Information Systems and e-Business Management (2021) 19:1175–1243
https://doi.org/10.1007/s10257-021-00537-0

ORIGINAL ARTICLE

Business model innovation driven by the internet of things technology, in internet service providers' business context

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Received: 25 November 2020 / Revised: 24 June 2021 / Accepted: 13 July 2021 /
Published online: 1 September 2021

Abstract

Business model innovation (BMI) describes the efforts made by the business in finding new business logic or new ways of value creation. Technological change is deemed to be the main driver of BMI. This study focused on the emergence of the internet of things (IoT) as a technological driver of BMI in internet service providers' (ISPs) business context, in the scope of wired access (WA) and fixed wireless access (FWA) providers, and addressed new ways of value creation for ISPs driven by IoT. To this end, a four-stage BMI process, including; *initiation*, *ideation*, *integration,* and *evaluation*, was used. In the implementation of the BMI process, we used the data extracted from the literature of IoT, BMI, and ISP business, as well as those obtained through interviews with experts. As a result of the process implementation, we identified possible ideas for the value creation of ISPs in the IoT domain, based on *connectivity service providing*, *cloud service providing*, *technical solution providing*, and *business solution providing*. Then, we proposed ISPs' business models in the IoT domain, in accordance with the identified ideas, based on Hedman and Kalling's ontology. To boost the validity of the proposed business models, the stress testing approach was recruited at the final stage of the BMI process. Implementing BMI, driven by IoT, in the ISPs' context, reduces constraints imposed by the paucity of knowledge in both BMI and IoT, helps ISPs' managers to anticipate and identify the IoT-based opportunities, and provides a starting point for further studies on new ways of value creation in other businesses in the telecom industry.

Keywords Internet service providers · Internet of things · Business model innovation · Stress testing approach · Uncertainty

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1 Introduction

The business model innovation (BMI) describes the efforts made by the business for finding new business logic (Casadesus-Masanell and Zhu 2013). BMI, manifested as new ways of value creation for the stakeholders (Casadesus-Masanell and Ricart 2010; Casadesus-Masanell and Zhu 2013; Landau et al. 2016; Lindgardt et al. 2009), is driven by a change in one or more components of the business model (Chesbrough 2010; Demil and Lecocq 2010; Mitchell and Coles 2003; Teece 2010).

In this respect, BMI not only covers both meanings of BMD (Business Model Development and Business Model Design) (Cortimiglia et al. 2016; Laudien and Daxböck 2016), but also is considered a complement to NPD (New Product Development) (Amit and Zott 2012; Chesbrough 2010; Teece 2010). In addition, BMI is seen as the source of new business opportunities and a key source of competitive advantage (Chesbrough 2007; McGrath 2010; Teece 2010; Venkatraman and Henderson 2008). Change in the business perspective, made by technological change or the emergence of new technology, forms the *basis of BMI* (Cortimiglia et al. 2016). In other words, technological change can lead to sustainable business growth when coupled with an innovative business model (Keskin et al. 2016). One of the technological changes is the emergence of IoT(Internet of Things) technology, among others. IoT is regarded as a global infrastructure for the information society that makes it possible to offer advanced services resulting from the connection of physical and virtual things based on ICT(Information and Communication Technology) (ITU 2012).

This technology will significantly impact almost every industry (Fugl 2015), thanks to its potential for creating new markets and changing competitive business conditions (Metallo et al. 2018). Success in value creation in IoT hinges on innovating business models in the context of this technology (Metallo et al. 2018).

Despite the emphasis placed on business model innovation in IoT (Leminen et al. 2012; Metallo et al. 2018; Westerlund et al. 2014), so far, few studies have been conducted in this area (Rai and Tang 2014; Tesch et al. 2019; Westerlund et al. 2014; Wirtz et al. 2016). The lack of extensive studies in this area has resulted in a poor understanding of the role and significance of BMI in IoT (Tesch et al. 2019). This poor understanding has not only been reported as the main reason for the failure of IoT projects (Andersson and Mattson 2015; Schneider and Spieth 2013) but has reduced the speed of developing this technology, as well (Bilgeri and Wortmann 2015).

It must be mentioned that the main focus of previous studies in the IoT domain has been on a generic explanation of BMI in this domain (Tesch et al. 2017). Hence, its key aspects, including identifying value creation opportunities, offering value creation ideas based on the identified opportunities, and proposing and evaluating business models according to those ideas, have remained untouched (Burkhart et al. 2011; El Sawy and Pereira 2013; Veit et al. 2014). Meanwhile, some studies have concentrated on BMI analysis in the context of a specific market or industry (Massa and Testa 2011; Yunus et al. 2010).

However, to the best of our knowledge and according to Fleisch et al. (2015), no research study has so far addressed the innovative business models of the telecom industry given the emergence of IoT, particularly in the last mile connectivity section, which refers to the final leg from the smart things to the internet network. However, in the telecommunications industry, IoT has indeed not only emerged as the creator of growth opportunities in the ICT domain (OCDE 2015), but also the highest potential for value creation in IoT has been anticipated with access to the internet and its integrated services (Burkitt 2014), which is the core business of ISPs(Internet Service Providers) (Künsemöller et al. 2013). The ISPs' success in creating value in the IoT domain will also depend on evolving and innovating their current business model (Sadowski et al. 2016; Sun et al. 2012).

The current business model of ISPs in the scope of connectivity service providing according to Hedman and Kalling's (2003) ontology was described by Hanafizadeh et al. (2019). However, as mentioned earlier, no study has been conducted in the area of ISPs' innovative business model driven by IoT (Fleisch et al. 2015). Despite the failure to propose ISPs' business models driven by IoT, connectivity service providers (like ISPs) are considered as a part of the IoT value chain (ITU 2016b); thus, their presence in the IoT value chain is required.

Consequently, given that the highest potential for value creation in IoT (Burkitt 2014) is related to the core business of ISPs[1] (Künsemöller et al. 2013), the importance of their presence in the IoT value chain (ITU 2016b), the dependency of their success in creating value in the IoT domain on innovating their current business model (Sadowski et al. 2016; Sun et al. 2012), and the fact that there is no report of their innovative business model impacted by IoT (Fleisch et al. 2015), this research focuses on implementing BMI, driven by IoT, in the ISPs' business context. Therefore, the research question (RQ) is posed as follows:

RQ: *What will the innovative business model of ISPs driven by IoT technology be like?*

It should be mentioned that the scope of ISPs' business in the telecom industry is very vast, and in offering connectivity services, it supports all three types of WA(Wired Access), FWA(Fixed Wireless Access), and MWA (Mobile Wireless Access) services. The present study specifically focuses on proposing innovative business model(s) of WA + FWA providers driven by IoT. Hence, providing MWA is out of the scope of the current study and can be included in the working scope of MNOs (Mobile Network Operators).

Accordingly, the main scientific contributions of this study are identifying possible ideas for the value creation of ISPs (WA + FWA providers) in the IoT domain and explaining the relevant business models. Another potential contribution is validating the ideas and the proposed business models together with materializing them. Besides, explaining the implementation of the whole steps of the BMI process driven by IoT in the context of ISPs can be regarded as a proper guideline for implementing BMI driven by this technology in other businesses of the telecom industry.

Implementing BMI driven by IoT, in the ISPs' context, reduces constraints imposed by the paucity of knowledge in BMI (Schneider and Spieth 2013), IoT (Patel 2016), and IoT-driven BMI (Wirtz et al. 2016), and provides a starting point for further studies in identifying new ways of value creation in other businesses in the telecom industry and even other industries influenced by this technology. The

[1] Access to the internet and its integrated services.

development of such a model can also help ISPs' managers to anticipate and identify the IoT-based opportunities (Moqaddamerad et al. 2017) and respond to them in a novel way (Patel 2016).

The outline of the remainder of this paper is as follows: in Sect. 2 (Literature Review; Data Gathering), the relevant studies are reviewed. In Sect. 3 (Research Methodology), the research method of the present study is elaborated. Section 4 (Data Analysis) focuses on the implementation of the BMI process. Section 5 presents the discussion, and Sect. 6 is devoted to the conclusion of the results, implications, and outlook.

2 Literature review

Implementing BMI driven by IoT in the ISPs' business context requires an understanding of the literature of three different areas, namely ISPs' business, IoT technology, and the BMI concept. To gain an insight into the literature on ISPs' business, a recent study conducted by Hanafizadeh et al. (2019) is cited, which has reviewed all research related to the ISPs' business.

Therefore, the following two subsections focus solely on reviewing the literature on IoT technology and the BMI concept.

2.1 IoT literature review

To review the literature on IoT, first, we collected the studies conducted in this area (see Sect. 3). In order to enhance the accuracy of extracting secondary data, we logically classified the studies related to the present research through content analysis using the open coding technique (Hsieh and Shannon 2005) by Atlas -Ti software ("Appendix 1").

As a result of conducting content analysis, the research on IoT was divided into the following six main classes (Table 1), including; IoT recognition, IoT architecture, IoT enabler technologies**,** IoT ontologies, the importance of innovating business models in the IoT domain, and IoT business components.

In the following, the findings of studies in each of the six mentioned classes are presented.

2.1.1 The first class: IoT recognition

This class was subdivided into five sub-classes, including; *definition and advantages of IoT*, *types of IoT*, *IoT potentials*, *IoT uncertainties,* and *IoT usecases*.

The studies in *definition and advantages of IoT* sub-class, while offering various definitions of IoT, regard its standard and global definition as developing. In addition, they focus on the individual and corporate advantages of this technology, such as enhancing efficiency, intelligent management of products, increasing scalability and efficiency of the business, optimizing the processes, decision analysis based on the sensor, and finally, improving personal life quality.

