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WHAT IS SMART ABOUT SERVICES? BREAKING THE BOND BETWEEN THE SMART PRODUCT AND THE SERVICE

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Research paper

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Abstract

While the conceptual delineation between conventional and smart products is rather conspicuous, the distinction between conventional services and their smart counterparts remains elusive. This study develops a conceptual framework for understanding the distinctive attributes of smart services and their relationship to smart products. In a systematic literature review of publications from top information systems outlets, 30 contributions holding relevant information on smart services are identified and subjected to content analysis. The analysis reveals a variety of different definitions and characterizations of smart services and relations to concepts like data-driven services and services associated to smart products and smart objects. These findings are used to examine artifacts developed in rather design-oriented papers to derive five dimensions that impact the level of smartness of services: richness of the data, the knowledge intensiveness of the engine for decision support, the level of sophistication of the outcome delivered to the service user(s), the architecture of the stakeholders, and the automation level of the service processes. Within this scope, the product can have four roles: sensor, computer, interface, or integrator. The paper concludes by identifying some gaps in the overall research landscape and provides directions for future research.

Keywords: Smart service, Smart product.

1 Introduction

With the internet of things, rapidly evolving information technologies promise to make businesses and societal systems smarter. Such systems are becoming interconnected, equipped with sensors, and enhanced with cognition that enables individuals as well as organization make better informed decisions (Demirkan et al. 2015). Managers now can use information gathered from intelligent and connected objects to improve their service offerings and let customers benefit from customized service features (Ostrom et al., 2015). The resulting potentials for innovation and transformation of existing business models are often referred to in expressions with the "smart" prefix, such as the smart factory, smart home, smart mobility, smart health, etc. (Beverungen et al., 2017a), which all relate to the concept of smart services (Kagermann et al., 2015). Smart services are receiving increasing attention in the literature. They are said to incorporate automation that handles some of the traditionally human functions, such as managing city traffic, diagnosing and treating patients, preparing legal cases or optimizing corporate financial portfolios (Peters et al. 2016, p. 139) and they are expected to make our processes and systems more efficient (Kagermann et al., 2015). From such early exploration of the concept, we find that smart services are systematically described or defined with respect to an object or a product equipped with smart properties. Allmendinger and Lombreglia (2005) describe them as "fundamentally preemptive services, rather than reactive or even proactive, that transcend the mere product upgrades both in their value to customers and in their cost efficiency. Their provision requires intelligence, i.e. awareness and connectivity, to be built into the products themselves" (p. 2). More explicitly, the German Academy of Science and Engineering addresses smart services as "individually configured bundles of products and services" (Kagermann et al., 2015, p. 4).

We observe that: i) services are often said to be tightly coupled to physical objects equipped with intelligence capabilities. ii) smart services tend to be considered as systems, since they are enabled by smart products which in return become a platform for offering various value propositions to multiple users involved in smart service systems (Beverungen et al., 2017a). iii) the relationship between the smart service and the (smart) product remains still rather opaque, as the term smart seems to be inherited from the object by the service, and there is no specification of the smartness that the service should possess itself neither in type (e.g. artificial intelligence) nor in its pervasiveness. While service systems capture the co-creation and actors configuration involved in the service, the narrower service lens envisions services from a product-centric perspective and allows for the development of models, methods and principles to engineer individual services (Böhmann et al., 2014). These observations motivate us to study the body of information systems (IS) knowledge about smart services to better understand the loci of their smartness and their link to smart products. This would to pave the way for future research concerned with the systematic design, engineering and innovation of smart services.

In the remainder of the paper, we first describe the overarching process of the systematic literature review then the inductive analysis method that we employ to answer the question: what is smart about services independently from smart products? We then synthesize the descriptions of smart services and smart products in the literature to highlight how tightly coupled these two constructs are and isolate the main characteristics of smart services: awareness, automation and decision support. Subsequently we construct a conceptual framework by focusing on the rather design-oriented publications that consider instances of smart services as artifacts. The framework is composed of five dimensions that impact the level of smartness of services: richness of the data, the knowledge intensiveness of the engine for decision support, the level of sophistication of the outcome consumed by the service user(s), the architecture of the stakeholders, and the automation level of the service processes. We also identify the role played by the smart product with regard to each of the dimensions. Finally, we highlight the contributions of our study and discuss themes for future research.

2 Method

Our research interests can be summarized in the following question: what is smart about services independently from smart products? To answer the question, we perform a systematic literature review (SLR). Based on Tranfield et al. (2003) we follow a clear protocol to deliver a replicable, scientific and transparent process, and to identify key scientific contributions of the IS research about smart services. According to vom Brocke (2009), the SLR method also allows us to synthesize past knowledge about the topic, identify important biases and knowledge gaps in the literature to finally propose future research directions. Moreover, with regard to the goals of the systematic literature review proposed by Rowe (2014), in this review we seek to provide an epistemic understanding of smart services through related concept(s) proposed in former research. We thus rely on interpretation and adopt a broad perspective about smart services by including the literature about smart products in the analysis. As theory on smart services is still nascent, this study emphasizes on the development of a conceptual framework. It does not explore deeper relationships within the framework, nor does it purport to elaborate a holistic theory. This review aims first and foremost at understanding the phenomenon of smart services to lay a reliable groundwork for future attempts of elaborating a theory, engaging in the current IS discussion about questions like “how can we make services smart?” (Peters et al., 2016), which are more geared toward explaining than understanding.

