From Services to Smart Services: Can Service Engineering Methods get Smarter as well?

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Abstract. Progress in technologies such as cloud computing or artificial intelligence currently paves the way for services that rely on the exploitation of data. The resulting smart services, however, are only gradually finding their way into practical application. A reason for this delay has been identified in the limited applicability of existing service engineering methods for smart services. In this paper, we identify critical perspectives to address in smart service engineering. Subsequently, we conduct a literature review to identify the extent to which these perspectives are covered by current smart service engineering methods. Our results indicate that even though there is a significant number of smart service engineering methods, some perspectives are rarely considered. We offer practitioners and researchers an overview of the status quo of smart service engineering, thus supporting the former in the selection of methods and pointing out avenues for future research to the latter.

Keywords: smart service, service innovation, smart service engineering, service development, systematic literature review

1 Introduction

In recent years, new digital technologies such as cloud computing, artificial intelligence (AI), or augmented and virtual reality have found their way into industrial firms. As a result, manufacturing companies have already accomplished reasonable progress in increasing the quality and efficiency of their products and services by building on digital technologies [1]. However, the increasing prevalence of these technologies does not only provide the potential for efficiency gains in production. Instead, it also creates new opportunities for delivering and creating value for the customer and business through innovative services based on smart products [2]. Such smart products are physical objects equipped with sensors and communication technology, enabling them to connect with each other and humans and collect, process, and exploit data for a new category of services called smart services [3]. Beverungen et al. [3, p. 12] define smart services as *"the application of specialized*

competences, through deeds, processes, and performances that are enabled by smart products."

As firms initiated this transition from product sales or the provision of "traditional" after-sales-services to smart services, methodological guidance was still missing because existing service engineering methods could not simply be applied to the development of smart services. While the DIN SPEC 33453 [4], for example, mentions the missing ability to handle the increased agility and complexity, others refer to the insufficient consideration of the various possibilities for service innovation provided by digital technologies [5, 6]. Lusch and Nambisan [7], amongst others, criticize the sole focus on the service perspective, arguing for a reconsideration of the distinction between service innovation and product innovation, as this approach is not appropriate in the digital era anymore. Their criticism is also shared by Barrett et al. [2] and reflected in a call for consideration of aspects such as data, sensors, actors, and software in smart service development by leading service scientists [8]. Many researchers have since answered this call for the development of dedicated smart service engineering methods, leading to a large variety of approaches with different foci in terms of considered aspects and steps from idea generation to market maturity.

Inspired by this observation, the following research question caught our interest that shall be answered in this article: *To which extent do current methods for service engineering support the development of smart services?* To answer this research question, we conducted a systematic literature review following the recommendations of Webster and Watson [9] and vom Brocke et al. [10].

As a result, our paper provides three contributions. First, we offer an overview of existing methods for the engineering of smart services, thus providing researchers with information on the status quo and guiding practitioners, who are looking for methods to support their smart service development. Second, we provide an assessment of the identified methods regarding the phases and aspects of smart service engineering they specifically support. Third, based on these insights, we propose avenues for the future development of smart service engineering as a discipline.

The paper is structured as follows: Section 2 presents theoretical foundations regarding service engineering and smart services, from which we derive four perspectives to be considered during smart service engineering. Sections 3 and 4 outline the methodology and results of our literature review by presenting an overview of the identified literature, analyzing to which extent these articles consider the four perspectives and which phases of service development these articles cover. Section 5 provides a discussion of our findings. Section 6 concludes with a summary.

2 Research Background

2.1 From Services to Smart Services

Allmendinger and Lombreglia [11] were the first to introduce the premises of smart services: machine intelligence and an environment of connected, smart objects digest

a vast amount of data to enable preemptive actions. Since then, various authors have discussed the capabilities and characteristics of smart services [12]. The German National Academy of Science and Engineering (acatech) [13] specifies smart services with four successive layers: smart spaces (technological infrastructure), smart products (networked physical platforms), smart data (software-defined platforms) and finally smart services (service platforms). Smart spaces comprise the connectivity infrastructure, which enables networking and information exchange between smart products [14]. Smart products have a unique ID, are aware of their specific location, can store, and process data, interact with their environment through sensors and actuators and can connect with other products, information systems, and people [3]. Smart products create a tremendous amount of contextual data. This data is analyzed and interpreted by data analytics to discover useful knowledge (smart data) [15] and eventually support or make decisions [16]. With smart data as an initial point, manufacturing companies can offer or implement innovative services (smart services) [17]. Comparably, Yoo et al. [18] specify a four-layered architecture for digital innovation: device (subdivided in physical machinery and logical capability), network (subdivided in physical transport and logical transmission), service, and contents layer.

