers and providers.

Finally, the applicability of the introduced design and development method for smart services is demonstrated by considering specific real-world use cases. These include services in the industrial and mobility sector, which were developed in direct cooperation with industry partners.

In the following paragraphs, each of the parts of the book is described in further detail.

Target Audience and Prerequisites

The main target audience of this book is industry-focused readers, especially practitioners from the industry, who are involved in supporting and managing digital business. These include professionals working in business development, product management, strategy, and development or as chief digital officers. The content of this book is relevant and beneficial for top level to middle management. To this end, it conveys the basics needed for developing smart services, given a consistent digital transformation strategy, and successfully placing them on the market. Furthermore, the necessary understanding of the technical aspects as well as practical use cases is taught.

There are no specific prerequisites necessary for appreciating the content presented here. However, some previous knowledge related to the background of smart services, such as a basic understanding of the effects of digitization, can be helpful. Similarly, a general understanding of components and architectures, as well as of business processes, could be beneficial too. The contents of the book are understandable regardless of the reader's academic background.

Overview of the Chapters

This book consists of five main parts, which build up from fundamental to more advanced topics.

Part I: Introduction

This part describes the central challenges in the management of smart services. This includes aligning business and technology, integrating smart services with the core business, and creating scalability. Solutions are shown for the challenges, and typical tasks of a smart service organization are presented.

Part II: Smart Service Design

Here, Smart Service Engineering—a development approach for smart services—is introduced. Based on fundamental principles of success in the development of smart services (interdisciplinary teams, strategic partnerships, etc.), Smart Service Engineering shows how smart services can be developed agilely from strategy development to market launch. It should be emphasized that the approach considers the entire development process. In particular, the step of market introduction with questions of pricing, communication of customer benefits, or the establishment of a sales organization represents a central challenge for the success of smart services.

Part III: Smart Service Architecture

This part describes how the smart services, which are designed by following the methods described in the previous part, can be turned into actual implementations. The foundation for realizing smart services is based on introducing reference architectures for guiding the installment of smart services. The currently very prominent approach of the digital twin is also described, as an example of a model-based representation of hardware. Finally, the communication between the components of a smart service is discussed, followed by a description of how data integration and management can be realized.

Part IV: Smart Service Analytics

This part describes the necessary foundations for quantitative analytics, especially the AI-based process of capturing, processing, and analyzing data generated from the execution of (smart) services, which then enables to improve, extend, and personalize services internally or externally, e.g., creating value for providers and/or customers.

Part V: Smart Service Use Cases

The applicability of the introduced design and development methods for smart services is demonstrated by considering specific real-world use cases. In particular, four different use cases are presented in detail. These include services in the industrial and mobility sector, which were developed in direct cooperation with industry partners.

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Part I
Introduction to Smart Services

Introduction to Smart Service Management

Maria Maleshkova, Niklas Kühl, and Philipp Jussen

Abstract Technology and customer focus lead to a new vision of integrated and digitized industries, fostering the development of a new kind of services—the smart services. In this introduction, we give a short overview and motivate our book on the topic of smart service management.

1 Introduction

The design and evolution of services and products are continuously influenced by multiple factors. On the one hand, market needs and demands determine the shape of new solutions. On the other hand, technology developments dictate what the new actual realization frontiers are and what practical implementation limits exist. The market influence and the technology state can be seen as two main creative forces behind services and products, which represent counterparts that need to be balanced out in order to be able to provide feasible solutions of superior quality.

Product and service evolution can be witnessed in multiple domains. These are shaped by a variety of forces driving the market. Especially in the context of services, shorter and shorter innovation cycles have been becoming more and more characteristic for the development process. The users are no longer only involved by consuming the finalized service but they take up the role of service co-creators and designers. User preferences, priorities, and needs become an integral part of the

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service requirements and thus the service design. As a result, continuous adaptation and customized solutions are not a commodity but rather a prerequisite in terms of expectations.

At the same time, technology developments determine the implementation limits of services and products but also inspire innovative solutions. Current trends, such as ubiquitous access, remote and distributed cloud storage, and distributed component-based applications, predefine user expectations and directly shape the realization of the service. In the context of smart services, data availability and abundancy, data analytics, and artificial intelligence (AI) methods have been particularly impactful in terms of enabling their development and shaping the specific functionalities.