Following a procedure adopted by authors like Glass et al. (2004) and Wareham et al. (2005), we prioritize coverage over exhaustiveness in the sense that we do not focus on collecting everything that exists about smart services but rather favor a reasonable number of relevant publications (vom Brocke et al., 2015). Thus, given the large amount of research being produced about smart services, this literature review explores how this subject is covered in IS publications from a sample of top IS journals that represent the discipline (vom Brocke et al., 2015). In fact, as noted by Webster and Watson (2002), the major contributions are likely to be in the leading journals. Therefore, in this study we search the leading IS journals (Guido et al., 2015) in the databases INFORMS and ACM (Ley and Ellis, 2006) that cover the Association for Information Systems journals and the top 50 leading IS journals analyzed by Lowry et al. (2004, p. 53). We also examine selected conference proceedings reputed for quality (Webster and Watson, 2002), and thus complement our journal search with five major conferences sponsored by or affiliated to the association of information systems (AIS): Americas, European, International, and Pacific Asia Conference on Information Systems, and Wirtschaftsinformatik.

We employ for the databases search the phrase "smart service" OR "smart product" OR "smart object" OR "intelligent service" OR "intelligent object" OR "intelligent product" to query the title, abstract and keywords. The search results in a total number of 244 publications in all sources until late 2018 (211 articles and 33 conference papers). After filtering them based on journals then topic relevance, 22 papers are selected for deeper analysis. Backward and forward search is performed thereafter, resulting into additional 8 publications from different sources which are frequently cited in IS papers. We reach a total set of 30 publications presented in Table 1. The process is illustrated in Figure 1.

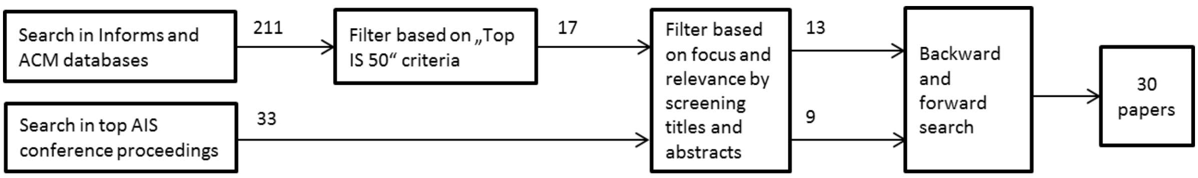

Figure 1. Systematic publications extraction process

Then, we proceed with content analysis following mostly the prescriptions of Miles et al. (2013) for an inductive approach, using the software MAXQDA for coding the literature material. The authors primarily distinguish between the themes relating directly to smart products and those to smart service as a deductive orientation. Then, they proceed with an inductive approach consisting of two coding cycles. The first coding cycle processes the selected literature through inductive category formation. It focusses on literature backgrounds, definitions and descriptions of smart services or smart products or other closely related themes, representations or models developed by the authors including taxonomies and typologies. The researchers put specific emphasis on being flexible and open in their coding as encouraged by Miles et al. (2013) and mixed between descriptive, *in-vivo*, and attribute coding in order to identify different themes relating to smart services and smart products. From this analysis, the authors not only assess the definitions of smart products and smart services separately to identify their respective characteristics, but also structure the large volume of information by aggregating the codes into nine main categories: (1) implications of smart products on smart services, (2) related concepts to smart products, (3) related concepts to smart services, (4) smart service system associated concepts, (5) characteristics of smart products, (5) characteristics of smart services, (6) collected data, (7) enablers of smart services, (8) intelligence manifestation, and (9) smart service contexts.