Digital innovation is an essential facilitator or enabler (operand resource) for new value potentials [2, 5, 19] and an initiator or actor (operant resource) in a service system [7]. The resulting smart services are *"hard to delineate, complex by nature, and include not only data and physical components, but also layers of knowledge, communication channels, and networked actors"* [20, p. 4]. Thus, an interdisciplinary approach is vital to comprehend the design, delivery, and support of smart services [21]. Guided by the characteristics of smart services and the layers of digital innovation, we argue for four axiomatic perspectives: service, product, software, and data.

The **service perspective** reflects the initial understanding of service engineering (see chapter 2.2) and focuses on planning and executing service delivery from a management viewpoint. As smart products form the basis for the service, the hardware in terms of the **product perspective** needs to be considered as well [7]. This includes the product (corresponding to the device layer) as well as the network layer that enables smart capabilities in the first place. However, smart products are not smart because of hardware and connectivity only but by software for interaction and operation nested on the service layer. Therefore, we derive a need for a **software perspective**. According to the smart services layer model of acatech [13], the link between smart products and smart services is smart data. In a similar vein, Yoo et al. [18] mention the importance of the data on the content layer for digital innovation. Thus, it is essential to understand the opportunities and challenges of data and to develop a suitable data management concept [22, 23]. This results in a need for a **data perspective**.

2.2   Service Engineering

Bullinger et al. defined service engineering as *"a technical discipline concerned with the systematic development and design of services using suitable procedures, methods, and tools"* [24, p. 2]. The objective is to enhance and automate service creation, service delivery, and service consumption [25] by adapting procedures of product engineering and software engineering [26]. Service engineering employs two different approaches: one focusing on the breadth and the other on the depth. First, process models feature stages for the entire service development cycle, usually beginning with idea generation and closing with the market maturity [27]. A common example are the seven stages established by the German Institute for Standardization (DIN) in 1998 [28]: idea generation, requirements analysis, service design, implementation, service delivery, evaluation, and detachment. Despite its seniority, this approach covers all central phases, which recent methods only slightly modify. Second, other models and tools support specific issues and tasks mostly in one specific stage, such as service blueprinting for process design [29].

Various researchers criticize that traditional service engineering research neither reflects service-centric business models and strategies with its initial product-centric perception of a service [30] nor offers cross-disciplinary models and frameworks [30] to achieve the full potential for systemic, mutual, and collaborative service innovation facilitated by digital innovations [5, 20]. Thus, service engineering needs to adapt.

3   Research Method

3.1   Definition of Review Scope

To answer our research questions, we conducted a systematic literature review, following the process proposed by Webster and Watson [9] and vom Brocke et al. [10]. Our review can be classified as a descriptive review with the overarching goal of

depicting the prior knowledge on a particular topic in order to analyze the progress in this field and derive potential areas for future research [31, 32]. The initial step in a systematic literature review should be the definition of the review scope [10, 33]. **Figure 1** summarizes the scope of this review.
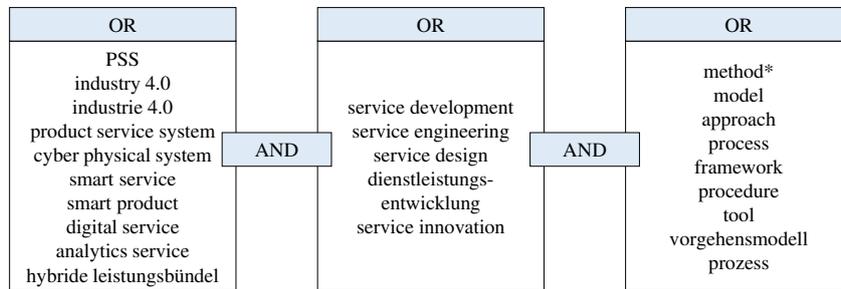
Focus	research outcomes		research methods		theories		applications	
Goal	integration			criticism			central issues	
Organization	historical			conceptual			methodological	
Perspective	neutral representation				espousal of position			
Audience	specialized scholars		general scholars		practitioners/politicians		general public	
Coverage	exhaustive		exhaustive and selective		representative		central/pivotal	

