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An In-Depth Analysis of Smart Service Systems: Exploring Concepts and Overcoming Challenges

Angga Prasetya
Teknik Informatika
Institut Sains dan Teknologi Terpadu Surabaya
prasetya_istt@gmail.com

Rusman Wibawa
Teknik Informatika
Institut Sains dan Teknologi Terpadu Surabaya
Arusman91@gmail.com

Paranita Riche
Teknik Informatika
Institut Bisnis dan Teknologi Indonesia
riche_pranita@gmail.com

Abstract—This comprehensive survey delves into the realm of Smart Service Systems, aiming to provide an in-depth analysis of its fundamental concepts and address the challenges faced in its implementation. Smart Service Systems represent a transformative paradigm that leverages cutting-edge technologies, such as artificial intelligence, Internet of Things, and cloud computing, to enhance the efficiency, effectiveness, and personalization of service delivery. The paper explores the key components and underlying principles that form the backbone of these systems, shedding light on their potential applications and benefits across various domains. However, the realization of Smart Service Systems comes with a set of formidable challenges that need to be tackled. These challenges encompass technical, ethical, legal, and societal aspects, among others. By examining and understanding these obstacles, the paper aims to propose potential strategies and solutions to overcome them. The analysis is further enriched with case studies and real-world examples to provide valuable insights for researchers, practitioners, and policymakers. In conclusion, this survey serves as a comprehensive resource for the exploration of Smart Service Systems, illuminating the path towards harnessing their full potential while addressing the complexities they present. It is hoped that this work will inspire further research and foster advancements in this burgeoning field, ultimately leading to the widespread adoption and integration of intelligent service systems for a more efficient and sustainable future.

Keywords— smart service systems, challenges technology, comprehensive survey

I. Introduction

Smart service systems are emerging as a key technology that enables businesses to provide high-quality services to their customers while improving operational efficiency. SSS is an integration of smart technologies such as the Internet of Things (IoT), artificial intelligence (AI), and cloud computing, and service systems that are designed to provide customers with personalized and context-aware services. The adoption of SSS has become a strategic imperative for many businesses, as they seek to enhance their competitiveness in today's digital economy. The advancement of computer science is no longer limited to the development of hardware devices. Instead, computers are now utilized to perform processing functions that cater to users' needs. The capabilities of computers have evolved to not only carry out simple processing tasks but also to engage in more sophisticated processes through data interaction. Data can be manifested in the form of applications, which enable algorithms to manipulate, store, and communicate digital information. Consequently, the focus of computer science has shifted towards digital information, which originates from various fields and comes in heterogeneous forms.

At present, diverse data in heterogeneous forms do not solely originate from computers, but also from various other hardware devices, namely the Internet of Things (IoT) that can be connected to the internet network. The interconnectivity among these devices demands particular attention to enable users to utilize them. This attention can be in the form of computing services provided by the devices. Such services are essential for users to ensure proper functioning of the devices. Very high service growth spread across various fields such as business, industry and engineering. The scientific disciplines that put forward the definition of services also vary. A service can be defined as an activity (or series of activities), in which various resources are utilized by providers (*suppliers*) who interact with customers (*consumers*), to obtain a solution to a particular need [1] . Vargo et al. 2008 reveals that service is the implementation or application of special competencies (*operant resources*), namely knowledge *and* skills *through* deeds/actions, processes, and performance for the benefit of other entities or the entities themselves [2] . The services put forward by previous research show the importance of service. This is the main key to implementing services by meeting the interactions between service providers and service users.

The growth of service systems has increased significantly, which in turn has led to challenges in both business processes and technology. Researchers have proposed various solutions to address these challenges by developing intelligent service systems. Nevertheless, the definition of an intelligent service system remains subject to debate and further research.

In part II, we summarize previous research using intelligent service systems. Section III presents the survey process of a systematic literature review as a research method. Section IV presents the results of the analysis from previous studies. Section V concludes the intelligent service system research.