Naturally, market push and technology developments are not the only factors that aid to promote the emergence of innovative services. A suitable environment that supports the adoption of new solutions is just as crucial. In the context of smart services, this environment was provided by the Industry 4.0 initiative, which was initially coined in 2011 by the high-tech strategy of the German government with the aim to promote the digital transformation of manufacturing. Industry 4.0, as originally conceptualized, focuses on providing custom and individualized solutions, which are enabled by adaptable and highly flexible production processes. These are realized by introducing new methods for self-optimization, self-configuration, and self-diagnosis leading to the development of cognitive and intelligent decision processes. Real-time monitoring and optimization of the complete value chain are the basis for ensuring the smooth running of the production processes.

This new vision of integrated and digitized industry fostered the development of a new kind of services—the smart services. There are multiple, partially inconsistent, definitions in terms of what smart services are. However, there is a general agreement on the key shared characteristics. Smart services are user-centered and cover a scope that goes beyond a single company. Furthermore, they are usually industry specific and rely on the integration of data, processes, value chains, and even business models. In terms of technology, smart services are highly dependent on the availability of data and integrated system and sensors. In some cases, smart services are used to refer to cognitive services or services that automatically adapt to user preferences, and recognize and support user needs. However, these are not the main focus of this book. In the following chapters, smart service characteristics and further relevant definitions are discussed in more detail.

Digital transformation, integration, and artificial intelligence are current main driving forces in both research and industry. Smart services unite these three concepts in order to enable the development of innovative services, which target a high-level of customization and automation. Thus, smart services are on the rise. However, while academia describes the theoretical background, the industry-wide take-up and implementation are still lagging behind. To tackle the challenge of real-world use cases and applications, especially for SMEs, this book captures the most important steps, from conceptualization to deployment, with a strong focus on industrial smart services.

The book benefits from both founded research background and multifold practical experience of leading researches and practitioners in the files of services and AI. The content of the book utilizes the experience of the authors and their institutions from more than 100 application-oriented research, industry, and consulting projects in the field of smart services. Particular emphasis is placed on the practical comprehensibility and applicability of the approaches presented.

Grasping the Terminology: Smart Services, Smart Service Systems, and Cyber-Physical Systems

Dominik Martin, Niklas Kühl, and Maria Maleshkova

Abstract During the past years, we can observe a rise of the concepts service systems, smart service systems, and cyber-physical systems. However, distinct definitions are either very broad or contradict each other. As a result, several characteristics appear around these terms, which also miss distinct allocations and relationships to the underlying concepts. Thus, in order to achieve a common understanding of the terminology used within this book, this chapter defines the concepts of service systems, smart service systems, and cyber-physical systems as well as related characteristics.

1 Introduction

As businesses become interconnected, new opportunities and challenges arise for collaboration and co-creation (Chen et al. 2012; Davenport and Harris 2017). Different concepts, such as (smart) service systems (Spohrer et al. 2017; Maglio 2014) and cyber-physical systems (Gunes et al. 2014) emerge and strive to allocate, structure, and explain phenomena in the field of digitally interconnected systems. However, these concepts are often used synonymously (Maglio 2014; Gölzer et al. 2015) or contradict each other (Gunes et al. 2014; Barile and Polese 2010)—which can lead to confusion and misunderstandings among practitioners and researchers. As a clear distinction of those concepts and related characteristics fosters common understanding, we aim to define services, smart services as well as distinct service

This chapter is based on the paper Martin et al. (2019).

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systems, smart service systems, and cyber-physical systems. To approach this topic, we perform a structured research to identify commonly used definitions. We consolidate the insights and define each concept on this basis. Based on this, we intend to overcome boundaries to other disciplines and allow for a common understanding as well as, accordingly, to accelerate new research and development in these areas.

The remainder of this chapter is structured as follows. First, we present theoretical foundations of services, smart services, systems, socio-technical systems, and system-of-systems. Second, we analyze the (smart) service systems and cyber-physical systems concepts in isolation and then summarize them through a conceptualization. Finally, we present a discussion followed by a conclusion.