Figure 1. Scope of the literature review based on [33] and [10]

The *focus* of our research lies in the research outcomes of the papers in the form of service engineering methods. The *goal* of our review is dual in nature: After we established central issues in the form of smart service engineering perspectives in an upstream literature review, we seek to identify current service engineering approaches and examine, to which extent these methods cover these pre-defined perspectives. As we want to assess the areas of smart service engineering that are addressed by methods to date, the *organization* of our review is conceptual as opposed to historical or methodological. With the descriptive nature of our review, the *perspective* applied is neutral. As we are presenting our results in this conference paper, the *audience* of our review are scholars, despite also offering guidance for practitioners. Regarding coverage, Müller-Bloch and Kranz [34, p. 12] argue that *"while it may be argued that literature reviews should always be exhaustive, we reckon that analyzing all prior research is neither always possible nor economical and necessary."* Thus, as appropriate for descriptive literature reviews, the *coverage* of our review is representative [32].
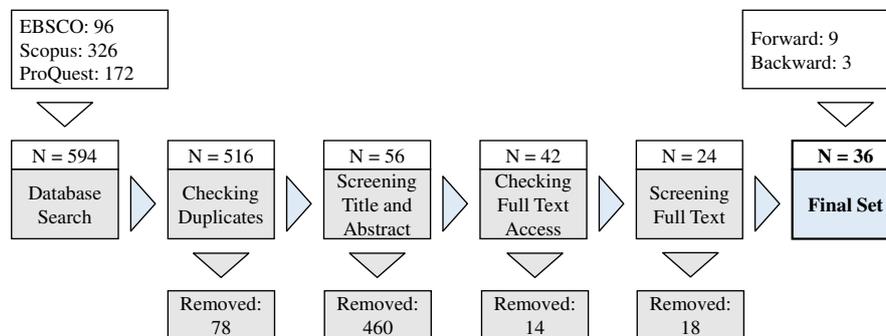
3.2 Literature Search

To identify relevant literature, we conducted a literature search across the three databases EBSCO, Scopus, and ProQuest. As smart services and especially the design of smart service is a rather young and emergent field, it is characterized by the typical spread in terms used to describe certain concepts. To identify the largest possible share of relevant articles while simultaneously limiting the number of irrelevant results, the design of an appropriate search string is necessary [35]. Accordingly, we devised a search string consisting of multiple terms, as depicted in **Figure 2**. We included German terms because of the service engineering discipline's origin in German literature.

OR
PSS
industry 4.0
industrie 4.0
product service system
cyber physical system
smart service
smart product
digital service
analytics service
hybride leistungsbündel

AND

OR
service development
service engineering
service design
dienstleistungs-
entwicklung
service innovation

AND

OR
method*
model
approach
process
framework
procedure
tool
vorgehensmodell
prozess

Figure 2. Literature search string

Figure 3 provides a structured overview of our literature search process. The initial search resulted in a total of 594 papers. After checking for duplicates, 516 papers remained, which were subsequently subjected to a screening of the titles and abstracts. A typical cause for exclusion at this stage were significant deviations in the understanding and applications of search terms compared to our understanding, for example in the case of PSS. While most authors stick to the initial understanding of "product-service system" (PSS) – the combination of products and services to extend the functional attributes of a physical product by additional services [36] without a "smart" aspect – only a few researchers use the term PSS in the context of smart services. Papers with traditional understanding were not included in the review. As a result, 460 papers were removed from the dataset. After removing 14 inaccessible papers, we checked the full text of the remaining 42 papers. Exemplary criteria for exclusion at this stage were the lack of focus on smart services both as a term per se or as our inherent understanding, as discussed in the research background section, or the mere application of a method as a peripheral aspect of the article. This left us with 24 articles. In the next step, we conducted a forward and backward search on the remaining papers as proposed by Webster and Watson [9]. Especially in the case of reviews with representative as opposed to comprehensive coverage, conducting a forward search is crucial to verify an identified research gap [34]. This step led to the identification of 12 additional articles, resulting in a final set of 36 articles for further analysis.