II. SURVEYS

In previous research, intelligent service systems continue to be developed in various environments. This trend has been carried out for the past decade by utilizing IoT technology in the development of intelligent service systems. Development of a more intelligent service system can pay attention to the network in the system. This was done by Van Den Heuvel et al. 2010 by proposing a new business transaction model for intelligent service networks that will utilize *real-time* information gathering from software services and sensor networks to more effectively manage service-based application principles [3] . The network is designed to increase the value for users in the network by connecting smart devices, *tagged objects* and sensors that have software services and are connected to the internet. The emerging trend is due to the significant growth of IoT producers and consumers. This device is in demand because it can be used directly by consumers. Castillejo et al. 's research . 2013 presents daily life applications involving *Wireless Sensor Networks* (WSN) as the basis for new scenarios on *wearable devices* , where physiological parameters are measured and sent to the WSN with the device used [4] . In addition, they also integrate different hardware platforms with the use of

Enterprise Service Bus (ESB) thereby adding the semantic value needed in an IoT-based system. Ye et al. 2019 also proposed a *Service-Aware Wireless Mixed-Area Network* (SA-WMN) architecture that can be applied to various intelligent services [5] . Apart from the research focus of intelligent service system network Guo et al. 2017 proposed an intelligent service system (SSS) architecture consisting of an intelligent service terminal (SST), and a smart service network (SSN) to realize IoT in a common environment with diverse communication networks, devices and services [6] .

As we all know, intelligent service systems are built to provide interaction between providers and customers. Service improvement can be done by knowing customer satisfaction. Shin et al. 2014 conducted research by proposing a *Customer Satisfacion Index* (CSI) model for smartphones [7] . CSI measures to gain practical implications for providers and offer recommendations with service improvements. Intelligent service systems require integration both because of differences in devices and processes in each development cycle. Anke et al. 2018 conducted research with a design approach to develop a meta-model, which was implemented in a web-based tool [8] . This study integrates financial business process assessment with the intelligent service design phase.

Smart service systems have various domains such as *smart city* , *smart agriculture* , *smart health* , and others. Sivamani et al. 2013 conducted research on *smart agriculture* by proposing *a Vertical Farm Ontology* (VFO). The proposed ontology model is based on OWL which helps to understand more deeply the relationship between domain factors [9] . Additionally, information from IoT is recomposed as context information and made understandable for other systems. Research in the *smart agriculture domain* was continued by Sivamani et al. 2018 by discussing safety measurements and their solutions in WSN related to automation in greenhouse environments [10] . The sensor format is designed using tags and to avoid data interference.

In *smart city domains,* Antiroiko et al. 2014 builds a framework for understanding the basic shape and dimensions of *smart public services* [11] . Researchers use a more integrative holistic approach by not only taking into account the complexity of technology but also humans and ecology which should be the basis of the system and provide added value in wider life. This has a similar principle to that of Concilio et al. 2014 . Concilio et al. 2014 who reported on the interaction between urban governance and smart service co-design in urban transformation [12] . In addition, researchers discuss the value of service co-design as a strategic practice for experimenting with new participatory governance in *smart cities. The smart city* part , namely *smart parking,* was studied by Tsai et al. 2018 by building a smart parking system formed by the integration of mobile device applications and IoT technology [13] .

The Social Internet of Things (SIoT) paradigm gave rise to a new trend where the connectivity and user-friendliness of *Social Network Services* (SNS) is showcased in IoT networks. This was disclosed by Hussein et al. 2017 by proposing a new service framework based on a cognitive reasoning approach for dynamic SIoT service discovery in *smart spaces* [14] .

In the *smart health domain* , Oliveira et al. 2015 introduced *the Nimbus Device* as an intelligent *middleware* to investigate data aggregation and analysis techniques encapsulated by *ubiquitous technologies* [15] . This *middleware* supports the integration of distributed and heterogeneous mobile sensor data. It also enables context analysis and data prediction. This study uses various data sources focused on fitness applications.