Table 1 The results of IoT literature review

Class	Sub class	Papers	
The first class: IoT recognition	The first sub-class: Definition and advantages of IoT	Sadowski et al. (2016), Wortmann and Flüchter (2015), Li et al. (2015), Tseng et al. (2018) and Miorandi et al. (2012)	Sundmaeker et al. (2010), Chui et al. (2010), Shi et al. (2010), Gubbi et al. (2013) and Conti et al. (2018)
	The second sub-class: Types of IoT	Bandyopadhyay and Sen (2011) and Palattella et al. (2016)	Palattella et al. (2014) and Da Xu et al. (2014)
	The third sub-class: IoT potentials	Fugl (2015), Burkitt (2014), Cho et al. (2015) and McKinsey (2018)	Fransman (2010), Krafft (2010), Sadowski et al. (2016) and Manyika et al. (2015)
	The fourth sub-class: IoT uncertainties	Böhle (2011), Brad and Murar (2014), Janasz (2009) and Razian et al. (2020)	Bilgeri and Wortmann (2017), Luchs et al. (2015) and Haaker et al. (2017)
	The fifth sub-class: IoT Usecases	McLoughlin et al. (2015), Charania and Li (2020), Morel et al. (2019), Nanni et al. (2017), Adapa et al. (2020), Saarikko et al. (2017), Ismagilova et al. (2019), Woo et al. (2015) and Gupta et al. (2019)	Lubrano et al. (2020), Mekki et al. (2019), Mekki et al. (2018), Havard et al. (2018), Andreadou et al. (2016), Queralta et al. (2019), Patel and Won (2017) and Burmaoglu et al. (2017)
The second class: IoT architecture	None	Sun et al. (2012), Domingo (2012), Matias et al. (2015), Abreu et al. (2017), Atzori et al. (2010), Da Xu et al. (2014), Pöhls et al. (2014), Yousuf et al. (2015) and Khan et al. (2012)	Qin et al. (2014), Desai et al. (2015), Zhou et al. (2013), Yue et al. (2014), Li and Xu (2013), Atzori et al. (2012), Rahimi et al. (2018), Tan and Wang (2010) and Wu et al. (2010)

Table 1 (continued)

Class	Sub class	Papers	
The third class: IoT enabler technologies	The first sub-class: Cellular technologies	Agiwal et al. (2016), Akyildiz et al. (2016), Akpakwu et al. (2017), Rahimi et al. (2018), Series (2015), Li et al. (2018), Zhang et al. (2016)	Ndiaye et al. (2017), Modieginyane et al. (2018), Ishaq et al. (2013), Elkhodr et al. (2016), Girson (2018), Deloitte (2017a, b), McKinsey (2018)
	The second sub-class: LPWAN (Low Power Wide Area Network) technologies	Mekki et al. (2018), Sinha et al. (2017), Mermer and Zeydan (2017), Raza et al. (2017), Patel and Won (2017), Centenaro et al. (2016), McKinsey (2018), Naik et al. (2016) and Naik and Jenkins (2016)	Oh and Shin (2016), Mikhaylov et al. (2016), Naik (2017), Andreadou et al. (2016), Nanni et al. (2017), Saarikko et al. (2017), GSMA (2017), Rebbeck et al. (2014) and Queralta et al. (2019)
	The third sub-class: Other technologies	Andrews et al. (2014), Shariatmadari et al. (2015) and Rahimi et al. (2018)	Mekki et al. (2018), McKinsey (2018) and Deloitte (2017a, b)
The fourth class: IoT ontologies	None	Li and Xu (2013), Holler et al. (2014), Chan (2015), Sun et al. (2012), Fan and Zhou (2011) and Liu and Jia (2010)	Qin and Yu (2015), Leminen et al. (2012), Bucherer and Uckelmann (2011), Dijkman et al. (2015) and Ju et al. (2016) and Turber and Smiela (2014)
The fifth class: The importance of innovating business model in IoT domain	None	Westerlund et al. (2014), Ritala et al. (2013), Ghanbari et al. (2017) and Lucero (2016)	Turber and Smiela (2014), Chan (2015) and Raza-Ullah et al. (2014)
The sixth class: IoT business components	None	Leminen et al. (2012), Ju et al. (2016), Qin and Yu (2015), Turber and Smiela (2014), Raza-Ullah et al. (2014), Dijkman et al. (2015), Bouncken et al. (2015), Shrimali (2010), Raju et al. (2012) and Ghezzi (2012)	Bucherer and Uckelmann (2011), Li and Xu (2013), Sun et al. (2012), Burkitt (2014), Coucheney et al. (2014), Westerlund et al. (2014), Bilgeri et al. (2015), Camponovo and Pigneur (2003) and Kelly (2003)

The studies grouped in the *types of IoT* sub-class address the meaning and difference between the two main applications of the IoT technology, including IIoT (Industrial IoT) and CIoT (Consumer IoT).

In studies of *IoT potentials* sub-class, the focus is on the different growth opportunities based on the IoT technology for various businesses. Using those opportunities in each business depends upon the type of the business's current value proposition, its key capabilities, and, most importantly, its ability to understand this new technology.

The studies in the *IoT uncertainties* sub-class, while defining uncertainty and its origins, explain the existence of uncertainty in IoT and focus on the main areas of uncertainty in IoT and its relevant areas (if any).

In the *IoT usecases* sub-class, studies address the characteristics, requirements, advantages, and limitations of the top ten IoT usecases according to the statistics presented by IoT analytics (2018).

2.1.2 The second class: IoT architecture

The studies in this class introduce ten important architectures in the area of IoT, as presented in Table 2.

2.1.3 The third class: IoT enabler technologies

This class was subdivided into three sub-classes, including *cellular technologies*, *LPWAN (Low Power Wide Area Network) technologies,* and *other technologies*.

The studies in the *cellular technologies* sub-class focus on the characteristics of cellular technologies with special emphasis on the features of 5G technology. In other words, while pointing to the advantages of 5G technology as an enabler of IoT, including low energy use, high reliability, wireless communication coverage, low delay time, high throughput, and high scalability, these studies address some challenges of using this technology in IoT domain such as scalability and network management, interoperability between HetNet (Heterogeneous Network), guaranteeing security and privacy, and lack of compatibility and appropriate standards between different systems.

In the studies of *LPWAN technologies* sub-class, the capabilities of these technologies are presented as the connectivity need of IoT due to four key features, namely, long range, low cost, low bit rate, and low power consumption.

In the studies of the *other technologies* sub-class, the name of other IoT enabler technologies, including mmWave (millimeter Wave), fiber optic, Het-Net, D2D(Device to Device) communication, MTC (Machine-Type Communication), WSDN (Wireless Software-Defined Networks), SSIM (Spectrum Sharing and Interference Management), MEC (Mobile Edge Computing), WNFV (Wireless Network Function Virtualization), MCC (Mobile Cloud Computing), big data, and terrestrial, are presented, and the characteristics of some of them are mentioned.

Table 2 Kinds of IoT architecture

Architecture's name	Architecture's description
1. Three-layered architecture (Domingo 2012; Sun et al. 2012; Yousuf et al. 2015)	This architecture is the most common IoT architecture, including three layers of perception, network, and application. The perception layer is tasked with identifying things and collecting their information. The network layer focuses on the real-time transmission of information collected by the perception layer. The application layer is tasked with a combination of data processing and intelligent analysis to meet industry requirements intelligently
2. SDN-based architecture (Qin et al. 2014)	This architecture aims at increasing the QoS (Quality of Service) in environments where there is a network of heterogeneous sensors
3. QoS-based architecture (Abreu et al. 2017; Matias et al. 2015)	This architecture focuses on enhancing service provision quality across a wide range of smart city applications to meet service quality requirements in this area
4. Service-oriented architecture (SOA) (Atzori et al. 2010; Da Xu et al. 2014; Desai et al. 2015)	This architecture focuses on designing processes related to service coordination, hardware, and software optimization. It consists of four layers of perception, network, service, and application
5. Mobility first architecture (Li and Xu 2013)	This architecture focuses on tackling the challenges associated with the use of smartphones in the IoT network
6. Cloud things architecture (Zhou et al. 2013; Yue et al. 2014)	The focus of this cloud-based architecture is on improving service compatibility in the next generation of the Internet
7. IoT-A architecture (Abreu et al. 2017; Da Xu et al. 2014; Pöhls et al. 2014)	This architecture pursues an increase in the security and confidentiality of IoT applications in the initial stages concerning the addition of relevant mechanisms
8. S-IoT architecture (Atzori et al. 2012)	This architecture focuses on integrating IoT and social networks, allowing for the integration of things in the social network and leading to the creation of S-IoT
9. 5G- IoT architecture (Rahimi et al. 2018)	The focus of this architecture is on increasing agility, effectiveness, scalability, and responsiveness to high demand. The architecture consists of eight interconnected layers as follows: (1) Physical devices layer; (2) Communication layer; (3) Fog computing layer; (4) Data storage layer; (5) Network management layer, cloud computing, and data analytics layer; (6) Application layer; (7) Collaboration layer and (8) Security layer
10. Five layered architecture (Tan and Wang 2010; Wu et al. 2010(	This architecture, known as IoT basic architecture (Khan et al. 2012), consists of five layers as follows: perception layer, network layer (communication layer), middleware layer (information processing), application layer, and business layer

2.1.4 The fourth class: IoT ontologies

The studies of this class introduce the ontologies in the area of IoT, as presented in Table 3.

Table 3 Types of IoT ontologies

Meta model	Description
MOP model (Li and Xu 2013)	It includes the following four dimensions: *Technology*, *Industry*, *Policy,* and *Strategy*
Three-dimensional model (Holler et al. 2014)	It includes the following three dimensions: *who* (describing ecosystem members), *where* (describing value co-creation resource), and *why* (describing the benefits ecosystem members can reap from their participation in value networks)
Four-dimensional model (Chan 2015)	In this model, the fourth dimension of *how* (including how to integrate value chain components, tactics, and strategy) is added to the proposed Holler's model (Holler et al. 2014)
DNA model (Sun et al. 2012)	This model, which emphasizes all components of Canvas BM (Business Model) (Osterwalder et al. 2011), includes the following three dimensions: *design* (focuses on supply infrastructure), *needs* (focuses on demand infrastructure), and *aspiration* (focuses on ends)
No name (Fan and Zhou 2011)	This model, customized for postal logistics, emphasizes the four components of Canvas BM, including value proposition, key partners, customer segment, and revenue streams
No name (Liu and Jia 2010)	This model, customized for the medicine supply chain, emphasizes the four components of Canvas BM, including key partners, key activities, and customer segment and revenue streams
Value net model (Qin and Yu 2015)	This model's essential factors for the telecom industry include understanding the needs of value chain members, the ability to integrate resources, and the quality of service providing. Therefore, it follows a customer-oriented, information sharing, and resource integration strategy
2 *2 matrix dimension (Leminen et al. 2012)	In this model, a 2 * 2 matrix is derived from the interaction of two longitudinal axes (including types of customers in both individual and corporate categories) and transverse axes (including types of ecosystems in two types of *closed private* and *open networked*
Canvas (Bucherer and Uckelmann 2011)	This model, which emphasizes Canvas BM components, accentuates the importance of information as a source of value creation
Canvas (Dijkman et al. 2015)	This model focuses on the important components of Canvas BM in accordance with the previous model (Bucherer and Uckelmann 2011)
Canvas (Ju et al. 2016)	This model aims to provide a generic business model based on identifying important components of two previous models (Bucherer and Uckelmann 2011; Dijkman et al. 2015) in the IoT domain
No name (Turber and Smiela 2014)	This model focuses on key requirements of designing an IoT business model, including network perspective instead of corporate perspective, considering the customer as a co-producer, considering each layer of the IoT architecture as a source of value creation, and the collaboration of all members of the ecosystem

2.1.5 The fifth class: the importance of innovating business model in the IoT domain

In the studies conducted in this class, while pointing to the concept of ecosystem, stressing the ecosystemic nature of IoT technology and value-creating roles in IoT ecosystem, the focus is on the necessity of innovation in the business model at the ecosystem level, as the requirement for the value creation of businesses in the IoT domain.