Year	Author	Title	Outlet
2017	Stocker et al.	Quantified Vehicles	BISE
2015	Demirkan et al.	Innovations with Smart Service Systems	CAIS
2016	Peters et al.	Emerging Digital Frontiers for Service Innovation	
2008	Resatsch et al.	Do Point of Sale RFID-Based Information Services Make a Difference?	EM
2008	Thiesse and Köhler	An Analysis of Usage-Based Pricing Policies for Smart Products	
2017	Beverungen et al.	Conceptualizing smart service systems	
2018	Anke	Design-integrated financial assessment of smart services	
2018	Laubis et al.	Enabling crowdsensing-based road condition monitoring service by intermediary	
2017	Beverungen et al.	Information systems for smart services	ISeB
2007	Nowlan et al.	Agent-mediated knowledge sharing for intelligent services management	ISF
2009	Satoh	Location-aware communications in smart environments	
2011	López et al.	Taxonomy, technology and applications of smart objects	
2016	Chung et al.	Knowledge-based health service considering user convenience using hybrid Wi-Fi P2P	IT&M
2012	Strueker and Weppner	A Cloud-based Messaging Service for Cross-Enterprise Data Exchange with Smart Objects	AMCIS
2016	Novales et al.	IT-enriched "Digitized" Products: Building Blocks and Challenges	
2017	Pourzolfaghar and Helfert	Taxonomy of Smart Elements for Designing Effective Services	
2018	Betzing	Beacon-based Customer Tracking across the High Street	
2017	Klötzer and Pflaum	Toward the Development of a Maturity Model for Digitalization within the Manufacturing Industry's Supply Chain	HICSS
2017	Nezhad and Schwartz	Towards Open Smart Services Platform	
2018	Rizk et al.	Towards a Taxonomy for Data-Driven Digital Services	
2017	Yavari et al.	ConTaaS: An Approach to Internet-Scale Contextualisation for Developing Efficient Internet of Things Applications	
2017	Dreyer et al.	Towards a Smart Services Enabling Information Architecture for Installed Base Management in Manufacturing	WI
Backward and forward search results			
1999	Abowd and Dey	Towards a better understanding of context and context-awareness	Symp.
2013	Demirkan and Delen	Leveraging the capabilities of service-oriented decision support systems	DSS
2005	Allmendinger and Lombreglia	Four strategies for the age of smart services	HBR
2014	Porter and Heppelmann	How smart, connected products are transforming competition	
2014	Perera et al.	Context aware computing for the internet of things: A survey	IEEE
2010	Kortuem et al.	Smart objects as building blocks for the internet of things	IEEE
2016	Püschel et al.	What's in a smart thing? Development of a multi-layer taxonomy	ICIS
2015	Kagermann et al.	Recommendations for the Strategic Initiative Web-based Services for Businesses	(report)

Table 1. Selected literature for in-depth analysis

The next step of the analysis consists of considering the design-oriented papers that develop instances of smart services. The authors follow a cross-case analysis employing a contrast table (Miles et al., 2013) in order to explore the variations of smartness between these instances along the identified smart service characteristics. This allows the emergence of new categories that are assigned to describe the smartness of services, and the cross-case analysis supports the development of a conceptual framework based on inductively derived dimensions relating to the characteristics of smart services. The authors also analyse the role of the described smart product in each of the instances and its implications for each of the delineated dimensions. Finally, a second coding cycle is conducted to critically review the codes and revise the categories and reassign the codes under the five main dimensions of the framework which embraces a dominant smart service perspective. For example, the categories (1) implications of smart products on smart services and (7) enablers of smart services are merged together since both consist of capabilities that allow for the emergence or delivery of smart services. Moreover, the smart product characteristics such as connectivity are also added to this larger category since these also indicate enablers for the smart service. From there, the authors derive the role of the product in each of the five dimensions of the framework.

In sum, four experts have been involved in the analysis of the literature, the generation of codes and their categorization. The categories assignment is achieved at individual levels then critically reviewed to consolidate the results. The framework is developed within the team of researchers. Regarding the quality of the analysis, the authors root their codes and categories in the extracted literature so that the dimensions of the framework are in line with the literature discourse, thus striving for semantic validity and construct validity. The involvement of multiple researchers and the careful description of the method and analysis process supports the reproducibility of the research (Mayring, 2014).

3 Characterization of smart products and smart services

The analysis of the literature on smart services and smart products allows the distinction of respective definitions and characterizations that we detail in the following sections.

3.1 Smart products

Products are becoming increasingly complex systems combining hardware, sensors, data storage, microprocessors, software and connectivity in multiple ways (Klötzer and Pflaum, 2017). In the case of retailing, smart products can act as a process interface and information source for retailers to inform them about for example how many times the product has been picked up by customers (Thiesse and Köhler, 2008). In addition to the general features of products, smart products combine actuators and built-in functionalities for data storage and processing, and therefore have the capacity to adapt autonomously to changes in their environments, condition, and use (Beverungen et al., 2017a). Porter and Heppelmann (2014) consider the smartphone to be the archetype of the smart connected product, since it combines regular physical parts like batteries and display with smart elements and with connectivity. Next to phones, vehicles also have turned into computers on wheels and evolved into what is called the quantified vehicle (Stocker et al., 2017, p. 126). In fact, the connected car can be interpreted as a customer device (Stocker et al., 2017). But it can also be technologically seen as networked embedded systems integrated into a physical object capable of processing information and data and of interacting with the environment. This is what Klötzer and Pflaum (2017) describe as a cyber-physical-system (CPS) (p.4211). According to them, while the smart product usually emphasizes a sort of final product, a CPS can be any given physical object becoming "smart" through the embeddedness of microelectronics (p. 4211). At a higher abstraction level, the quantified vehicle can be considered as a smart object (López et al., 2011). Kortuem et al. (2010) describe smart objects as entities "that autonomously interpret sensor data and make decisions" (p. 45). Smart objects interact with organizational information systems and participate in decision making to increase the overall efficiency of the system (López et al., 2011, p. 282).