Smart service system research is not only in one domain. Research on multiple domains was conducted by Georgakopoulos et al. 2016 by introducing an IoT platform that is able to integrate almost all IoT devices, store IoT data in the cloud, and perform *realtime IoT analysis* using a new approach based on microcomputing driven by micro summary data [16] . Poniszewska-Maranda et al. 2018 investigated the use of artificial intelligence in the IoT paradigm [17] . To achieve this approach, smart-IoT is built on artificial neural networks. Unlike the previous research, Al-Hamadi et al. 2019 conducted research by building an intelligent service community as a cloud utility that can be accessed through mobile applications installed on users' IoT devices, such as smartphones [18] .

In addition to experimental research, conceptual research by conducting literature reviews has been carried out before. The literature review carried out can produce various outputs such as models, frameworks and aspects of service interaction. Wiegard et al. 2017 developed a research model from literature reviews and interviews with experts [19] . Beverungen et al. 2017 investigated aspects of the complex interaction between information technology, information systems and service science to design innovative information technology artifacts for intelligent services [20] . Research by Beverungen et al. 2017 continued with developing a framework based on various streams of technical and managerial literature and in-depth interviews with informants from five industrial service systems that implement intelligent products as object boundaries [21] . Ko et al. 2018 suggested a smart service model that keeps a history of user services, which the user has used while in a place [22] .

Alt et al. 2019 conducted a literature review on intelligent service systems. Smart services allow customers to not only get offers but also to make configurations according to the customer's individual preferences [23] . With this capability, intelligent services can support customer orientation shifts that are applied to smart economy services. Customer orientation is the key to service transformation and the service economy is growing exponentially with intelligent services. Apart from Alt et al. 2019 , Dreyer et al. 2019 also conducted a literature review on a similar topic. The interactions between customers and service providers form the basis for creating shared value. Researchers grouped research into five phases of the intelligent service life cycle. The results show that there is a wide range of knowledge related to various topics related to intelligent services. One finding shows that economic aspects such as new business models or pricing strategies are rarely considered in the literature [24] .

Spohrer et al. 2018 concluded that all service innovation supported by information and communication technology must be human-centered and focus on creating shared value [25] .

III. RESEARCH METHODOLOGY

In conducting our survey, we used the method of systematic literature review on intelligent service systems. The literature process is carried out by identifying, classifying and interpreting from previous studies. An important objective of this systematic literature review is to answer the research problems presented by questions such as TABEL I. .

TABEL I. RESEARCH QUESTIONS (RQ) [26]

ID	Research Questions	motivation
RQ1	Is the concept of an intelligent service system	To identify the concept of an intelligent service system
RQ2	What are the challenges of intelligent service systems research	To identify existing challenges in intelligent service systems

To answer each research question, we track research results published in the Scopus journal database using specific keywords. The keywords used to find suitable literature are TITLE ("smart service" OR "smart service system") AND (LIMIT-TO (SRCTYPE,"j")) AND (LIMIT-TO (LANGUAGE,"English") OR EXCLUDE (LANGUAGE,"German")) AND (EXCLUDE (LANGUAGE,"Spanish")) AND (LIMIT-TO (SUBJAREA,"COMP")). Then we applied inclusion and exclusion criteria to select suitable research candidates for further review.

TABEL II. INCLUSION AND EXCLUSION CRITERIA

Criteria	**Reason**
Inclusion Criteria	• I1 - Smart service system is one of the main criteria for this study. • I2 - Only research written in English is selected • I3 – Only research published in selected journals • I4 - Only intelligent service systems research in selected *Computer Science subject areas*
Exclusion Criteria	• E1 - Only studies published in the Scopus journal database that are ranked in Q1 and Q2 are selected and other studies that are not suitable are not used • E2 - This research only concentrates on intelligent service systems

After applying the inclusion and exclusion criteria we get 35 suitable studies. We also conducted quality assessments to evaluate keywords, abstracts that demonstrate the contribution of this research. The quality assessment includes the following questions: a) What is the research in the field of intelligent service systems? B) What are the concepts and challenges presented in the research? Then research with inappropriate abstraction is not used. The systematic literature review process can be seen in 0.