2 Foundational Concepts

This section provides an overview of the terminology related to (smart) service systems and cyber-physical systems. In particular, it introduces the concepts services, smart services, socio-technical system, system, and system-of-systems.

2.1 Services and Smart Services

The term *service* has multiple, very heterogeneous meanings. It is often used in everyday life and also in specific domains such as the computer science, medical, or economic ones (Vargo and Lusch 2004). For this book, the two relevant definitions are in terms of *economic services* and of *IT services*. Economic services are intangible, as in they are not manufactured, transported, or stocked, they are perishable—they “disappear” after completely delivered to the customer, and they are variable, since exactly the same service cannot be repeated twice in terms of for instance the time, location, circumstances, conditions, etc. A service is an exchange or a transaction between a seller and a buyer or a provider and a consumer, which does not have the primary objective to transfer physical goods, e.g., products. Economic services are frequently described as the non-material equivalent of a good. All of these service characteristics hold also for smart services, since they are a specific type of service, that also relies on IT services for its realization.

IT services are services that are made available to one or more customers or service consumers by an IT service provider. An IT service uses information technologies and supports the business processes of the customer. It consists of a combination of actors (persons), processes, and technologies and is commonly defined by stating what is expected to be delivered, by whom, and in what quality as part of a Service-Level-Agreement (SLA). Similarly to economic services, all characteristics of IT services also hold for smart services, since they rely on information technologies for their implementation.

The heterogeneity of the definition of *smart services* is very similar to the one for services. Currently, we can distinguish three main groups of definitions. First, smarts services understood as *cognitive services* that use artificial intelligence technology and methods in order to implement a technical solution that can learn, improve, and perform in an "intelligent" manner. These services usually rely on machine learning approaches and focus on supporting learning, self-improving, or optimization functionality. They are able to grasp (i.e., cognition) the current state of data, processes, businesses, etc. and act accordingly.

Second, smart services understood as *adaptable and user-centric services*. These are services that take the user as a co-creator and co-designer of the final results. They adapt to different customer needs and provide flexibility for reacting to different situational or requirement circumstances. The "smartness" aspect is realized by offering specific services for specific needs and abandoning the "one fits all" approach.

Finally, smart services as defined in the context of *Industry 4.0 services* and as understood in this book. Smart services are IT services that are based on a connection between the physical and the digital world. They aim to optimize and upgrade the value creation and economic efficiency by relying on the integration provided by Industry 4.0 and new technology developments. Furthermore, smart services are user-centered and cover a scope that goes beyond a single company. They are usually industry specific and are facilitated by the integration of data, processes, value chains, and even business models. In terms of technology, smart services are highly dependent on the availability of data and integrated system and sensors. Naturally, these three groups of definitions have some overlaps. For instance, a smart service, as understood in the context of Industry 4.0 can be realized via analytics or machine learning approaches, i.e., via a smart service understood as cognitive service. In some cases smart services are also implemented via services that automatically adapt to user preferences, and recognize and support user needs.

2.2 Socio-Technical Systems

The term *socio-technical system* is often used to describe complex systems consisting of several interacting components (Baxter and Sommerville 2011). Originally, however, the term was used to describe a set of people and related technologies that are structured in a certain way to produce a specific result (Bostrom et al. 1977).

A *system* is generally referred to as a "collection of components organized to accomplish a specific function or set of functions" (Boulding 1956, p. 73). Boulding (1956) particularly stresses the system boundaries which delimit a system and determine which parts belong to a system and which to the environment. In an open system, interactions can take place with the environment, whereas in an isolated system no interactions can take place (Standards Coordinating Committee of the Computer Society of the IEEE 1990). Interactions can be both the exchange of information (from an Information Systems (IS) viewpoint) (Standards Coordinating

Committee of the Computer Society of the IEEE 1990) and the exchange of mass or energy (from a nature science viewpoint) (Sagawa 2013). Particularly complex open systems consisting of multiple parts that perform complex interactions with each other and with the environment are widely spread in reality (von Bertalanffy 1950). In order to categorize (smart) service systems and cyber-physical systems and form a better understanding of these terminologies, the basic concepts socio-technical systems and system-of-systems are introduced.