While some authors like López et al. (2011) address the capabilities of the smart product as storage, sensing, actuation, decision making, control and networking, other authors like and Porter and Heppelmann (2014) enumerate their composing elements as physical components, smart components comprising the sensors, microprocessors, data storage, control, software, user interface, and the connectivity components such as antennas and protocols. All these items characterizing smart products can be bundled within three main characteristics: *awareness* including the sensorial and data collection and storage capabilities, *computation power* including the decision making and control capabilities enabled by the microprocessors and embedded software and finally *connectivity* comprising the interface with the users as well as the networking capabilities though antennas and protocols.

However, while awareness and computation can be integrated into the products by means of sensors, hardware and software, connectivity requires in addition to embedded modules a larger infrastructure, such as IoT to support the development of smart services via the discovery and integration of Internet-connected devices and their data (Yavari et al., 2017). By being networked together and to other entities, smart products become a service platform that can provide value propositions to multiple stakeholders involved in the system (Satoh, 2009; Beverungen et al., 2017b).

3.2 Smart services

In their paper about smart objects, López et al. (2011) consider *smart* to be equivalent to *intelligent* which means “having the ability to make informed decisions on the basis of some available information for one’s own benefit” (p. 285). This definition captures a property of smart services that often repeats in the literature as indicated in Table 2, namely the decision making or support based on available information. Allmendinger and Lombreglia (2005) describe smart services as based upon “machine intelligence” that can be reached by equipping products and devices with awareness and connectivity capabilities, so that these can digest billions of data points, communicate to each other and control one another in real-time (p. 2). Such applications enabled by smart connected products are called *smart product applications* by Porter and Heppelmann (2014), who group them into four areas: (remote) *monitoring* of the product’s condition, the external environment and the product’s operation and usage, *control* of product functions or personalization of the user experience, *optimization* of product operation and use in order to enhance the product’s performance, and *autonomy* in product operation, self-coordination of operation with other products and systems such as self-diagnosis and self-service. Because of their heavy reliance on the data, these applications are also called by Anke (2018) *data-driven services for technical product* as they are provided as bundles of products and services (p.2). Such bundles should be individually configurable (Kagermann et al., 2015, p. 4) and should first of all integrate data acquisition mechanism to build the awareness (Rizk et al., 2018). Awareness can be framed as the acquisition of context (Dey and Abowde, 1999), meaning any information that can be used to characterize the situation of an entity that users interact with to derive a value (Perera et al., 2014). This is achievable by equipping the entities with sensors to become aware of their environment, where the entity can be any person, place, or object that the user of a service interacts with. In fact, the embedded intelligence into the products can support the understanding of the customer’s needs and the challenges faced when dealing with it (Resatsch et al., 2008). Therefore, data-driven services should also integrate data exploitation mechanisms like information processing and advanced analytics (Rizk et al., 2018) to generate for example knowledge about the customer’s experience with the product in use (López et al., 2011). Then, these services should leverage the insights from the analysis into recommendations or autonomous decision-making. Demirkan et al. (2015) refer in this context to *cognitive systems* which can provide high-quality recommendations to help customers make better data-driven decisions (p. 739). Finally, smart services should enable interactions within the service system (Rizk et al., 2018). In fact, from a systemic perspective, Beverungen et al. (2017a) find that the smart connected product digitally mediates the interactions between the stakeholders involved in a smart service system, by supporting the integration of knowledge, skills, resources, activities, and information systems of the stakeholders.

Concept	Definitions	Reference
Smart service	"they are fundamentally preemptive rather than reactive or even proactive. Preemptive means your actions are based upon hard field intelligence". "to provide them, you must build intelligence - that is, **awareness** and connectivity - into the products themselves."	Allmendinger and Lombreglia (2005)
	"Smart service is the application of specialized competences, through deeds, processes, and performances that are enabled by smart products". "A smart service is constituted by **introducing smart devices** into a digital service system"	Beverungen et al. (2017a)
	"services that are configurable, adaptive, context- and client- **aware**, intelligent, or autonomous, i.e., self-healing and self-recovery, potentially through leveraging multitude of interchangeable service providers"	Nezhad and Schwarz (2017)
	"Smart devices display physical and digital features at the same time, such that they can **observe**, identify, and analyze physical and digital events, **make decisions**, and perform physical and/or digital actions."	Beverungen et al. (2017b)
	"Smart services also differ from business services in that they integrate single business services and provide an **automatic tailoring** to the customer's needs."	Laubis et al. (2018)
	"data-driven services for technical products". "Smart services [..] involve a multitude of parallel and interlinked sensors, computers, and machines, which collect and interpret data to **decide** on this basis and **control** real-world physical processes."	Anke (2018)
Smart product applications	"Software applications running on remote servers that manage the **monitoring, control, optimization, and autonomous operation** of product functions"	Porter and Heppelmann (2014)
clinical decision support system	"One of the most well-known knowledge-based medical services, the clinical **decision support** system (CDSS), accumulates grounds for diagnosis in real time and provides an advanced medical service that takes into account various elements".	Chung et al. (2016)
Location-based service	"an umbrella term for all services that use the absolute or relative **geographical position** of the service user as a resource in service delivery."	Stocker et al. (2017)