2.1.6 The sixth class: IoT business components

This class of studies describes some business components in the IoT domain as following:

The *customer segmentation* of IoT services is B2C and B2B (Leminen et al. 2012) or three groups of ordinary, vertical market, and global market customers (Ju et al. 2016). According to Turber and Smiela (2014) and Qin and Yu (2015), *customer relationship* methods in all IoT-related businesses involve co-creation, self-service communication, and fast feedback. Ju et al. (2016) introduced the internet and mobile as the IoT domain's service *distribution channels*. Also, software providers, data analysis firms, and equipment manufacturers can be considered the IoT's specialized *key partners* (Bucherer and Uckelmann 2011; Dijkman et al. 2015; Li and Xu 2013). Reza-Ullah et al. (2014) reported that the interaction among the IoT ecosystem members is of coopetition type, which means cooperation and competition beside each other. The types of *value proposition* in IoT for different industries can be convenience, performance, customization, and share (Dijkman et al. 2015; Leminen et al. 2012; Li and Xu 2013; Qin and Yu 2015; Sun et al. 2012). The general format of the *cost structure* in the IoT domain has been reported as IT cost, the required infrastructures' cost, and the maintenance cost (Dijkman et al. 2015; Ju et al. 2016; Li and Xu 2013; Sun et al. 2012). According to previous studies, the IoT domain's *revenue streams* can be in the form of a subscription fee, service fee (Bucherer and Uckelmann 2011; Dijkman et al. 2015), profit sharing, or products sale (Ju et al. 2016). On the other hand, the revenue streams of ISPs in the IoT domain have been reported as users' subscription fees, service fees, and information-based service sales (Camponovo and Pigneur 2003; Coucheney et al. 2014). In addition to FAB (Fulfillment, Assurance and Billing) processes (Kelly 2003), the key processes of the IoT domain involve product promotion, platform development, partner management, big data analysis, and platform and resources integration (Dijkman et al. 2015; Qin and Yu 2015). According to VCT (Value Configuration Theory), the *value configuration* type of the telecom industry businesses in the IoT domain can be considered as value shop, due to the provision of supporting capabilities, and value network, due to the importance of value net model in this industry (Qin and Yu 2015). Finally, the *key resources* of the IoT domain, according to RBT (Resource Based Theory) (Bilgeri et al. 2015), include sensors, cloud service, IoT specialized network, and the capabilities required for data analysis (Ju et al. 2016), that, in sum, can be considered as three factors of software, information, and customer-required resources (Bucherer and Uckelmann 2011; Qin and Yu 2015; Sun et al. 2012).

2.2 BMI literature review

To review BMI literature, first, the studies conducted in this area were collected (see Sect. 3). To increase the accuracy of secondary data extraction, the focus was on the logical classification of the studies related to the present research through content analysis using the open coding technique (Hsieh and Shannon 2005) by Atlas-Ti software ("Appendix 2").

As a result of conducting content analysis, the research on BMI was divided into four classes as follows: the concept of BMI, drivers of BMI implementation, advantages of BMI implementation, and BMI implementation procedures (Table 4).

In the following, the findings of the studies in each of the four classes are presented.

2.2.1 The first class: concept of BMI

The studies in this class focus on the concept of BMI. They define it as business guidance through a new method, finding a new business logic, and describing new value creation methods for the stakeholders.

2.2.2 The second class: drivers of BMI implementation

The studies of this class address the factors such as globalization, changing laws, ICT development, and social and organizational factors as the BMI implementation drivers. In this regard, *technological change* is introduced as the *main driver of BMI* implementation. Success in the face of technological changes depends upon the provision of an innovative business model.

2.2.3 The third class: advantages of BMI implementation

The studies of this class concentrate on the necessity of BMI implementation. They consider BMI implementation as the origin of new business opportunities, the key source of competitive advantage, driver of profit enhancement, harnessing competitive threats, reducing costs, improving strategic flexibility, using new market opportunities, and reducing investment risk.

2.2.4 The fourth class: BMI implementation procedures

In this class, studies address the procedures of BMI implementation. Some studies have implemented BMI as a process (Frankenberger et al. 2013; Laudien and Daxböck 2016; Teece 2010). Frankenberger et al. (2013) argued that successful BMI implementation depends upon a four-stage iterative process including *initiation*, *ideation*, *integration*, and *implementation* (*evaluation*). Their proposed BMI process has been used in many studies as a framework of BMI implementation (Tesch et al. 2019). The main focus of the studies using the proposed process of Frankenberger et al. (2013) has been on the two initial stages, i.e., *initiation* and *ideation*

Table 4 The results of BMI literature review

Class	Papers	
The first class: concept of BMI	Chesbrough (2010), Demil and Lecocq (2010), Mitchell and Coles (2003), Teece (2010), Casadesus-Masanell and Zhu (2013), Lindgardt et al. (2009) and Casadesus-Masanell and Ricart (2010)	Abdelkafi et al. (2013), Mitchell and Coles (2004), Schneider and Spieth (2013), Skarzynski and Gibson (2008), Zott and Amit (2010) and Landau et al. (2016)
The second class: drivers of BMI implementation	Keskin et al. (2016), Tesch et al. (2017), Sorescu et al. (2011), Chesbrough (2007) and Calia et al. (2007)	Casadesus-Masanell and Ricart (2010), Chesbrough and Rosenbloom (2002), Casadesus-Masanell and Zhu (2013), Whitmore et al. (2015), Cortimiglia et al. (2016)
The third class: advantages of BMI implementation	Björkdahl (2009), Chesbrough (2007), Comes and Berniker (2008), McGrath (2010), Mitchell and Coles (2003) and Teece (2010)	Chesbrough and Rosenbloom (2002), Baden-Fuller and Morgan (2010), Venkatraman and Henderson (2008), Casadesus-Masanell and Ricart (2010), Pohle and Chapman (2006) and Sun et al. (2012)
The fourth class: BMI implementation procedures	Teece (2010), Veit et al. (2014), Frankenberger et al. (2013), Bilgeri et al. (2015), Bouwman et al. (2012), Bouwman et al. (2009), Burkhart et al. (2011), Tesch (2016), De Reuver et al. (2013) and Haaker et al. (2017)	Tesch et al. (2019), Amit and Zott (2012), Cavalcante (2014), Chesbrough (2007), Chesbrough (2010), Cortimiglia et al. (2016), Demil et al. (2015), Giesen et al. (2007), Laudien and Daxböck (2016) and Wirtz et al. (2016)

(Bilgeri et al. 2015), and the lowest attention has been paid to the two final stages, i.e., *integration* and *implementation* (Tesch 2016; Veit et al. 2014). Besides, in the implementation stage, little emphasis has been put on the evaluation of the proposed business model(s) (De Reuver et al. 2013), while evaluation plays a significant role in promoting the validity and capability of the proposed business model(s) (Bouwman et al. 2012) as well as their successful implementation (Haaker et al. 2017). Therefore, in BMI implementation, particularly in new areas like IoT where there are many assumptions and uncertainties, performing an evaluation method, as part of the BMI process (Burkhart et al. 2011; Veit et al. 2014), is more valuable than implementing the BMI process alone (Tesch 2016).

3 Research methodology

In this section, the different aspects of the research, inspired by Saunders et al. (2009), are elaborated on as follows.

The philosophy of the present research is interpretivism[2] due to the study's dependence upon the experts' interpretations, description, experiences, and views, and the limited knowledge on the areas of IoT (Patel 2016) and BMI (Schneider and Spieth 2013), and BMI driven by IoT (Wirtz et al. 2016).

The present research employed a deductive-inductive approach because, on the one hand, it used Hedman and Kalling's ontology as the business model framework (deductive), and on the other hand, it collected data and discovered the relationship among them to explain each component of Hedman and Kalling's model (inductive).

To identify the appropriate strategy to elaborate on the innovative business model(s) of ISPs driven by IoT, from among the studies conducted on how BMI is implemented (the 4th class of Table 4), the four-stage process proposed by Frankenberger et al. (2013), as the most popular process (Tesch et al. 2019), was selected as follows.

- In the *initiation*[3] stage, after identifying all drivers of BMI and selecting the driver of BMI implementation in this study, i.e., the emergence of IoT technology as a technological driver of BMI, the focus will be on identifying the different aspects of the selected driver.
- In the *ideation* stage, the new business logic of ISPs driven by IoT will be explained based on business model thinking in the form of new ideas. The definition of new business logic influenced by IoT requires a change in the current business logic and a shift from the business level to the ecosystem level (Westerlund et al. 2014). Therefore in this stage, considering the current capabilities of ISPs, after identifying the ISP's value creation opportunities in the IoT ecosystem, the best compatible solutions are proposed as the ideas of ISP's value creation in the IoT ecosystem.

[2] Which means the dependency on the experts' interpretation.

[3] Or Identification stage.

- In the *integration* stage, the ISP's business model influenced by IoT is explained in accordance with each of the ideas outlined in the *ideation* stage. In other words, after selecting an appropriate ontology in the IoT domain, at first, the ISPs' business model components driven by IoT are described according to the selected ontology based on secondary data and then, the ISP's business model components, related to each of the proposed ideas are elaborated based on the primary data and inspired by the described factors.
- The *evaluation stage* of the BMI process, driven by IoT, focuses on evaluating the proposed business model(s) outlined in the *integration* stage. Due to the following purposes, using stress testing approach (STA) is recommended to evaluate the business model (Bouwman et al. 2012; Haaker et al. 2017); (1) the integration of BMI and STA in the field of IoT (Bouwman et al. 2009, 2012) enhances the credibility and robustness of the proposed business model(s) (Tesch 2016), (2) the use of STA can account for the relationship between the components of the proposed business model and the existing uncertainties, (3) the result of STA analysis can help one select a suitable model from among several innovative business models (Haaker et al. 2017) and, (4) it can provide an acceptable vantage point for implementing the proposed business models prior to any investment (Christensen et al. 2016). Therefore in this study, STA analysis is conducted in the evaluation stage of the BMI process as follows; at first, after identifying all uncertainties in the IoT domain, the IoT uncertainties affecting ISPs' business and their anticipated outcomes are identified. Then, the impact of the selected uncertainties on the proposed ISPs' business model components is explained.

The present study is a qualitative one from different perspectives: first, due to the dependency of this study on the experts' knowledge and experiences in the different areas, the collected data are verbal that are analyzed qualitatively. Second, the research question has an explorative nature, answering which requires qualitative data analysis. Finally, in this study, predicting the behavior of ISPs' business in the IoT ecosystem is rather difficult due to the variety of existing variables (Coze 2005).

The research time span is beyond a cross-section; since descriptive and explanatory studies of a specific phenomenon in a given time interval are considered cross-sectional studies, and value creation of ISPs in the IoT ecosystem is an evolutionary approach, the time span required to explain this phenomenon is beyond a cross-section and involves near future.

To elaborate on the research data collection and data analysis methods, it should be mentioned that the novel and multi-dimensional aspect of the present study and lack of sufficient knowledge in the domains of IoT (Patel 2016), BMI (Schneider and Spieth 2013), and BMI implementation driven by IoT (Wirtz et al. 2016) require the use of several data sources including primary and secondary data for the implementation of the four stages of BMI in this study. In the following, the data collection and analysis methods for both data types are presented as two successive steps.