Figure 3. Literature search process

4   Results

As discussed in the research background, we see the need for an integrated smart service engineering approach with service, product, software, and data as vital perspectives. Therefore, we identified smart service development literature and assessed the perspectives taken. **Table 1** illustrates the result of our review. A paper considers a perspective when it highlights its importance for developing a smart service and expands the knowledge base with new insights. E.g., Kim et al. (2018) [15] specify a design process for a service based on customer behavior data. The process includes the identification and analysis of customer demands from which a service concept is derived. The authors also explicate the process of data preparation and data analysis. Thus, the paper considers the service and data perspectives. As some papers consider a specific perspective, but only discuss it superficially, we additionally established the classification "partially considered." Similarly, we determined which phase(s) of the service development process according to DIN [28] are addressed by the authors. As most publications treat delivery and evaluation equally, we adopted this understanding for our assessment. A first insight that stood out initially was the moderate number of articles addressing smart service (13) or smart products (3). This is astonishing insofar, as research and business firmly discuss the properties and opportunities of smart services. Instead, most authors apply the term "product-service system" (PSS) (21).

Table 1. Literature review results

	Perspective	*Development Process*

Author(s)	Object of development	Service	Product	Software	Data	Idea generation	Requirements	Design	Implementation	Delivery	Detachment
● Considered topic						○ Partially considered topic					
SS Smart Services	SP Smart Product					PSS Product Service System					
# of appearances: ● (○)		28 (8)	10 (6)	5 (1)	6 (5)	8 (1)	16 (4)	29 (3)	5 (2)	6 (3)	2 (0)
Abeywickrama, Ovaska 2016 [37]	SS	●			●		●	●	●		
Ahram et al. 2012 [14]	SP	○	●				●	○			
Allmendinger, Lombreglia 2005 [11]	SP	○	●				●	●			
Andriankaja et al. 2016 [38]	PSS	●	●				●	●	●		
Anke 2019 [39]	SS	●				●	○	○			
Apostolov et al. 2018 [40]	SS	●		●			●				
Bullinger et al. 2015 [41]	SS	●					●	●	●	○	
Campos et al. 2017 [42]	PSS	○		●	○			●			
Dreyer et al. 2017 [43]	PSS	○			●			●			
Dutra, Silva 2016 [44]	PSS	●		●			○	○			
Freitag, Schiller 2017 [45]	PSS	●	●					●			
Freitag et al. 2018 [17]	PSS	●	●					●			
Freitag, Wiesner 2018 [46]	SS	●			○	●	●	●	●	●	●
Georgakopoulos, Jayaraman 2016 [47]	SP		○		●			●	○		
Geum et al. 2016 [48]	SS	○	●		○	●					
Höckmayr, Roth 2017 [20]	SS	●						●			
Kim et al. 2018 [15]	SS	○			●		●	●			
Lee, Kao 2014 [49]	PSS	●				●					
Lim et al. 2015 [23]	SS	●			●	○	○	●			
Lim et al. 2018 [22]	SS	○			●			●		●	
Neves-Silva et al. 2016 [50]	PSS	○		●	○			●			
Pezzotta et al. 2013 [6]	PSS	●				●		●		●	
Pezzotta et al. 2014 [51]	PSS	●					●	●			
Pezzotta et al. 2017 [52]	PSS	●	○				●	●			
Pezzotta et al. 2018 [53]	PSS	●	○				●	●		○	
Proper, Sandkuhl 2018 [54]	SS	●					○	●	○	○	
Rondini et al. 2014 [55]	PSS	●					●	●			
Rondini et al. 2015 [56]	PSS	●				●		●			
Rondini et al. 2016 [57]	PSS	●	○			●	●	●			
Scherer et al. 2016 [58]	PSS	●						●			
Shimomura, Sakao 2007 [59]	PSS	●						●		●	
Song, Sakao 2017 [60]	PSS	●	●				●	●			
Valencia et al. 2015 [61]	PSS	●	○					●			
Verdugo Cedeno et al. 2018 [62]	SS	●	●	○	○			●			
West, Di Nardo 2016 [63]	PSS	●				●					

Author(s)	Object of development	Perspective				Development Process					
		Service	Product	Software	Data	Idea generation	Requirements	Design	Implementation	Delivery	Detachment
Zine et al. 2016 [64]	PSS	●	●				●			●	

4.1 Perspectives

The **service perspective** focuses on planning and executing service delivery from a management perspective. Benkenstein et al. [1] analyzed typical subject areas which can be addressed individually or in combination. Several of the 36 reviewed articles cover these areas: (1) Höckmayr et al. [20] and Pezzotta et al. [52] address the design of the service operation with focus on organization, processes and personnel, (2) Freitag and Schiller [45] and Anke [39] handle the description and evaluation of the service encounter, (3) Lee et al. [49] aim for the measurement of customer wishes and reactions, (4) Pezzotta et al. [51] and Valencia et al. [61] perform the analysis of the supplier-customer relationship, and (5) Campos et al. [50] explore the measurement of service experience and quality. Most of the articles consider this perspective, at least partially.