Table 2. Selected definitions of smart services and closely related topics in current discourse

3.3 Synthesis

Unlike products that exist within determined and observable physical boundaries, services are more versatile and integrate both physical and non-physical parts that blur these boundaries. Therefore, while the literature about smart products has been able to delineate smart products from their non-smart counterparts – equipped with sensors to sense their environment and with embedded electronics for performing minimal to advanced data processing – the case of smart services is different as these are often linked to the smart product that acts as an enabler. This provides the motivation of a deeper analysis, as we find that the distinction between smart services from their non-smart counterparts requires further elaboration and a detailed understanding of the subject matter. In fact, we are so far unable to identify the tipping point from which the service cannot be assimilated as smart. Considering the original definitions and set of characteristics associated to smart services, i.e. awareness, automation and decision support, we turn to the instances of smart services found in the literature in an attempt to understand why those services are qualified as smart.

4 Conceptual framework for characterizing smart services

The cross-case analysis allows the distinction of two additional smart service characteristics, namely the service outcome and the architecture of the stakeholders involved in the service. In fact, the authors observe that some services involve more users than others. This increases the value generated within the service system, based on a product used as a platform for connecting all stakeholders and for enabling the smart service as highlighted by Beverungen et al. (2017b). For example, Kortuem et al. (2011) describe the case of a one-to-one architecture between the construction worker and the company employing him where recommendations are provided about required work activities in construction sites by pavement breakers. On the other hand, Laubis et al. (2018) describe a system involving many road users, the service intermediary and the road authorities, all involved in the delivery of one service of smart crowd-based road condition monitoring. Regarding the outcome, we find that the type of value proposition varies from one smart service to the other. They can take the shape of visualized information, as in the case of the smart wine purchase example in Resatch et al. (2008), or recommendations for Chung et al. (2016) in the case of knowledge-based individualized health service for patients, or a physical action like the automatic shutting off of water valves in the case of remote home monitoring and control in Almendinger and Lombreglia (2005). We thus create a new category called *outcome* that bundles the various value proposition manifestations of a smart service. Furthermore, the awareness characteristic is fine tuned to become *data richness* as the authors find that data are collected not only from products equipped with sensors but also from other sources like tags and online databases such as in the case of Resatch et al. (2008). This modification is further substantiated by the findings of Rizk et al. (2018) about the origins of raw data in data-driven digital services. Awareness becomes thus strictly related to smart products that act as an enabler or mediator for smart services.

By comparing the examples of smart services to each other with regard to the identified characteristics, we put forth five dimensions that enable the consideration of smart services within a spectrum of *smartness with varying manifestations*. These dimensions are *data richness*, *decision support engine*, *outcome*, *architecture of stakeholders* and the *automation of service processes*. The framework, indicated in Table 3, can be a tool for comparing smart services to each other but not for classifying services into smart and not smart. In fact, we resort to the term framework and avoid using the term taxonomy or classification of smart services since no systematic method for classification is applied. The framework's dimensions are now further explored and connected to the literature.

4.1 Dimension 1: Data richness

This dimension is concerned with the types and number of sources feeding raw data into the decision support engine. Some of the early work established about data with respect to smart services is the research by Satoh (2009) about location-based services within smart environments like smart homes. They construct a model that tracks contextual information detected by an installed sensing system. The model uses location as its primary attribute for discovering and selecting services. When the service involves smart entities like smart objects, it becomes possible to discard the installed sensing infrastructure as the smart objects can collect data about the environment (Lopez et al., 2011). Such systems are called context-aware, as they use relevant information about entities' situations from raw data to provide relevant information and/or services to the user (Dey and Abowd, 1999; Perera et al., 2014). For Rizk et al. (2018), raw data can be captured whether from trackers and sensors, open data portals or even other secondary services. For organizations such as OEMs – machine component suppliers and machine owners/operators – useful data can also exist in IT systems (e. g. ERP, MES, CRM) to inform for example about a machines' installed components, locations and maintenance protocols (Strueker et al., 2012; Dreyer et al., 2017). While some smart services can be delivered leveraging one source, others require multiple sources of data. In the case of a smart health service (Chung et al., 2016), a device captures the biological signals of the patient. However, for Laubis et al. (2018), the data is collected from the smartphones of the drivers about their real-time location and damages on the roads then fused with data from expert equipment to evaluate roads conditions accurately and frequently.