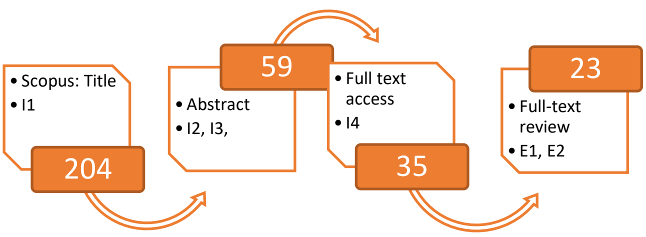

Figure 1. Systematic Literature Review Process

The research results were refined and 23 studies became the main reference for this study with distributions like 0.

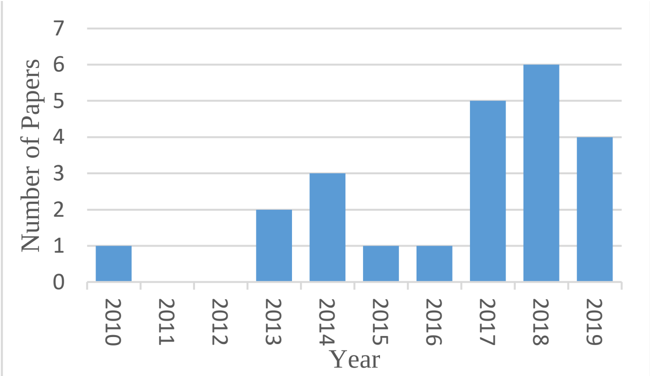

Figure 2. Distribution of the main research references by year of publication

IV. RESULT AND DISCUSSION

This section details or explains each of the research questions defined in section III and compares the research taking into account the concepts and research challenges.

A. *Draft*

The concept of an intelligent service system was put forward in previous research. In research that is the main reference, not all researchers reveal the concept of intelligent service systems. Van Den Heuvel et al. 2010 states that service systems can create value for three levels in society: individuals, such as employees, consumers, and public officials; companies, such as businesses and supply chains, public entities, or user communities; and national, continental, and global populations.

Antiroiko et al. 2014 saw intelligent services from two perspectives, namely (1) individual use and consumption processes (2) and organizational interactions in service provision. When viewed from the service platform adopted, the main functions in the service platform consist of:

- access, to provide easy access to service processes.
- creativity, to provide new ideas in the development, distribution of services and solutions to regulatory problems.
- *sharing* , to communicate and share ideas and collaborate with stakeholders.
- Integration, to ensure single sign-on access across an organization's services.