According to Cartelli (2007), a socio-technical system consists of two components (subsystems): The technical subsystem represents assets such as machines and equipment, as well as processes and tasks that are responsible for the conversion of input resources into outputs. The social subsystem is made up of people (such as employees) who are structured in groups and have assigned certain roles to operate, control, and use the components of the technical subcomponent. Cartelli (2007) emphasizes the facet of knowledge, which is "socially constructed and developed in the interactions among people" (Cartelli 2007, p. 3), as part of the social subsystem and its value for a socio-technical system.

Both subsystems are "jointly independent, but correlative interacting" (Bostrom et al. 1977, p. 17) in order to pursue and adapt to goals in the socio-technical system's environment and are therefore not separable from each other due to their manifold dependencies (Baxter and Sommerville 2011).

2.3 Systems-of-Systems

A *system-of-systems* has—like a typical system—interdependent components operating together to accomplish a certain common goal (Gideon et al. 2005). Unlike a typical system, the components of a system-of-systems are themselves systems (Maier 1998). According to Maier (1998) a system-of-systems is an "assemblages of components that are themselves significantly complex, enough so that they may be regarded as systems and that are assembled into a larger system" (Maier 1998, p. 269). However, Maier names two limitations: First, the components must be operationally independent. That is, if a system-of-systems is broken down into its components, they must be able to fulfill their original purpose independently. Second, the component systems can not only work independently of each other, they do so as well. Thus, the subsystems maintain their operational independence continuously. Gideon et al. (2005) summarize a system-of-systems as a "system build from independent systems that are managed separately from the larger system" (Gideon et al. 2005, p. 357).

3 State-of-the-Art Definitions in Academia

In order to cover relevant and yet established definitions we conduct a systematic literature research in July 2018 and focus on peer-reviewed articles from the field of Information Systems, Service Science, and Computer Science. Overall, we regard an amount of 354 articles, which are selected by reading the abstract in order to exclude unrelated articles. Through forward and backward search, further relevant articles are identified. By completely reading the remaining articles, all in all 110 relevant articles are selected and analyzed in a final step.

The results of the literature search and the analysis of the definitions depicted in each article are summarized in the following sections. In order to provide the reader with a comprehensive picture of the differences and similarities of the definitions, first the concepts are considered individually, before they are compared with each other.

3.1 Service Systems

The concept Service System appears most frequently in the results of our conducted literature search. Overall, 64 articles refer to the term Service System. According to Spohrer et al. (2007) a Service System comprises "service providers and service clients working together to coproduce value in complex value chains or networks" (Spohrer et al. 2007, p. 72). Components of a Service System are "people, technology, internal and external service systems connected by value propositions, and shared information" (Spohrer et al. 2007, p. 72) and examples include individuals, firms, and nations. Based on this article, Spohrer et al. (2007) and Maglio (2014) synthesize the definition and formulate: "Service systems are value-co-creation configurations of people, technology, value propositions connecting internal and external service systems, and shared information (e.g., language, laws, measures, and methods)" (Maglio et al. 2009, p. 18). Examples include cities, businesses, nations, as well as individuals as the smallest representative of a service system and world economy as the largest (Maglio et al. 2009).

The majority of articles adopt this definition (Maglio 2014; Barile and Polese 2010; Maglio et al. 2009; Baekgaard 2009; Edvardsson et al. 2011; Jaakkola and Alexander 2014; Zhou et al. 2014), while others phrase it slightly different, but in principle remain faithful to the overall message (Kleinschmidt et al. 2016; Kleinschmidt and Peters 2017; Ralyté et al. 2015; Eaton et al. 2015; Knote and Blohm 2016; Herterich et al. 2016; Brust et al. 2017; Spohrer et al. 2017). Besides the more detailed definitions, some authors like Kleinschmidt and Peters (2017) and Lintula et al. (2017) use shorter and thus less specific descriptions. Böhmann et al. (2014), Dörbecker et al. (2015), and Li and Peters (2016) state that a Service System is a "socio-technical system that enables value co-creation guided by a value