Generally, smart devices can supply and store three types of data: status data, usage data, and environment-related data (Beverungen et al., 2017b). Therefore, when the product supports data collection within a smart service, it acts like a sensor thanks to its embedded hardware. In the example of crowdsensing where the drivers collect data while driving their cars (Laubis et al., 2018), these have been complemented by the smartphones that already contain the necessary sensors to form a larger product cluster [car x smartphone]. We point to such clusters as smart objects, as they do not constitute a simple product anymore. In fact, a smart product usually emphasizes a sort of final product while a smart object can be any given physical object becoming smart through the embeddedness of microelectronics (Klötzer and Pflaum, 2017), like the case of the car.

4.2 Dimension 2: Decision support engine

Decision support is a central theme in the examined literature. A common type of decision support applications is business intelligence applications (Demirkan et al., 2015) which are "used to analyze an organization's raw data to provide historical, current, and predictive views of business operations and customer behavior to help make stronger business decisions" (p. 741). In fact, after collecting the data, it is necessary to analyze it for enabling services to be provided based on the generated insight. Laubis et al. (2018) apply analytics to provide a decision support service to road users and road authorities to make better informed decisions based on the conditions of the roads. Chung et al. (2016) implement probabilistic judgment to give advice to the medical staff about treatments to be administered to the patient. Besides, Yavari et al. (2017) stress that in order to make a decision within the scope of a specific application, context or contextual information is necessary for reducing the amount of reasoning required via filtering, aggregating, and inferring the data. The transformation of the raw data into context is called here *contextualization* (Dey and Abowd, 1999). This level of data processing can be sufficient in some services where visualization of data matters, such as in the case of the projection of road damages on a map. However, contexts can be further utilized by advanced analytics services for deriving more value. In fact, analytics services support the discovery of meaningful patterns in data (Demirkan et al., 2015), and rely on optimization, data mining, text mining, simulation and automated decision systems (Demirkan et al., 2013). The most advanced type of analytics is data *analysis for optimized systems* (Kagermann et al., 2015) and includes all tasks that relate to using the raw data to forecast situations. At a lower level, there is *analysis for monitoring* such as following the evolution of the heart rate of remote patients (Chung et al., 2016) and *analysis for control* when a water valve is closed automatically when abnormal flow is measured (Allmendinger and Lombreglia, 2005). In sum, from contextualization to analysis for optimization, there is an increasing level of knowledge that is necessary for building such decision support engines, and predictive analytics has been distinguished as smarter than other Big Data streaming analysis by the German Academy of Science and Engineering (Kagermann et al., 2015).

For the product to participate in the decision support engine, it requires embedded computing capabilities for executing local analysis and potentially running some applications (Porter and Heppelmann, 2014). The product is thus assimilated to a computer.

4.3 Dimension 3: Outcome delivered to the service user(s)

Once the data is fed to the decision support engine, insights are generated to be further utilized by the stakeholders. It is in fact one of the main characteristics of data-driven services (Rizk et al., 2018). The most basic way of utilizing an insight is through *visualization,* where information is intelligibly communicated to the user. This is the case of a home owner who can visualize and monitor his power consumption on his smartphone (Kortuem et al., 2010). The second level of outcome is *recommendations*, where the service beneficiary receives recommendations in a given situation in order to accomplish given tasks. The recommendation can either be a reaction to the collected data or a prescription in anticipation of an event; depending on the level of advancement of the decision support engine. In the case of Laubis et al. (2018), where the drivers are recommended the best route, the outcome is reactive to the collected data. This is in contrast with predictive recommendations where for example a patient receives prescriptions of exercises and diet to avoid contracting a disease (Chung et al., 2016). Finally, the service outcome can take the shape of an *action*, where a task is executed for the beneficiary instead of limiting the outcome to the delivery of recommendations. This level of outcome captures a decision made for the account of the beneficiary, and not only the provision of decision support, such as the automatic shut-off of water valves when abnormal flow in a smart home (Allmendinger and Lombreglia, 2005).

With respect to the outcome, the smart connected product may act as an interface between the digital and physical world. It will either present a communication interface such as a display for showing information to the users like in the case of the smart pavement breaker (Kortuem et al., 2010), or the product will present actuators that enable given actions as a substitute to an operator's intervention (López et al., 2011). The products are not passive anymore, but can manipulate the physical reality in their proximity (Beverungen et al., 2017a).