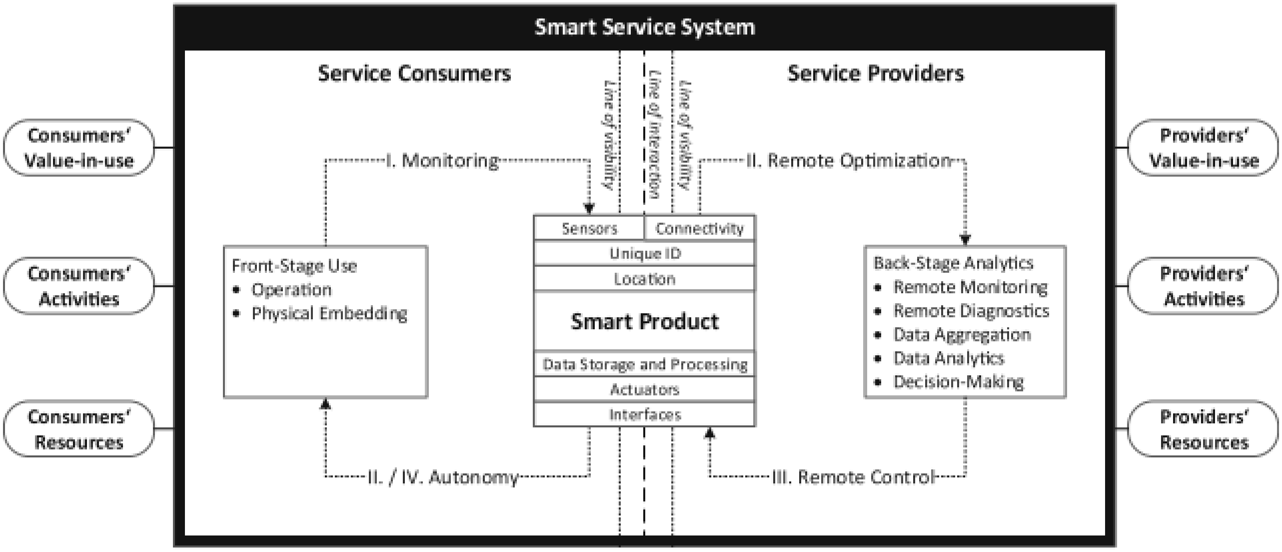

Figure 3. Conceptualization of intelligent service systems using smart products as boundary objects – Image taken from [21]

Beverungen et al. 2017 states that intelligent services are the application of specific competencies, through actions, processes and performance enabled by intelligent products [21] . Meanwhile, an intelligent service system is a service system in which *a smart product* is a boundary object that integrates the resources and activities of the actors involved for mutual benefit. Furthermore, Beverungen et al. 2017 explained in another study that intelligent services are formed by introducing smart devices into digital service systems [20] . Smart device digital network competency of actors involved in digital service systems and/or mediating their interactions. Smart devices display physical and digital features simultaneously, so they can observe, identify, and analyze physical and digital events, make decisions, and perform physical and/or digital actions. Therefore, smart services integrate physical and digital competencies in a complex sociotechnical service system. In 0shows the conceptualization of smart service systems on *smart products.*

Anke et al. 2018 conducted a literature review and identified five characteristics of intelligent service systems namely data transmission, external services, services as a combination of functions, and shared value creation, as well as various types of cost and price models. Then defines intelligent service as a service system, which enables the creation of shared value between service providers and beneficiaries through joint performance of service activities.

Spohrer et al. 2018 defines intelligent service systems as instrumented (sensors), interconnected (data stored in *the cloud* and accessible from mobile devices) business and social systems (cognitive systems can provide high-quality recommendations to customers and help customers make informed, data-driven decisions). better).

Dreyer et al. 2019 reveals that intelligent services are individualized, highly dynamic and quality-based service solutions that are convenient for customers, realized by intelligence and analysis of technology, environment, and social context data (partly in realtime), which result in shared value created between customers *and* providers in all phases from strategic development to intelligent service improvement. The strategic development phases revealed in research into the five life cycles of an intelligent service system [24] are shown in 0. The following are the five intelligent service life cycles:

- The intelligent service strategy phase, defines process objectives based on user requirements, service strategy and service capabilities.
- Intelligent service design phase, using predefined strategies to design services.

- The smart service transition phase, describes the way in which new or changed smart services are implemented.
- Intelligent service operations, failure management, maintenance, and execution of tasks and processes phases.
- Intelligent service continuous improvement phase, learning from past successes and failures. It then adapts services on an ongoing basis, using related data and information, and engaging customers.

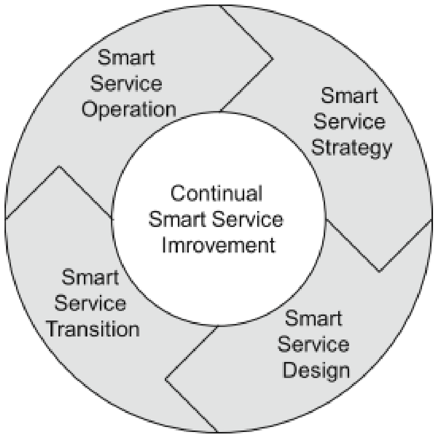

Figure 4. Intelligent service lifecycle – Image taken from [24]

Ko et al. 2018 proposed an intelligent service flow like 0below.