3.1 The first step: secondary data collection and analysis method

Implementing BMI driven by IoT in the ISPs' business context requires access to the secondary data of three different areas, i.e., ISP business, IoT technology, and BMI concept. To access the secondary data on the ISPs' business, Hanafizadeh et al.'s (2019) study was used. Thus, we addressed the secondary data collection methods of IoT and BMI domains in what follows.

To review the research undertaken in the *IoT domain*, we searched google scholar, web of science, and Scopus search engines using the following keywords in the title, abstract, and keywords of the articles: *Internet of things*, *Business model of IoT*, *IoT in the telecom industry*, *Business model of IoT in the telecom industry* and *Value creation of ISPs in IoT domain*. Therefore, articles extracted via scientific databases such as ProQuest, Science Direct, Emerald, Springer, IEEE Explore, etc., were taken into consideration. We determined the timeframe between 2000 and 2020 for choosing the articles. Hence, the number of research undertaken in the mentioned domain amounted to 168. In order to select the relevant articles, we performed the next step filtering based on the following criteria:

- We did not consider the articles in which the term "internet of things (IoT)" was randomly used.
- We selected the articles whose primary focus was on evaluating the impact of IoT on the industries' value creation.
- Our specific focus was on articles that sought to develop or describe a business model in IoT in a particular industry, especially in the telecom industry.

  According to Fig. 1, the result of the mentioned filtering was 112 articles that focused on the IoT domain.

  To review the research undertaken in the *BMI domain*, in the same search engines, databases, and the timeframe, we searched for the following keywords in the title, abstract, and keywords; *Business model innovation* (*BMI*), *BMI implementation methods, and BMI implementation in IoT*. Hence, the number of research undertaken in the mentioned domain amounted to 98. In order to select the relevant articles, we performed the next step filtering based on the following criteria:
- We excluded the articles in which the term BMI was randomly used.
- We selected the articles whose main focus was on BMI in different businesses.
- Our specific focus was on articles that sought to implement BMI, especially in the IoT domain.

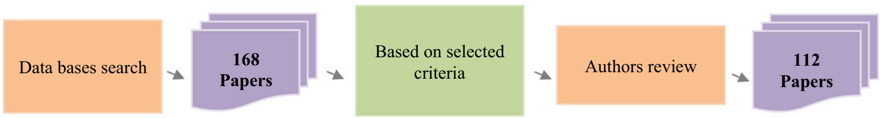

Fig. 1 Selection process of the research in the IoT domain

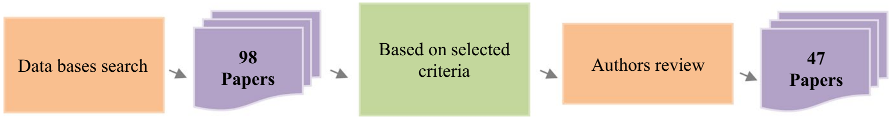

Fig. 2 Selection process of the research in the BMI domain

According to Fig. 2, the result of the mentioned filtering was 47 articles that focused on the BMI domain.

The secondary data analysis method was a *content analysis* of studies on IoT and BMI domains and then, *descriptive analysis* of studies related to each class or sub-class related to both domains. In other words, for logically segmenting the collected data to enhance the accuracy of extracting the secondary data, at first, content analysis was performed through the open coding method (Hsieh and Shannon 2005) for each of the mentioned domains. Then, the studies of each segment (class or sub-class of Tables 1 and 4) were described based on the proposed pattern (Smith and Firth 2011).

The steps of content analysis in both domains are as follows:

- Studying the title, abstract, and introduction of the selected articles to determine each study's main class in each domain;
- To determine the sub-classes of each class, the entire text of the selected articles was studied, and coding was done based on the implications of the study.
- Since some articles were associated with more than one class or sub-class, the relationship between classes and sub-classes, if any, had to be elaborated in this step.

To ensure the reliability and integrity of the coding process, the articles were evaluated and coded separately by authors. The final coding was carried out after ensuring consistency.

3.2 The second step: primary data collection and analysis method

Given the novelty of IoT technology, the scant applied research in BMI implementation driven by IoT (Wirtz et al. 2016), and hence, deficiencies in the secondary data, it was inevitable to interview the experts to gather the knowledge needed to complete the implementation of the stages and substages of the BMI process. To this end, an attempt was made to consult the experts specialized in technical, industry, business, security, marketing, and regulation from different value networks in the two areas of IoT technology and ISP business. Working in the BMI projects (Laudien and Daxböck 2016) or participating in the IoT ecosystem were determined as criteria for selecting the experts. Accordingly, twenty-three experts from the mentioned areas (11 cases) were selected using the snowball sampling method, according to Table 5.

Table 5 The characteristics of the selected experts

Case	Business name	Core competency	Experts' number	Experts' role
1	TCI (Telecommunication Company of Iran)	Internet service providing	3	IT design manager Network manager Senior consultant Business analyst Network specialist
2	TIC (Telecommunication Infrastructure Company)		3	
3	TechMahindra		2	
4	Huawei		2	
5	AT & T	Internet of things	1	Business developer
6	Orange		1	Senior expert Business developer
7	Bosch IoT lab		2	Business solution Provider
8	Linkap		3	LPWAN access Provider
9	Arya hamrah		2	
10	Communication regulatory authority	Regulation	2	General managers
11	Information technology organization	Security	2	Security manager Security operation manager (in SOC)
Number of cases: 11			Number of participants: 23	

The interviews were semi-structured. The interview questions for each stage of the BMI process were specific. Due to the iterative nature of the BMI process (Frankenberger et al. 2013), the number of interviews was more than the BMI stages. The same questions were asked from all participants, and the experts were free to provide their answers in any possible way. The participant's responses to the interview questions were recorded, and appropriate notes were taken in the form of voice or text.

Due to the variety of the interview questions, we will present the questions related to each stage of the BMI process in Sect. 4, describing the four stages of this process.

In order to analyze the collected responses to the interviews related to each stage of the BMI process, interpretative analysis was used based on the proposed pattern (Schmidt 2004) as follows; the interview transcripts were reviewed several times, and redundant points were omitted in each review while important and non-repetitive points were highlighted. The previous literature review yielded some insights into coding the themes and concepts (Vaismoradi 2016). Accordingly, after screening out the contents of the interviews, the codes were defined. Obviously, in summarizing the results, the coding sequence of the highlighted themes was taken into consideration. Accordingly, the concepts of the text content were analyzed and interpreted. Finally, peer review was performed to triangulate the analysis.

Since the type of coding performed when analyzing the responses related to each stage of the BMI process was different, in Sect. 4, in the analysis of the relevant responses, we will explain the codes related to the interview responses of each stage of the BMI process in detail.

To summarize the points mentioned so far, the stages and sub-stages of implementing the BMI and STA consolidated process, the required data, and the data collection and analysis method are presented in Table 6.

4 Data analysis: BMI process implementation

Several drivers drive the business model innovation process. However, in this research, more attention is paid to the technological origin of the drivers that result from the emergence of IoT technology. As explained in the methodology section, first, the BMI process goes through a way that the opportunities driven by IoT in the ISPs' business are identified. Then, ideas are presented to make the most advantage of these opportunities. These ideas are synergistically integrated to create new business models for ISPs in the IoT domain. Ultimately, the proposed business models are evaluated. The details of these steps are as follows:

4.1 Initiation (identification)

This stage focuses on identifying the driver of BMI implementation in this study and the different aspects of the selected driver.

Table 6 The stages of BMI (Frankenberger et al. 2013) and STA (Haaker et al. 2017) consolidated implementation

BMI process stages	Sub-stages	The required data	Data gathering methods	Data analysis methods
Initiation (Sect. 4.1)	4.1.1 Identification of the driver of BMI implementation in this study	*Data 1* Identification of all types of BMI implementation drivers and selecting the appropriate driver in this study	*Data 1* Secondary data based on the results of the second class of Table 4	*Data 1* Descriptive analysis (Smith and Firth 2011)
	4.1.2 Identification of the different aspects of the selected driver	*Data 2* Identification of: the IoT ecosystem roles IoT architecture layers	*Data 2* Secondary data based on the results of the fifth class of Table 1 the results of the second class of Table 1	*Data 2* Descriptive analysis (Smith and Firth 2011)
Ideation (Sect. 4.2)	4.2.1 Identification of the ISPs' value creation opportunities in the IoT domain	*Data 3* Determining the ISP's contribution to value creation in the IoT ecosystem, in the form of the selected roles, in each layer of IoT architecture	*Data 3* Interview with selected experts (see Table 5)	*Data 3* Interpretative analysis (Schmidt 2004)
	4.2.2 Elaborating the ISPs' value creation ideas in the IoT ecosystem	*Data 4* Identification of the best compatible combinations of ISPs' value creation opportunities in the IoT ecosystem	*Data 4* Interview with selected experts (see Table 5)	*Data 4* interpretative analysis (Schmidt 2004) and then, using Delphi method (Hallowell and Gambatese 2010)

Table 6 (continued)

BMI process stages	Sub-stages	The required data	Data gathering methods	Data analysis methods
Integration (Sect. 4.3)	4.3.1 Selecting the appropriate ontology to elaborate on ISPs' business model driven by IoT	*Data 5* Identification of the types of ontologies in the IoT context and selecting the appropriate ontology from among them for this study	*Data 5* Secondary data based on the results of the fourth class of Table 1 (described in Table 3)	*Data 5* Descriptive analysis (Smith and Firth 2011)
	4.3.2 Elaborating ISPs' business model influenced by IoT in accordance with each of the explained ideas	*Data 6* describing business components of ISPs in the IoT domain based on the selected ontology	*Data 6* Secondary data based on the results of the sixth class of Table 1	*Data 6* Descriptive analysis (Smith and Firth 2011)
		Data 7 Completing the described the components of ISPs business and elaborating ISPs' business model in accordance with each of their value creation ideas in the IoT ecosystem	*Data 7* Interview with selected experts (see Table 5)	*Data 7* interpretative analysis (Schmidt 2004)

Table 6 (continued)

BMI process stages	Sub-stages	The required data	Data gathering methods	Data analysis methods
Evaluation (Sect. 4.4)	4.4.1 Identification of the IoT uncertainties affecting ISPs' business	*Data 8* Identification of the types of IoT uncertainties in general	*Data 8* Secondary data based on the first class (fourth subclass) of Table 1	*Data 8* Descriptive analysis (Smith and Firth 2011)
		Data 9 Identification of the IoT uncertainties affecting ISPs' business	*Data 9* Interview with selected experts (see Table 5)	*Data 9* interpretative analysis (Schmidt 2004)
		Data 10 Identification of the anticipated outcomes of IoT uncertainties affecting ISPs' business	*Data 10* Interview with selected experts (see Table 5)	*Data 10* interpretative analysis (Schmidt 2004)
	4.4.2 Map the proposed business model components to the uncertainties and create a heat map	*Data 11* Identification of the impact of selected uncertainties (Data 9), based on their perceived outcome (Data 10), on the components of the proposed ISPs' business model(s)	*Data 11* Interview with selected experts (see Table 5)	*Data 11* interpretative analysis (Schmidt 2004)
	4.4.3 Analysis of the results of the STA implementation			

4.1.1 Identifying the driver of BMI implementation

Generally, *technology push* or *market pull* can be considered BMI implementation drivers (Tesch et al. 2017). In other words, BMI is either creatively implemented by predicting or estimating the market needs or imposed by the business environment after the need arises (Casadesus-Masanell and Zhu 2013; Sorescu et al. 2011). In this regard, the technological change is deemed to be the primary driver of BMI (Calia et al. 2007; Chesbrough 2007; Chesbrough and Rosenbloom 2002; Whitmore et al. 2015), and BMI implementation has come to be known as a prerequisite for business success in the context of technological changes (Keskin et al. 2016). It is worth mentioning that BMI implementation drivers are not confined to technological change; globalization, changes in law and regulation, the promotion of information and communication technology, and social and organizational factors have also been identified as BMI drivers (Casadesus-Masanell and Ricart 2010).