4.4 Dimension 4: Architecture of stakeholders

The fourth dimension concerns the relationship between the service provider and the service user and captures both their number and physical proximity. It stems from authors like Beverungen et al. (2017a, 2017b) who consider smart services from a systemic perspective and position them as smart service systems. Demirkan et al. (2015) also mention that new types of IT platforms that interconnect people, business, citizens, and governments to co-create new smart service offerings based on big data and analytics. Co-creation in this sense is a characteristic of services, where the value is a result of a configuration of people, technologies and organizations that interact together (Maglio, 2009). The word "user" rather than "service consumer" is used because in a single company that consumes a service, there can be many users who require different levels of customization. Also, a service provider (e.g. road authorities that repair roads) can also simultaneously be service consumers (e.g. consuming the service provided by the IT integration firm). The study of Laubis et al. (2018) has implicitly explored this architecture dimension. In the case of their road maintenance service, road authorities receive prediction about the state of the roads and the drivers receive recommendations about the routes, both provided by one IT intermediary. They describe a one-to-many configuration, where all parties are remote from each other. Had the service stopped at the level of drivers who receive the recommendations, it would have been a case of a single provider catering to a single type of consumers, located remotely as the drivers roam freely in their cars. In the case of a doctor and a patient facing each other (Chung et al., 2016), the relationship is very local. The doctor gets his decision supported by an engine that can compare the diagnosis to a large database of cases. The other configurations include when there are many service providers interacting with a single class of consumers, and when many consumers and many providers are involved, which can be common in the automotive industry with OEMs and many machine components suppliers (Dreyer et al., 2017). The stakeholders can either be in direct contact within a local perimeter or geographically remote from each other.

Concerning the role of the product with respect to this dimension, Beverungen et al. (2017a) have described smart products as boundary objects that integrate service consumers' and service providers' resources and activities. Smart products are thus integrators that mediate the interaction on either side of service provision or service use, such as the transmission of data and events to the information systems operated by the service provider (p. 1).

4.5 Dimension 5: Automation of service processes

This dimension brings clarity to implications of autonomy as a cornerstone of smart services, such as when it comes to the automation of traditionally human functions (Peters et al., 2016), automatic tailoring to customers' needs (Laubis et al., 2018), autonomous operations (Porter and Heppelmann, 2014), autonomy as self-healing and self-recovery (Nezhad et al., 2017) and autonomous decision making (Rizk et al., 2018). By examining the series of processes involved in the considered cases, three distinct phases are identified as potential for automation: data collection, decision making and execution of physical actions.

The level of automation of services is contrasted by the level of intervention of human stakeholders, and the different processes leading to the fulfilment of the service that can be automated, from the data collection to the decision making leading to the physical actions. These can be either fully human, semi-automated or fully automated. In the case of fully automated data collection, the products are standalone and sometimes capable of mobility like self-driving cars (Beverungen et al., 2017a).

Dimensions	Data richness	Decision support engine	Outcome	Architecture of stakeholders	Automation of service processes
Explanation	*Number of types of sources feeding data into the decision support engine*	*Level of knowledge intensiveness of the performed analysis*	*Levels of sophistication of the outcome consumed by the service user(s)*	*Relationship between service provider and user*	*Level of Intervention of human stakeholders in the delivery of the service*
Values	Smart product	Contextualisation	visualization of insight (captures the model of information-as-a-service)	One-to-one, in direct contact	Data collection, can be: fully automatic AC, semi-automatic SC fully human HC
	Tracker			One-to-one, remote from each other	
	Enterprise IS (e.g. ERP)	Analysis for monitoring	Recommendation (reactive or predictive, depending on the decision support engine)	One-to-many, in direct contact	Decision making AD, SD, HD
	Other services (Facebook for accessing data about users and customers)	Analysis for control		One-to-many, remote	
	Open data portals (data coming from other sensors, e.g. Weather data)	Analysis for optimizing	Physical action (can also be reactive of predictive)	Many-to-many, in direct contact	Physical actions AA, SA, HA
				Many-to-many, remote from each other	
How can a smart connected product enable the service?	- Embedded sensors for collecting data - Connectivity	- Embedded software for performing local analysis - Connectivity	- Interface for communicating information (e.g. visualization on a display) - Actuators for performing actions - Connectivity	- Communication interface - Connectivity	- Embedded sensors - Embedded software - Actuator - Connectivity
	Product as a sensor	**Product as a computer**	**Product as an interface between the digital and physical world**	**Product as a connector**	**Product as a... Autonomous sensor Decision maker Robot**

Table 3. Framework for conceptualizing the smartness of services

For fully automated decision making, the human stakeholders do not get their decisions supported but the decisions are made for them, whether by a centralized analysis engine or locally at the product level that is equipped with software and embedded systems that allow for such scenario (Porter and Heppelmann, 2014). Finally, in the case of the fully automated action, human stakeholders are not necessary for accomplishing tasks, and are replaced by robots, whether software (like for the automatic replenishment of machine parts mediated by enterprise software) or hardware (like when a machine auto-maintains itself). Moving from human processes to fully automated processes within smart services requires the integration of advanced hardware and software from the products side. In the case of the crowdsensing roads condition monitoring of Laubis et al. (2018), the data collection could be fully automated had the cars been self-driving cars, equipped with smartphone-like modules, so that the operator – or driver in this case – is no longer required. In the same example, the decision making could have also been completely automated had the repair teams been automatically dispatched without the intervention of any human decision maker. Finally, the physical actions could have been fully automated had the repair teams been artificial actors like robots that are trained at repairing roads. The level of automation of the service processes not only affects the level of advancement of the service, but especially influences the utility perceived by each stakeholder involved in the delivery of the service, and thus affects the business model of the service (Laubis et al., 2018).