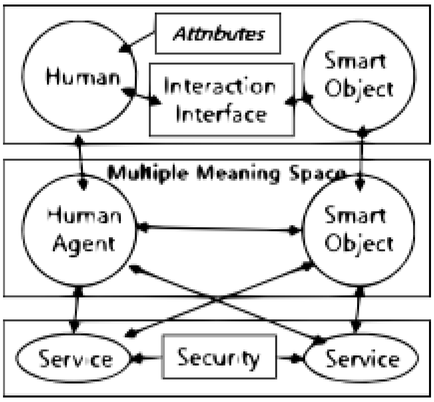

Figure 5. Smart service flow – Image taken from [22]

Based on the concepts stated above, it can be concluded that the concept of an intelligent service system is the entire process and activity that utilizes devices that have the ability to monitor, identify, analyze, optimize, automatically adapt, make decisions and further actions based on the goals and needs of the users created. from the interaction between service providers (*service providers*) and service users (*service consumers*) to provide value and benefits for both.

B. *Challenge*

The challenges of intelligent service systems vary according to the solutions proposed by previous researchers. Van Den Heuvel et al. 2010 revealed that *Web Service* technology helps distributed applications in service networks to connect and work together [3] . However, there is no Web Service that is capable of creating a reliable service network with the scalability and complexity to ensure the accuracy and completion of business interaction processes. There are also challenges in designing a support network with optimal resource management while achieving a quality experience for intelligent services [5] . In addition, Concilio et al. also experienced problems with system scalability . 2014 with the spread of new *tools* and technologies in city governance [12] .

Castillejo et al. 2013 stated that the Internet of Things (IoT) is growing rapidly with new devices connected all the time [4] and providing similar services [18] . Smart devices and terminals are connected to each other, which can vary widely through wireless networks [6] . As a result, communication between these devices will only be realized using *a gateway node* . This will lead to inefficient use of wireless resources. Applications with multiple hardware components introduce the problem of heterogeneity in the network which requires integration of services [8] into a single application. The problem of IoT heterogeneity, communication and development was investigated by [14] [17] . This heterogeneity problem continues in the data stored on the device as stated by Oliveira et al. 2015 . Oliveira et al. 2015 revealed the health and wellness domain, many devices and technologies on the market are limited to platforms, usually working separately with hardware settings. Consequently, an important challenge is to investigate techniques for aggregating and analyzing the data encapsulated by *ubiquitous technologies* [15] . The unavailability of semantic interoperability between IoT can cause the system to become complex [9] . In addition, to realize the unprecedented potential of IoT, it is necessary to develop IoT solutions to find the IoT devices needed by each application, collect and integrate their data, and filter high-value information for each application need. This solution makes it possible to do it in real-time, and safely [16] .

The development of intelligent service systems will continue to be improved. Improvements made cannot be separated from the role of system users. But to continue to make improvements the system must be able to get acceptance from the user. This is obtained by conducting *a customer satisfaction index* [7] .

A new perspective on the service economy creates both opportunities and challenges for municipalities. Challenges include how to integrate physical products and devices with services and how to 'package' manual and silo-based services into digital and integrated service systems [11] . This creates complexity across service providers which often requires substantial coordination [23] .

Service users deploy, monitor, and independently adapt *smart products* , while service providers collect and analyze longitudinal data to optimize and remotely control how their installed base of *smart products is used in the field* [21] . Beverungen et al. 2017 revealed that the properties of these intelligent service systems challenge the basic concepts on which the field of service science has been built. In particular, Beverungen et al. 2017 discusses why interactions in intelligent service systems are increasingly technology-mediated, continuous, and routinized. Rapid advances in information technology have made it possible to design new information systems that allow entirely new configurations of service systems [27] . The configuration must be consistent with human-centered innovation and focus on creating shared value [25] . Innovations continue to be made on *smart parking* due to problems finding a parking space due to insufficient parking resources [13] .

Wiegard et al. 2017 revealed that information sensitivity has the greatest impact on perceived privacy risks for service users [19] . Therefore, the prerequisite for the successful implementation of a service in the market is the collaboration of each service provider and device manufacturer and offer solutions for data security and more data protection before further development of device features. Security problems revealed by Sivamani et al. 2018 how to maintain service automation without fail.

Table III below shows the challenges of intelligent service systems by domain on the main research references.