In this study, we focused on the main driver of BMI, *technological change*, i.e., the emergence of IoT technology. The reason for focusing on this technology is its high capability to create new markets, growth potentials, and changing competitive business conditions (Metallo et al. 2018) in many industries, mostly the telecommunication industry. In other words, in the telecommunication industry, IoT has not only emerged as the creator of growth opportunities in the ICT domain (OCDE 2015), but also the most potential for value creation in IoT has been anticipated in relation to access to the internet and its integrated services (Burkitt 2014), which is the core business of ISPs (Künsemöller et al. 2013).

4.1.2 Identifying the different aspects of the selected driver

This stage focuses on identifying the driver of BMI implementation in this study and the different aspects of the selected driver

In this sub-stage, the focus is on identifying the important aspects of the selected driver, *the IoT technology,* required for BMI implementation in the context of ISP's business.

Given the complex technological nature of IoT, successful implementation of this technology relies on the collaboration and participation (Saarikko et al. 2017) of *IoT value chain* members, leading to the creation of an *IoT ecosystem*. Lucero's research (2016) indicated that value creation in the IoT domain is contingent on the interaction of the four roles involved in the IoT value chain, including *components and hardware provision*, *connectivity management*, *application enablement,* and *solution provision* (Lucero 2016). Based on the mentioned research, in this study, the IoT value chain members whose participation leads to IoT ecosystem creation are determined as follows:

- Design equipment + Implement and make equipment + Repair and sell equipment as *components and hardware provision* in Lucero's research
- Service operation and maintenance + Service providing as *connectivity management and application enablement* in Lucero's research
- Solution providing as *solution provision* in Lucero's research

On the other hand, any IoT architecture layer can be considered as a source of value creation in this technology (Turber et al. 2014). To the authors' best knowledge, among the types of IoT architectures (as shown in Table 2), the five-layer IoT architecture (Tan and Wang 2010; Wu et al. 2010) illustrates the different dimensions of this technology more lucidly. This architecture, known as IoT basic architecture (Khan et al. 2012), consists of five layers, including the perception layer, the network layer (communication layer), the middleware layer (information processing), the application layer, and the business layer. The main responsibility of each of the five layers mentioned is as follows:

- The *perception layer* collects useful information from things or the environment.
- The *network layer* or *communication layer* acts as an information bridge to provide a communication link between the sensing and service layers for the data transmission.
- The *middleware layer* or *information processing layer* can process the information and make decisions without knowing the exact use of the application layer.
- The *application layer*'s primary responsibility is to ensure effective communication among objects and build a reliable bond.
- The *business layer* manages the whole IoT system, including applications, business and profit models, and users' privacy.

After identifying the two important aspects of the IoT technology; the IoT ecosystem members based on Lucero's study (Lucero 2016) and selecting the appropriate IoT architecture (Tan and Wang 2010; Wu et al. 2010), in the next stage of the BMI process, the innovative ideas of value creation of ISPs driven by the IoT are explained.

4.2 Ideation

In the ideation stage of the BMI process, driven by IoT, the new business logic of ISPs will be explained based on business model thinking in the form of new ideas. The definition of new business logic driven by IoT requires a change in the current business logic and a shift from the business level to the ecosystem level (Westerlund et al. 2014). The current business logic of ISPs without IoT, elaborated by Hanafizadeh et al. (2019), only involves how the value is created at *ISPs' business level* in the telecom industry. In contrast, the definition of the new business logic of ISPs in the IoT domain involves ISPs' value creation ideas at the *IoT ecosystem level.*

Explaining the ideas of ISPs' value creation in the IoT ecosystem is undoubtedly dependent on the identification of their value creation opportunities in the IoT domain as well as their current capabilities and value creation methods, reported in the form of providing *connectivity services*, *cloud computing services* and c*ontent services* (Altmann 2000; European Commission 2016; GSMA 2016).

In this respect, to elaborate on the ISPs' value creation ideas in the IoT domain, we first focus on identifying ISPs' value creation opportunities in the next sub-stage.

4.2.1 Identifying the ISPs' value creation opportunities in the IoT domain

Research on the possibility of ISPs' value creation opportunities in IoT has only dealt with the provision of connectivity services (Burkitt 2014), failing to provide relevant details. This sub-stage focuses on identifying all the opportunities for ISPs' value creation in the IoT ecosystem. The ISPs' value creation opportunities in the IoT ecosystem can be identified based on the contribution degree of ISPs, made by the roles involved in the IoT ecosystem for value creation in each layer of the IoT architecture. Therefore, the ISPs' value creation opportunities in the IoT ecosystem, explained by Table 7, are elucidated based on the identified IoT ecosystem roles (Lucero 2016), the appropriate IoT architecture (Tan and Wang 2010; Wu et al. 2010), the three conditions of innovative opportunities selection in each business[4] (Sarasvathy 2001) and the current value creation capabilities of ISPs (Altmann 2000; European Commission 2016; GSMA 2016). The results emanating from the experts' interviews were also taken into consideration. Therefore experts were asked to answer the following questions:

Q2.1 Given the current value creation capabilities of ISPs (Altmann 2000; European Commission 2016; GSMA 2016), in what form of the six roles in the IoT ecosystem and in which layer of IoT architecture can ISPs create value?

Q2.2 Given the three conditions of determining value creation opportunities (Sarasvathy 2001), what is the fitness degree of ISPs' current capabilities with each of the opportunities identified for value creation in the IoT ecosystem based on the weights 0 to 3?

Q2.3 Among the value creation opportunities for ISPs in the IoT ecosystem, which one has the potential to be realized as a core service[5], and which one can be considered as an enhancing service?[6]

To analyze the Q2.1 responses, using *interpretative analysis* (Schmidt 2004), after screening out the contents of the interviews, 24 codes corresponding to each of the 24 cells of Table 7 were defined.

Based on the frequency count of the codes in each cell, we concluded about the presence or absence of ISPs' value creation opportunities in each of the 24 cells of Table 7. Accordingly, the various value creation opportunities of ISPs were identified as each member of the IoT value chain in each layer of the IoT architecture.

After summing up the Q2.1 responses, the answers to the two questions Q2.2 and Q2.3 were analyzed using the codes defined in the legend.

It should be mentioned that the weights mentioned in Q2.2 are effective in proposing more proper ideas for ISPs' value creation in the IoT domain. As mentioned

[4] i.e. fit to the capabilities, affordable loss and customer demand.

[5] A service package consists of three parts, namely core service, enabling service and enahancing service (Huotari & Hamari, 2012).

[6] This classification can help to explain the ideas of ISPs' value creation.

Table 7 ISP's value creation opportunities in the IoT ecosystem

IoT architecture	Focus of each layer	IoT value chain					
		Design equip	Implement and make equip	Repair and sell equip	Service operation and maintenance	Service providing	Solution providing
Perception layer	Sensing	0	0	1*	1*	–	–
Communication layer	Connectivity	**0**	**0**	**1***	**3***	**3■**	**2***
Information process layer	Cloud computing	0	0	0	2*	2■	1*
	Data analytic	0	0	0	0	2*	1*
Application layer		Different IoT Use-cases					

High participation: 3, Medium participation: 2, Low participation: 1, No participation: 0, As a core service: ■, As an Enhancing service: *

before they were only defined for determining the fitness of the current capabilities of ISPs to their identified value creation opportunities in the IoT domain (resulting from summing up the responses to Q2.1). Therefore, they are not related to the investments required, the human resources needed, interests predicted for the identified opportunities.

The results of the interview analysis, according to Table 7, indicates that the participation of ISPs in the form of the six mentioned roles in the IoT ecosystem for creating value in IoT architecture is as follows:

- The current capabilities of ISPs in providing connectivity service (Künsemöller et al. 2013) lead to their high participation (score 3) in the connectivity layer of the IoT architecture in the form of two roles; *connectivity service providing* as a core service (■) and *connectivity service operation & maintenance* as an enhancing service (✱). As a result, there is a great potential to create value in these areas.
- Medium participation (score 2) of ISPs in the IoT ecosystem was considered in the role of *cloud service providing* as a core service (■) and three roles of *connectivity solution providing*, *cloud service operation & maintenance,* and *data analytics service providing* as enhancing services (✱). ISPs have a high degree of participation in providing *technical solutions* to their clients' IoT networks (Score 3). However, in providing *business solutions*, ISPs need access to their customers' IoT network data. They also need to have mastery over their B2B customers' industry and, consequently, consultants from the industry in question. Since ISPs' participation in providing a *business solution* is not high, their participation in *solution providing* is deemed medium (score 2) and is considered in the form of an enhancing service (✱).
- Low participation (score 1) of ISPs in the IoT ecosystem was considered in the roles of *repair and sell IoT equip.*, *repair and sell connectivity equip., perception service operation and maintenance, cloud solution providing, and data analytics solution providing as enhancing services* (✱).

Of course, ISPs' no participation in *design and manufacturing equip*. in the IoT domain is predictable as this value creation method was not in the working scope of ISPs before the emergence of IoT (Altmann 2000; European Commission 2016; GSMA 2016).

Based on the identified value creation opportunities of ISPs in the IoT ecosystem, the next sub-stage focuses on elaborating their value creation ideas in the IoT ecosystem.

4.2.2 Elaborating the ISPs' value creation ideas in the IoT ecosystem

Due to the paucity of reports on ISPs' value creation ideas driven by IoT, for elaborating the mentioned ideas, considering the current capabilities of ISPs in value creation (Hanafizadeh et al. 2019) and their value creation opportunities in the IoT ecosystem (Table 7), experts were asked to answer the following question:

Q2.4 Considering the current capabilities of ISPs and their identified value creation opportunities, what are the best possible ideas for ISPs' value creation in the IoT ecosystem?