The **product perspective** refers to the physical properties of a smart product. In addition to sensors and actors, computer hardware, and ICT infrastructure components [8], this also includes physical functions and interdependencies. Within the sixteen identified articles addressing this perspective, Ahram et al. [14], Allmendinger and Lombreglia [11], and Valencia et al. [61] discuss properties of smart products or PSS and argue for synchronizing product development and service development. With this, service and product can be harmonized to realize the full potential [53, 62] but also to identify potential physical obstacles early. In this regard, Freitag and Schiller [45] and Freitag et al. [17] highlight the importance of testing a PSS.

In conjunction with the product perspective, the **software perspective** encompasses the virtual level of a smart product. Only in conjunction with software, e. g. applications, does a product become a smart product [3]. The software perspective prioritizes developing and evaluating appropriate models and methods for processing and analyzing data, as well as ensuring monitoring and control functions. Only six of the reviewed articles occupy this perspective [40, 42, 44, 50].

The **data perspective** focuses on managing the required data in terms of storage, availability, administration, security, governance, and related tasks. For instance, Dreyer et al. [43] present a conceptual model for an information architecture as a prerequisite for smart services. Sensor data and data from MES, CRM, and ERP systems are gathered, analyzed, and transformed into information [43]. Although eleven researchers already address data management, e.g., in IT management or information systems, the overall planning process needs to be synchronized with

service development. In this context, Lim et al. (2018) [22] identified nine critical factors that should help planning service delivery, focusing on the data perspective.

With thirteen records, most papers take a pure service perspective. Almost on the same level is the combination of service and product in eleven articles. The combination of service and data with six appearances ended up third. The remaining combinations of different perspectives are hardly remarkable. In the end, exclusively Verdugo Cedeno et al. [62] combine all four perspectives but only view the design step.

4.2 Development Process

The accumulation of requirements, the design, and the implementation of service form the central pillars of service engineering [65]. This statement of Bullinger and Schreiner is generally consistent with our observations. 32 articles at least partially take into account the phase *design,* and 20 papers consider *requirements*. E.g. Pezzotta et al. (2014) [51] develop the SErvice Engineering Methodology (SEEM), which constitutes 4 necessary steps which the group of authors also further develop in subsequent publications [50, 52, 53, 55, 56]: customer need analysis, process prototyping, process validation and offering identification and analysis. Notably, the large number of publications focusing on *design* indicates a considerable interest in research and practice, but also a certain degree of saturation. Although Bullinger and Schreiner [65] emphasized the importance of the *implementation* phase for successful service engineering, this phase has been neglected by research so far with only seven publications. The phases *requirements* and *implementation* are rarely treated by themselves, but often in combination with *design*. Methods for *idea generation* and *delivery* are sparsely developed and usually only include the service perspective. E.g., Geum et al. [48] describe a method of generating variances of a service concept with the help of a morphological box to generate ideas for alternative customer segments and demands. Freitag and Wiesner [46] are the only authors to cover all six phases of service development with the method smart service lifecycle management. However, they focus exclusively on service and do not fulfill the need to integrate all four perspectives.

5 Discussion

The results of our literature review indicate that there is still a need for smart service engineering methods that allow firms to approach the development of smart services comprehensively, paying attention to all necessary perspectives and phases. Only by considering all perspectives, a smart service can realize its full potential, for both service providers and customers. To achieve this, smart service development activities will be increasingly performed cross-disciplinary, including officials of different departments, each having a more in-depth focus on one of the perspectives and directed by own interests and instructions. The tension between the disciplines' different approaches might not be sufficiently solved by solely developing an

overarching service engineering process and single methods and models for each development step. Instead, researchers should consider integrating these approaches by focusing on models and frameworks for cross-disciplinary collaboration [30], by e.g. determining stages of information exchange between different stakeholders during the development progress, and in this matter defining which information is relevant for exchange.