TABEL III. INTELLIGENT SERVICE SYSTEM CHALLENGES BY DOMAIN

Domain	**Challenge**	**Study**
Smart City	Scalability due to deployment of new tools and technologies	[12]
	Integration of products and physical devices with services	[11]
	Inefficient creation of new services	[22]
	The large number of providers providing similar services	[18]
SmartHealth	Techniques for aggregating and analyzing data encapsulated by *ubiquitous technologies*	[15]
Smart Agriculture	Systems become complex without interoperability between IoT	[9]
	Service security	[10]
SmartDevices	heterogeneity	[4] [17]
	User acceptance	[7]
	Find, collect, integrate IoT device data needed by each application, and filter high-value information for each application need.	[16]
	The privacy risks associated with sensitive information	[19]
	Integration in the intelligent service design process	[8]
SmartCampus	Inefficient use of wireless resources	[6]
Smart Products	The basic concepts that form the basis of the field of service science on the characteristics of intelligent service systems	[21]
	Entirely new service system configuration	[20]
Smart Spaces	IoT heterogeneity, communication and development	[14]
SmartTourism	Not yet considering the interaction of technological, economic and social dimensions	[23]
Smart Parking	Find a parking space because parking resources are insufficient	[13]
Smart Service Network	Reliable service network with scalability and complexity	[3]
	Design a support network with optimal resource management	[5]
Multiple Domains	Consistent in human-centered innovation and focus on creating shared value.	[25]
	Categorization of relevant literature that does not yet exist	[24]

1) *Architecture*

The literature review conducted found several common architectures that can be used in intelligent service systems as shown in 0, 0, and 0

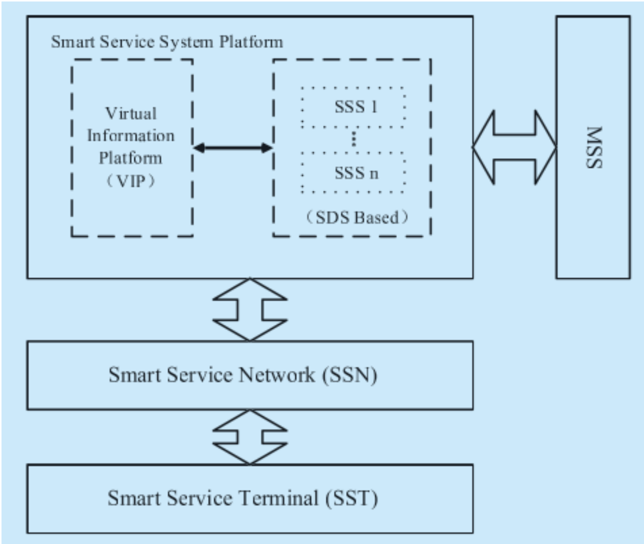

Figure 6. Intelligent service system architecture for IoT – Image taken from [6]

Intelligent service system architecture for IoT to realize smart information services in a broad spectrum. The key point of this architecture lies in the universal architecture that supports various types of terminals and devices, various types of network technologies, various available information sources, various types of existing and emerging services and applications. Furthermore, information systems based on this architecture will become universal smart information systems. The intelligent service system architecture for IoT consists of three layers:

- Layer *Smart Service Terminal* (SST), which is actually a virtual terminal (VT). At this layer, several heterogeneous terminals are connected by local network technology to form a single terminal.
- Layers *Smart Service Network* (SSN) , which is actually a virtual network (VN). This layer allows multiple networks to function as a single network.
- Layers *Smart Service System* (SSS), which consists of a virtual information platform (VIP) sublayer, and an integrated services platform (ISP) sublayer