Using *interpretative analysis* (Schmidt 2004), after screening out the contents of the interviews, the ISPs' value creation opportunities in the IoT ecosystem were coded. The code sequences are presented in the conclusion. The results of the interviews analysis showed no consensus among experts on providing the best possible ideas for ISPs' value creation in the IoT ecosystem. Therefore, given the iterative nature of the BMI process (Frankenberger et al. 2013) and perhaps the need to repeat the interview process, the interviews in this stage of the BMI process were repeated based on the questions raised to diminish the discrepancies. However, there were still some discrepancies, making it difficult to elaborate on the proposed ideas. Therefore, the *Delphi method* (Hallowell and Gambatese 2010) was used to reach a logical consensus over deciding the results of this stage because, in this case, all requirements for running the *Delphi method*[7] were met. Hence, to elaborate on the best possible ideas for the ISPs' value creation in the IoT domain, the points of disagreement resulting from the interpretive analysis of the interviews were provided to experts in the form of four decision options (Table 8). The experts were asked to choose from among the options and to give reasons for their choices.

It is worth mentioning that fifteen out of 23 available experts participated in this step. At most, ten rounds were specified as the number of rounds. At each round, the experts had to choose only one of the four options, being able to modify their choice

Table 8 The decision options in ISPs' value creation ideas in IoT ecosystem

Decision options	Items of each option
Option A	1. Connectivity S. P. (Service providing) + Connectivity service operation & maintenance 2. Connectivity S. P. + Solution P. + IoT equipment partnership 3. Connectivity S. P. + Cloud S. P. + Technical solution P 4. Connectivity S. P. + Cloud S. P. + Business solution P
Option B	1. Connectivity P 2. Connectivity S. P. + Cloud S. P 3. Connectivity S. P. + Cloud S. P. + Technical solution P
Option C	1. Connectivity S. P. + Technical S. P 2. Connectivity S. P. + Cloud S. P. + Technical solution P 3. Connectivity S. P. + Cloud S. P. + Total (technical + business) solution. P 4. Cloud S. P. + Total (technical + business) solution P
Option D	1. Connectivity S. P. + Equipment partnership 2. Connectivity S. P. + Connectivity service operation & maintenance + Technical solution P 3. Connectivity S. P. + Cloud S. P. + Equipment partnership 4. Connectivity S. P. + Cloud S. P. + Business solution P. + Technical solution P

[7] Required expert judgment, required collective consensus on the results, the existence of complex and interdisciplinary conditions, disagreement on a result, and inadequate knowledge (Beretta 1996; Landeta 2006; McKenna et al. 2002; Powell 2003).

based on the feedbacks and arguments provided by other experts. After seven rounds of discussion, the best possible ideas for ISPs' value creation in the IoT ecosystem were provided as four ideas of choice C as follows:

The first possible idea: *Connectivity S. P. + Technical solution P.*

The second possible idea: *Connectivity S. P. + Technical solution P. + Cloud S. P.*

The third possible idea: *Connectivity S. P. + Technical solution P. + Cloud S. P + Business solution P.*

The fourth possible idea: *Cloud S. P. + Technical solution P. + Business solution P.*

The logic of proposing the four ideas of choice C as the possible ideas for ISPs' value creation in the IoT domain, based on the identified opportunities, is as follows.

The start of ISPs' value creation in the IoT domain was explained based on their key capability, which is connectivity service providing, focusing on the gateway (connectivity S. P. + technical solution P.). In continuation and as a result of providing connectivity service and gaining recognition in the IoT ecosystem, ISPs can move beyond the dumb pipe, as Delloitte (2015) puts it, and focus on providing value-added services. In this regard, the best option is to provide cloud services, in which ISPs also have valuable experiences. Therefore, focusing on providing cloud services, besides focusing on providing gateway, was the second value creation idea for ISPs in the IoT domain. Furthermore, as a result of providing cloud services and enabling the integration and access to their customers' data, ISPs can focus on analyzing the aggregated data related to their customers to provide technical and practical solutions. Thus, focusing on providing business solutions in addition to providing gateway and cloud services was the third idea for ISPs' value creation in the IoT domain. In order to identify all possible ideas for ISPs' value creation, some ISPs may suffice to the existing communication networks to meet the connectivity needs of some IoT domain usecases, instead of investing in building an LPWAN network. For these ISPs, connectivity service providing is not considered an innovative value creation idea in the IoT domain. Their value creation in the IoT domain is defined based on the fourth proposed idea.

To complete the argument and the results presented, it should be noted that by proposing innovative ideas for value creation of WA + FWA providers in the IoT domain, this study aimed to suggest solutions based on their current capabilities to meet the specific needs of the IoT domain.

Based on the four identified ideas, the ISPs' business models driven by IoT is explained in the next stage of the BMI process.

4.3 Integration

This stage of the BMI process focuses on explaining the ISPs' business model influenced by IoT, according to each of the elaborated ideas, in accordance with substages in Table 6 as follows:

4.3.1 Selecting an appropriate ontology in the IoT context

Several studies have been carried out on the appropriate ontologies aimed at describing business models driven by IoT (see Table 3). Reviewing the mentioned studies illustrates that there is no consensus on the most appropriate IoT ontology. In other words, some of the studies (e.g., Chan 2015; Holler et al. 2014; Leminen et al. 2012; Li and Xu 2013; Qin and Yu 2015; Sun et al. 2012; Turber and Smiela 2014) have focused on presenting new ontologies in the field of IoT. Some other studies (e.g., Bucherer and Uckelmann 2011; Dijkman et al. 2015; Fan and Zhou 2011; Ju et al. 2016; Liu and Jia 2010) pointed to the inefficiency of existing ontologies for the following reasons (Ju et al. 2016) and accordingly proposed modifications in some of them (such as Canvas) to make them more suitable to IoT;

- IoT's need to focus on the ecosystem level, not the firm level (Turber and Smiela 2014)
- The need of the IoT ecosystem's nature to collaborate amid the competition with industries (Chan 2015) and to develop a shared value to motivate this type of collaboration (Bilgeri et al. 2015)
- IoT's need to diversify its activities, processes, required resources and create a network of actors (Leminen et al. 2015)
- The possibility of earning money in the IoT domain through a direct or indirect exchange of information as a valuable asset (Bilgeri et al. 2015)

  Also, in one of the studies conducted in this field, the *Value net model* has been introduced as the appropriate ontology for the telecom industry (Qin and Yu 2015); however, this ontology and some other types of ontologies, such as the *MOP model* (Li and Xu 2013), lack the necessary details to account for the IoT technology's key features (Ju et al. 2016). The results of some studies also indicate that the existing ontologies should meet two conditions to be used in the IoT domain as follows: (1) taking into account the ecosystem nature of the IoT (Turber and Smiela 2014) and hence *value creation in* the *IoT ecosystem;* and (2) taking into account *data as a valuable asset* which paves the way for value creation in business (Bilgeri et al. 2015).

  Based on the obtained results, in this research, to elaborate on the ISPs' business model driven by IoT, a well-known existing ontology, Hedman and Kalling's ontology (Hedman and Kalling 2003) was selected for the following reasons:

- There is no consensus about the appropriate ontology specific to IoT, and it is still possible to use existing ontologies.
- In this study, both conditions of using existing ontologies in IoT (Bilgeri et al. 2015; Turber and Smiela 2014) have been considered. In other words, in the ideation stage of the BMI process, the ISPs' value creation opportunities were initially explained *in the IoT ecosystem*. Then, based on the identified opportunities, the possible ideas for the ISPs' value creation were elaborated *in the IoT ecosystem*. Also, *data was considered as a valuable asset* with the ability to generate indirect revenue by incorporating *business solutions providing, based on leveraging their customer data,* in the ISPs' value creation ideas in the field of IoT.

- In addition, Hedman and Kalling's ontology has also been used to explain the current business model of ISPs without IoT (Hanafizadeh et al. 2019). Therefore, its use in this research allows comparing the ISPs' business model changes driven by IoT technology.

To describe the selected ontology, it should be mentioned that Hedman and Kalling (2003) consider the business model at four levels (market, offerings, activity & organization, and resources) and seven related components. These components that initiate with the market level comprise customers, competitors, value proposition, key activities, key resources, key suppliers, and the seventh dimension.

After selecting the appropriate ontology, the ISPs' business model driven by the IoT is explained based on the selected ontology and corresponding to each of the four value creation ideas identified in the ideation stage.

4.3.2 Elaborating the ISPs' business model influenced by IoT in accordance with each of the explained ideas

To elaborate on the ISPs' business model in IoT, initially, their business components influenced by IoT are described based on the secondary data (the fifth class of Table 1) according to Hedman and Kalling's ontology (Table 9).

For elaborating the ISPs' business model influenced by IoT, it is not possible to rely solely on the components described in Table 9 for the following two reasons:

- First, in the secondary data, some business components of the ISPs in the IoT domain, including *competitors*, *communication channels*, *key processes*, *key resources*, and *cost structure,* are addressed generally concerning all industries, rather than specifically for the telecommunications industry.
- Second, in the secondary data, the role of ISPs influenced by IoT in providing connectivity services has merely been pointed out (Burkitt 2014). There is no explicit reference to their role in other layers of the IoT architecture. It is, therefore, unclear whether the components described in the secondary data are exclusively related to the role of ISPs in providing connectivity services in the IoT area or whether another role for the ISPs has been selected but not explicitly addressed. Therefore, there is little reliability regarding the certainty or uncertainty and the adequacy or inadequacy of the components described in Table 9.

Accordingly, to explain the ISPs' business model driven by the IoT, the selected experts were asked to explain the component of the ISPs' business model driven by the IoT according to each of the four ideas presented, based on Hedman and Kaling's ontology.

The number of interview questions (Q3.n) in this stage of the BMI process corresponds to Hedman and Kalling's ontology components for each elaborated idea. The description of the ISPs' business components in the IoT had yielded worthwhile ideas regarding themes and notions coding featured in the interviews. Hence, using *interpretative analysis* (Schmidt 2004), after screening out the contents of the interviews, the codes were defined based on the described ISPs' business components

Table 9 Describing the ISPs' business components in the IoT domain

Level	Components	Findings
Market level	Customers	Customer segment B2B & B2C (Leminen et al. 2012) General Customers, Vertical Market and Global Market (Ju et al. 2016) Customer relationships Customer relationship management techniques in the IoT domain include Co-Creation, Self-Service Communication, and Fast Feedback (Qin and Yu 2015; Turber and Smiela 2014) Channel Service distribution channel or the method of providing the proposed value in the IoT domain are deemed to include the Internet and Mobile (Ju et al. 2016)
	Competitors	Competitors are also members of the business ecosystem[a](Moore and Curry 1996) The type of interaction among ecosystem members in the telecom industry is coopetition, which means cooperation and competition together (Raza-Ullah et al. 2014), and it is the sign of the presence of competitors in the business ecosystem
	Key suppliers	Specialized IoT partners include software providers, data analytics companies, and device manufacturers, who can collaborate and participate in line with given the type of business value proposition (Bucherer and Uckelmann 2011; Dijkman et al. 2015; Li and Xu 2013)
Offering level	Value proposition	Kinds of the value proposition in the IoT domain can be summarized in the concepts including convenience, performance, customization and share (Dijkman et al. 2015; Leminen et al. 2012; Li and Xu 2013; Qin and Yu 2015; Sun et al. 2012) Network providers, including ISPs, focus on providing access to the internet and its integrated services (Burkitt 2014)
	Revenue streams	Revenue streams in the IoT domain can include subscription fees and service usage fees (Bucherer and Uckelmann 2011; Dijkman et al. 2015), as well as profit sharing and product sales (Ju et al. 2016) ISPs' revenue streams, based on the type of value proposition, include user subscription fees, service usage fees, sale of information-based services (Camponovo and Pigneur 2003; Coucheney et al. 2014)
	Cost structure	The overall cost structure for creating value in the IoT domain consists of IT infrastructure cost and maintenance cost (Dijkman et al. 2015; Ju et al. 2016; Li and Xu 2013; Sun et al. 2012)