5 Discussion and conclusion

IS literature attributes smartness to products as well as services. Wherever services are concerned, smartness often seems to be inherited from a product that is related to the service and the inherent characteristics that make a service smart remain unclear. Starting from definitions provided in the IS literature about smart services, we identify awareness, decision support, automation and bundling of products and services to be central features of such services (Allmendinger and Lombreglia, 2005; Beverungen et al., 2017a). Scrutinizing how such features are designed enables us to develop a conceptual framework that places smart services on a spectrum of varying inherent manifestations of *smartness*, depending on (1) the richness of the data in number and type (data collected by the product only or combined with other services' data like customers' data from Facebook, enterprise resources data, or data from open data portals), (2) the knowledge intensiveness of the engine for decision support (from contextualization of the information to analysis for monitoring, control or for optimizing), (3) the level of sophistication of the outcome consumed by the service user(s) (visualization of information, recommendation for making decisions, or physical actions based on decisions made by the underlying information system infrastructure), (4) the architecture of the stakeholders (from dyadic relationships between a service provider and service users to more intricate networked architectures), and (5) the automation level of the service process thus the propensity of human intervention in the operations of data collection, decision making and physical actions execution. This framework breaks with a tradition of defining or characterizing smart services with reference to the smart product, and exposes the areas where the product can be instrumental to each of these dimensions. The smart product could be used as a sensor for data collection, or as a computer for performing local analyses, or as an interface between the results of analyses in the digital world and the physical world for delivering outcomes to users, or as an integrator that connects stakeholders together. This is further illustrated in Table 4. with more details about applications from the literature.

Our findings contribute to the theory on services, as they allow a better differentiation of various forms of smartness in services and a better delineation between smart products and smart services. Furthermore, it creates new options to relate concepts of smart services to other well-established lines of research in the IS field, from data warehousing over decision support and artificial intelligence to business model innovation and business ecosystems. Our findings also contribute to the practice of service design and implementation, as they make it easier to pinpoint the actual loci of smartness in product-service bundles and larger systemic structures which are called smart. This also creates new possibilities for the evaluation of the contributions of different stakeholders to such structures and find avenues for improvement and further innovation.

	Kortuem et al. (2010)	Allmendinger and Lombreglia (2005)	Chung et al. (2016)	Laubis et al. (2018)	Resatsch et al. (2008)
Smart service	Recommendations provision about required work activities in construction sites	Remote home monitoring and control	Knowledge-based individualized health service for patients	Smart, crowd-based road condition monitoring service	Smart wine purchase
Product as a...	Pavement breaker as a sensor, as a computer for monitoring the activities of the workers, as an interface for recommendations delivery about better usage of the tool, and as a connector between the worker and company's processes.	Smartphone as an interface for visualizing the sensor's status and controlling the water valves, and as a connector between the actuators in the house and the user.	Smart health device as sensor of bio signals of the patients in hospitals, as an interface for recommendations delivery to the doctor, and as connector between the doctor and the patient.	Smartphone as a sensor of roads conditions, as an interface for providing recommendations to the driver about good roads, and as connector between the road users and the service intermediary.	Smartphone as an interface between the wine bottles and the customers thanks to the NFC reader to visualize information about the wine bottles, and as a connector between the customers and the retailer

Table 4. Set of cases of smart services developed in the literature and the roles of the products

Future directions for research are twofold. First, the presented framework needs to be further developed by studying the relationships between the dimensions, their interdependencies, and their influence on the type of smart service that results from possible configurations. For that, we favour an empirical approach that evaluates a large number of smart services to derive a typology that accounts for the level of smartness of the service. Second, we believe that our framework contributes to elaborating a design theory about smart services (Gregor, 2006) by laying a reliable foundation for future research concerned with how to design such services (Peters et al., 2016). In fact, the differentiation of smartness within isolated dimensions helps understanding how the value is co-created within smart services and what the service delivery process depends on. In the future, service can emancipate from the product-driven view on smartness, where products can be replaceable and the design is driven by the architecture of stakeholders, the interactions between them, as well as the business models that govern their relationships (Anke, 2018).

Limitations of this study result from the fact that the literature search is confined to the exploration of top IS journal and conference papers. Nonetheless, information systems are fundamentally connected to service systems as they are systems that support people with information for making informed decisions (Demirkan et al., 2013, p. 413). Therefore, this framework can be extended by broadening the scope of the literature. Furthermore, it can also be widened by bridging concepts and principles developed in more service-oriented outlets, especially in what concerns value co-creation and stakeholders management (Wünderlich et al., 2015), particularly in the context of the digital transformation of services (Matzner et al., 2018).

All in all, smart services present an opportunity for information systems research to develop emergent design concepts to further maturity, where the path for innovation is both technology- and value-driven, and where the roles of companies and industrial partners are redefined within value networks (Porter and Heppelmann, 2014), building up to ICT-enabled service innovations that are ultimately human-centric (Demirkan et al., 2015).

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