The actual coverage of all four perspectives imposes significant demands in terms of knowledge and capabilities in different areas, which is ambitious, especially for smaller companies. A way to mitigate these challenges to some extent is offered by the characteristic of smart products to act as platforms that are accessible to others via standardized interfaces to develop complementary market offerings [18]. This leads to a shift in the focus of innovation from within the firm to actors in the periphery, a phenomenon that has been described by Parker et al. [66] as "inverting the firm." Although the successful development of smart services requires the full accomplishment of all four perspectives, not all perspectives need to be covered by a single organization. However, new challenges and complications emerge simultaneously. Shifting from an internal to an external environment with various actors entails additional management efforts, e.g. in terms of governance, coordination, and alignment [67, 68]. While the four perspectives for smart service development themselves stay intact, these management efforts are ambient activities.

As such, it makes sense to consider and integrate current service (eco-)system literature into smart service engineering, as it already reflects upon areas such as the cooperation of a multitude of actors to provide services and co-create value [5, 69]. In recent years, a reasonable amount of articles have been considering the role of digital technologies in service systems [5, 70]. This led to the conceptualization of smart service systems as "*service systems in which smart products are boundary-objects that integrate resources and activities of the involved actors for mutual benefit*" [3, p. 12]. However, the traditional product-centric perception of service in service engineering [20, 30] is still lacking consideration of such organizational and social aspects [5, 70] and therefore would benefit from a (smart service) systems orientation. The first step in this direction could be to adopt the fundamental understanding of service-dominant (S-D) logic [7, 71] in the development of smart services, as it focuses on the co-creation of a service with various actors. This is consistent with the shift of digital technologies away from being subordinate supporters towards participating as vital actors in value co-creation [19]. S-D logic also unites intangible services and tangible products into a comprehensive service view with a focus on the value-in-use [72, 73]. This value-in-use interpretation is increasingly relevant in the context of smart services, as smart products allow the manufacturers to monitor how customers use their products and thus provide more profound insights into potentials for enhancing product performance [3]. In the resulting situation in which the line of visibility shifts and the provider's awareness of the product use increases [3], S-D logic can help to inform the development of smart service engineering methods in this regard. A possible direction for such revised methods could subsequently be an increased focus on the delivery phase.

6   Conclusion

In this paper, we presented the results of a systematic literature review on smart service engineering. As we discussed, the sole focus of service engineering methods on the service perspective is not appropriate in the digital era anymore [7]. Instead, various researchers argue for a reconsideration of the distinction between service innovation and product innovation [2, 8]. We address this deficit by studying literature on the properties of smart services from which we derived four critical perspectives to consider during smart service engineering: service, product, software, and data. We then analyzed to which degree existing smart service engineering methods consider these perspectives. Our literature review shows that the domain of smart service engineering has attracted the attention of researchers, especially in the last several years. Nevertheless, our research also uncovered some shortcomings of these approaches that limit their applicability for smart services development, as hardly any article considers all four recommended perspectives.

It is essential to mention that the purpose of this review is not to criticize these past endeavors of other researchers. Instead, our objective is to identify gaps in current literature regarding perspectives of smart service engineering that have not been considered thoroughly yet but are critical for overall service composition. As a result, the following demand and avenues for future research can be derived from this literature review: to realize the full potential of smart services, more integrated smart service engineering methods, which consider and configure all four perspectives, have to be developed. Furthermore, we argue to increasingly integrate a service systems view into smart service engineering. Third, smart service engineering would benefit significantly from adopting the S-D logic, as this is more appropriate for smart services than the previous product-centric perception of service prevalent in service engineering.

Finally, similar to any research, this study is subject to some limitations. The first limitation is the restricted coverage of literature. Although three databases have been employed to search for suitable literature and forward and backward searches have been conducted to verify the research gaps [34], a non-comprehensive review always faces the risk of missing relevant literature. Second, even though the search string observed most of the synonyms and abbreviations of service engineering methods and smart services, smart products, or PSS, the prevailing ambiguity of terms in this relatively young field is challenging to grasp in a search string with reasonable length. Thus, several relevant articles might not have been identified. Nevertheless, our study offers a representative overview of the relatively young field of smart service engineering and, thus, a strong foundation for future research.

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