Table 9 (continued)

Level	Components	Findings
Activity and organization level	Key processes	FAB according to the eTOM (enhanced Telecom Operation Map) framework (Chang 2011) Key processes of the IoT domain include product development, platform development, partners management, big data analysis, integration of platform and resource (Dijkman et al. 2015; Qin and Yu 2015)
	Value configuration	Value Network (Qin and Yu 2015)
	Scope of management	In the field of IoT, both value perception (or value capture) is emphasized in addition to value creation (Westerlund et al. 2014)
	Longitudinal dimension	The ways to accomplish value capture consist of customer entry into the business ecosystem as co-creative (Qin and Yu 2015) as well as providing connected product[b] and hybrid solution (Fleisch et al. 2015)
Resource level	Key resources	RBT theory has been employed to identify key resources of IoT (Bilgeri et al. 2015) Generally, key resources of IoT include sensors, cloud service (software), IoT dedicated network, and business analytics capability (Ju et al. 2016), which can boil down to three components, including software, information and resources required by customers (Bucherer and Uckelmann 2011; Qin and Yu 2015; Sun et al. 2012)

[a] A business ecosystem consists of customers, lead producers, competitors and other stakeholders (Moore and Curry 1996)

[b] The composition of *physical product* and *digital service*

(Table 9). Therefore, four business models based on the four ideas identified in the output of the ideation stage were explained as follows:

To explain the first business model based on the first idea (Fig. 3), the selected experts were asked to suggest all the components of Hedman and Kalling's ontology corresponding to the ISPs' value creation connectivity S. P. and technical solution P. The coding of the answers was extracted from Table 9 and the results were summarized based on the frequency count of the codes.

In explaining the second business model based on the second idea (Fig. 4), the experts were asked to explain all components of Hedman and Kalling's ontology solely based on the ISPs' value creation with regard to cloud service providing; because the second idea is the outcome of ISPs' value creation based on the first idea plus their value creation on the basis of cloud service providing. Therefore, the

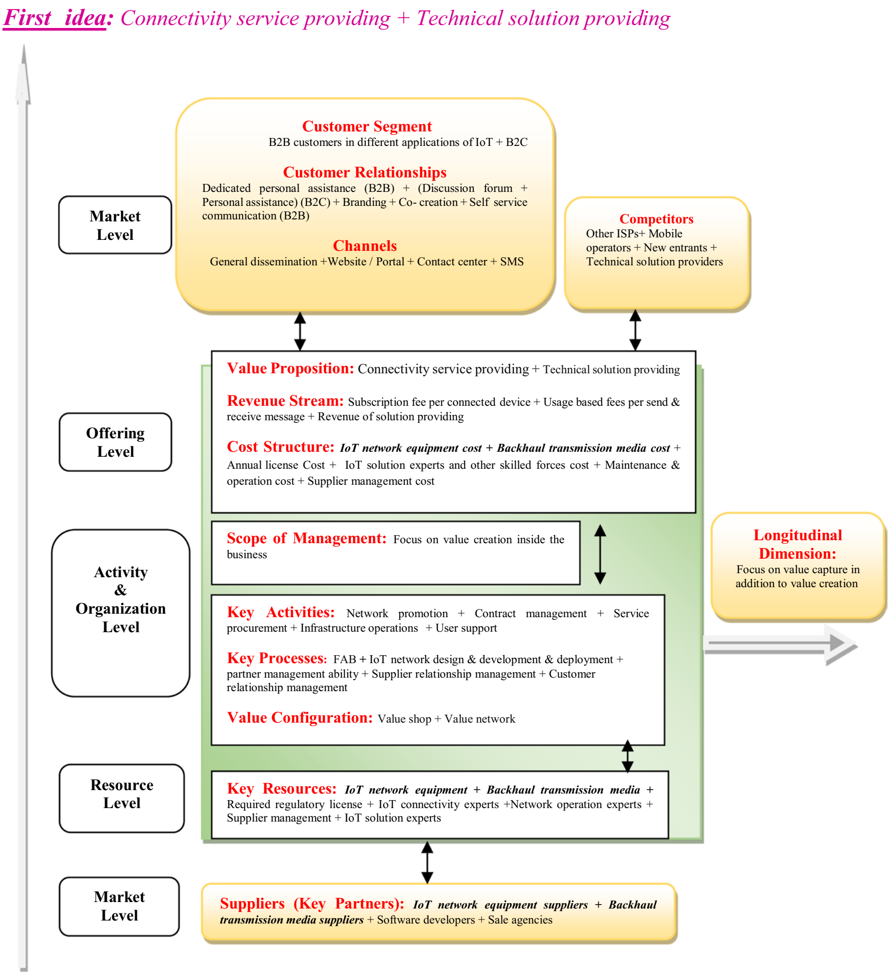

Fig. 3 The first of the proposed business models

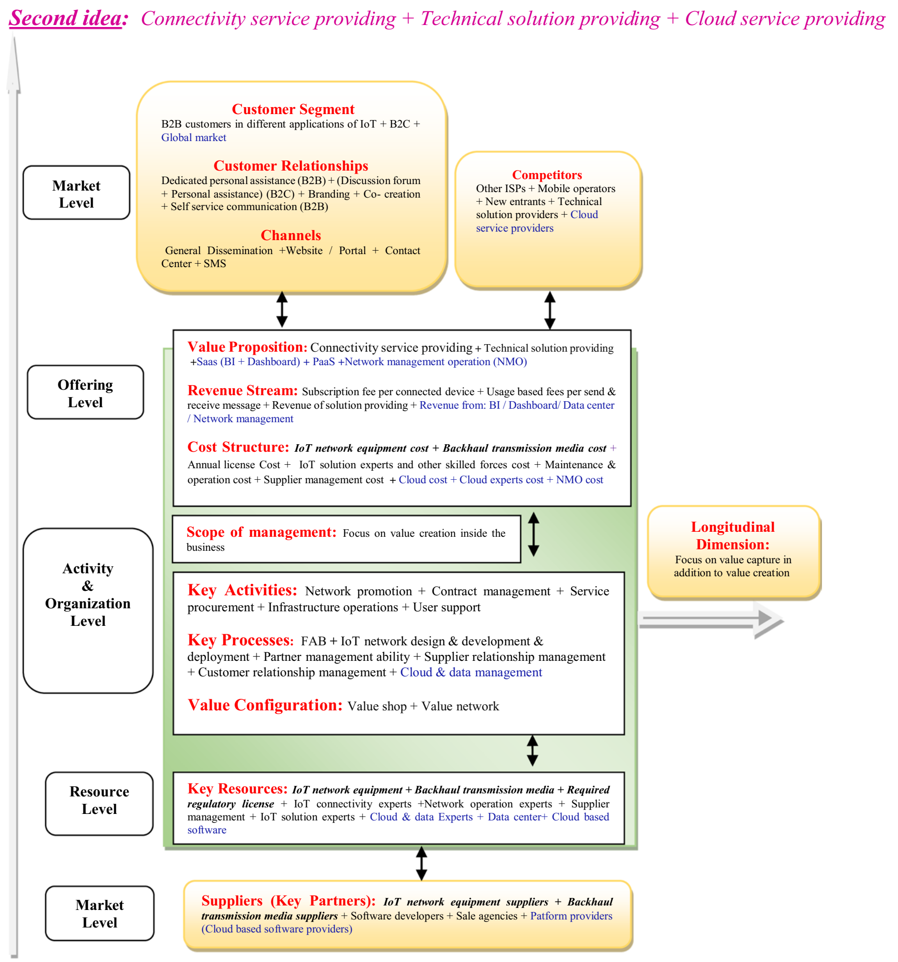

Fig. 4 The second of the proposed business models

explained components in blue were added to the business model components based on the first idea (Fig. 3) to explain the business model based on the second idea, as shown in Fig. 4.

To explain the third business model based on the third idea (Fig. 5), the experts were asked to explain all Hedman and Kalling's ontology components solely based on the ISPs' value creation concerning business solution providing. The reason was that the third idea of ISPs' value creation has been proposed based on the second idea besides their value creation based on business solution providing. Hence, the explained components in green were added to the business model components based on the second idea (Fig. 4) to yield the business model based on the third idea presented in Fig. 5.

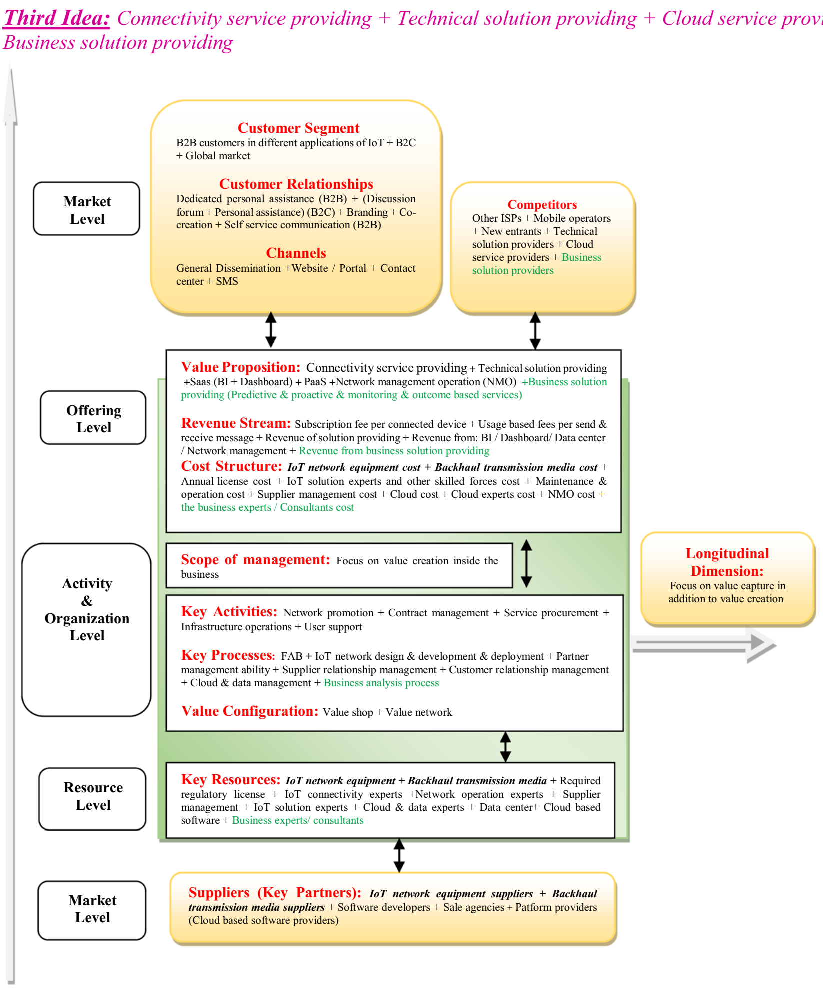

Fig. 5 The third of the proposed business models

In explaining the fourth business model based on the fourth idea (Fig. 6), since the fourth idea was the result of ISPs' value creation based on the third idea excluding their value creation based on connectivity service providing, it was sufficient to remove the components related to ISPs' value creation based on connectivity service providing (explained by the experts in Fig. 3) from the third business model (Fig. 5). Thus, the business model based on the fourth idea was explained as indicated in Fig. 6.