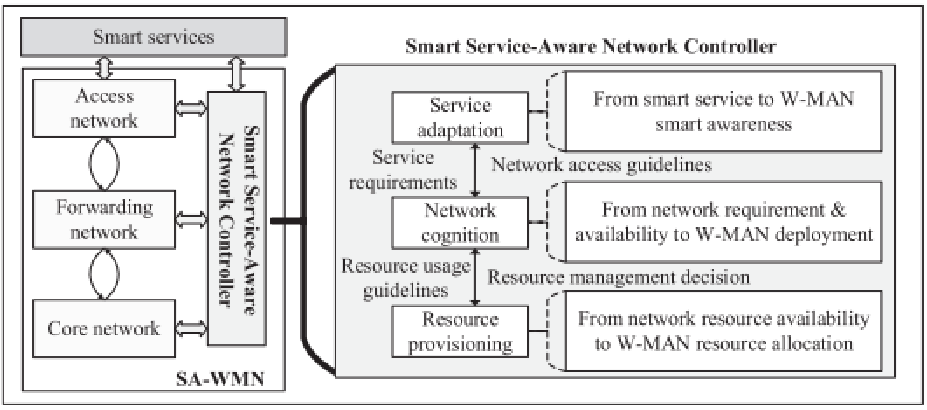

Figure 7. Service-aware wireless mixed-area network (SA-WMN) architecture – Image taken [5]

The SA-MAN architecture generalizes and combines network layer control of various wireless networks so that various types of wireless network technologies can be efficiently managed in a unified architecture. The new design is an intelligent system that manages network structure and provision of resources based on *Quality of Experience* (QoE) requirements for intelligent services and user capabilities. This requires close interaction between users, smart service providers and traditional network service providers. SA-WMN is a *hybrid* network architecture consisting of an access network, a forwarding network, and a core network. Access network is an edge network for attaching access nodes to SA-WMN; forwarding networks are used to fulfill service requirements by transmitting data transmissions from/to the core network; the core network is the backhaul connected to application resources (eg, internal company databases, or the Internet). All three types of networks are managed by service-aware network controllers. This controller aims to generalize and combine network layer control of various wireless networks so that various types of heterogeneous wireless networks can be efficiently managed in a unified SA-WMN architecture. Specifically, the network controller consists of three logical control modules: service adaptation, network cognition, and resource provisioning.

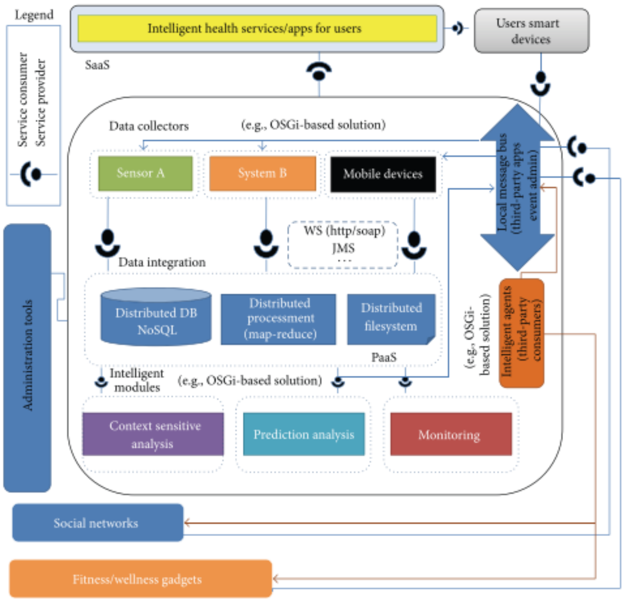

Figure 8. Nimbus Device Architecture – Images captured [15]

From a functional point of view, context-aware systems that on the *Nimbus Device* architecture can be represented as layered middleware consisting of sensors, raw data capture, preprocessing, storage or management, and application layers. This approach allows data to be integrated from smart devices in terms of context awareness: for *text mining* , sentiment analysis, classification of nodes in the context of the application domain

V. Conclusion

Research in intelligent service systems continues to evolve and grow exponentially. Previous research has shown various concepts put forward with their own challenges. Although this systematic literature review is expected to be thorough and complete for a survey of research in the field of intelligent service systems, it may still experience various validity threats. Thus, researchers expected to understand or openly use the analysis or the results of this literature review in future research should bear in mind the following limitations: a) Research Scope, b) Research Questions, c) Study and Publication Bias, d) Completeness and e) Data Extraction.

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