Regarding the four proposed business models, it should be mentioned that the ISPs' value creation in the IoT domain based on the *connectivity service providing* is justified when the ISPs create a distinct network specific to the IoT domain based on appropriate connectivity technologies for this area. For this group of ISPs, the three

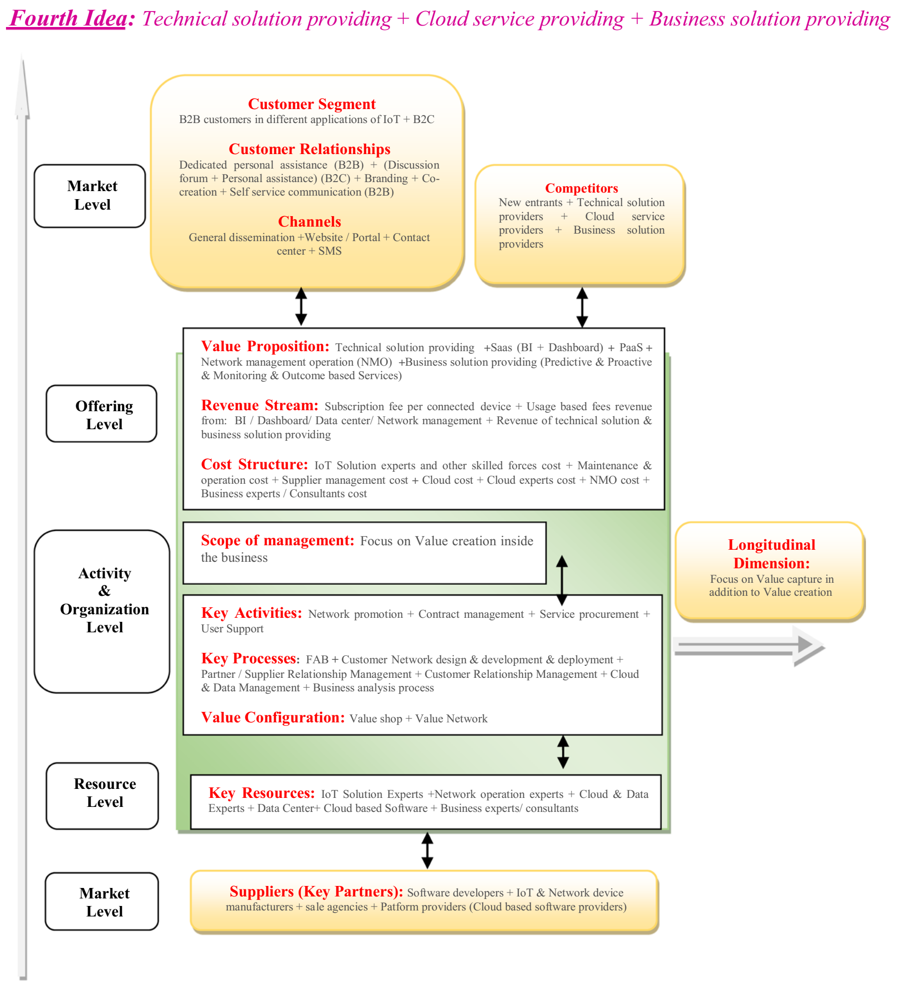

Fig. 6 The fourth of the proposed business models

first ideas and hence, the three first proposed business models (Figs. 3, 4, 5) are applied. When the IoT connectivity requirements can be met by the existing ISPs' network, *connectivity service providing* is not considered as an innovative value creation idea of the ISPs driven by the IoT. In this study, this condition is considered as the fourth idea and the fourth proposed business model (Fig. 6).

4.4 Evaluation

In this stage of the BMI process, to assess the robustness of the proposed business models, i.e., evaluation of the impact of IoT uncertainties on the components of the proposed business models, the STA method, adapted from Haaker et al. (2017), is used in accordance with sub-stages in Table 6 as follows.

4.4.1 Identification of the IoT uncertainties affecting ISPs' business

Uncertainty refers to any change that may be unpredictable due to an absence of adequate information (Janasz 2009). Uncertainties driven by IoT technology, which are an integral part of this technology (Böhle 2011) and complicate the BMI process (Bilgeri and Wortmann 2017; Luchs et al. 2015), can be classified from different perspectives. Haaker et al. (2017) divided the IoT domain's uncertainties into three categories: regulatory-related, technological, and market-related uncertainties. Brad and Murar (2014) reviewed the research related to IoT uncertainties and categorized them into four groups, including technological, sociological, legal, and other uncertainties unrelated to the three mentioned groups. Buntz (2015) also elaborated on ten types of the most important challenges and uncertainties in the IoT domain, ranking them according to their importance, while most were technological in nature.

The research results mentioned earlier show that the IoT uncertainties can be broadly classified into four groups, including *technological*, *social*, *legal,* and *market-related* categories. However, there is no report on the IoT uncertainties effective in the telecommunications industry.

Therefore, to elaborate on the IoT uncertainties effective in ISPs' business in the telecom industry, experts were asked to answer the following questions:

Q4.1 Out of the uncertainties related to the IoT domain, what uncertainties affect the ISPs' business?

Q4.2 What are the expected outcomes for each of the uncertainties elaborated in Q4.1?

Using *interpretative analysis* (Schmidt 2004), after screening out the contents of the interviews, to analyze the responses of Q4.1, the codes were defined based on the uncertainties reported in the three studies mentioned above. To analyze the responses of Q4.2, the codes were defined based on the items outlined as the outcome of each uncertainty elaborated in the analysis of the Q4.1 responses.

Centered on the results obtained through the experts' consensus, IoT uncertainties affecting the ISPs' business along with the anticipated outcomes were pointed out according to Table 10.

According to Table 10, IoT uncertainties affecting ISPs' business can be divided into two general groups, i.e., *technological* and *legal*. Evidently, both types of uncertainties also affect the market domain as they reduce market growth and market size; hence, they can be considered market-related.

After determining the uncertainties affecting ISPs' business in the IoT domain, in the next sub-stage, the impact of these uncertainties on the proposed business models' components (Figs. 3, 4, 5, 6) are elaborated.

Table 10 Types of IoT uncertainties effective in ISPs' business

Uncertainty	Domain	Outcome
Security and privacy	Technology	Limited interest Reducing market size Reducing market growth
Immature technology	Technology	Increasing the implementation and operation cost Reducing the numbers of customers and consequently, market size Posing a threat to the feasibility of the proposed business models
Interoperability	Technology	Increasing the implementation and operation cost Focusing solely on specific products which have their standard Tardiness in product development
Regulation license	Legal	Limitation for offering the required license to ISPs, for providing connectivity services in IoT domain increasing license fee, which leads to reducing new entrants, competition, and market growth

4.4.2 Map the proposed business model components to the uncertainties and create a heat map[8]

Elaborating the impact of the selected uncertainties, based on their perceived outcome, on the components of the four ISPs' business models in the IoT ecosystem (Figs. 3, 4, 5, 6), experts were asked to answer the following question:

Q4.3 What is the impact of each of the selected uncertainties given their expected outcomes on each component of the ISPs' business models (Figs. 3, 4, 5, 6) based on Hedman and Kalling's ontology?

To answer Q4.3, experts were asked to fill in Tables 11, 12, 13 and 14 cells with four codes 3, 2, 1, and 0 corresponding to red, yellow, green, and grey, which are defined respectively as high negative impact, low negative impact, positive impact, and no impact.

The results were summed up by counting the codes in each of the cells in Tables 11, 12, 13 and 14, which indicates the extent to which each ISPs' business component is affected by each uncertainty.

4.4.3 Analysis of the results

The STA implementation results (according to Tables 11, 12, 13, 14) are as follows;

- None of the four uncertainties affecting ISPs' business influence the robustness of the components of key processes, key resources, key suppliers, the scope of management, customer segment, competitors type, customer relationship, chan-

[8] a representation of data in the form of a map in which data values are represented as colours.

Table 11 The impact of the selected uncertainties on the components of the first of the proposed business models

Business model components		Selected uncertainties			
		Security and privacy	Immature technology	Interoperability	Regulation license
Market level	Customers	Reducing *market size*	Reducing *market size*	Reducing *market size*	Reducing growth rate
	Competitors	Reducing *market growth* and consequently, reducing *new entrants* and *competition*	Reducing *market growth* and consequently, reducing *new entrants* and *competition*	Increasing *competition* as a result of decreasing *coopetition*	Reducing *new entrants* and *competition* as a result of increasing entrance barriers
	Key suppliers				
Offering level	Value proposition	Connectivity service providing + Technical solution providing			
	Cost structure	Increasing *cost* as a result of performing specific measures to harness this uncertainty	Increasing the *cost*	Increasing the *cost*	Increasing the *cost* due to getting a license
	Revenue streams	Reducing the amount of *revenue*	Reducing the amount of *revenue*	Reducing the amount of *revenue*	Reducing the amount of *revenue*
Organization level	Key processes				
	Value configuration				
	Scope of management				
Resource level	Key resources				
7th component		Reducing *value capture*	Reducing *value capture*		

nels, cost structure type, revenue streams type, and value configuration of the four proposed business models.

- All four uncertainties will increase the costs and thus reduce the profits in the first three proposed business models (Figs. 3, 4, 5). Therefore, they can be considered a threat to the economic justification of these models. Regarding the fourth proposed business model corresponding to the fourth idea of value creation of ISPs driven by IoT, it should be noted that due to the failure to consider connectivity service providing in the mentioned idea, regulation license uncertainty will not have any impact on any of the components of the fourth proposed business model.

Table 12 The impact of the selected uncertainties on the components of the second of the proposed business models

Business model components		Selected uncertainties			
		Security and privacy	Immature technology	Interoperability	Regulation license
Market level	Customers	Reducing *market size*	Reducing *market size*	Reducing *market size*	Reducing growth rate
	Competitors	Reducing *market growth* and consequently, reducing *new entrants* and *competition*	Reducing *market growth* and consequently, reducing *new entrants* and *competition*	Increasing *competition* as a result of decreasing *coopetition*	Reducing *new entrants* and *competition* as a result of increasing entrance barriers
	Key suppliers				
Offering level	Value proposition	Connectivity service providing + Technical solution providing + Cloud service providing			
	Cost structure	Increasing *cost* as a result of performing specific measures in order to harness this uncertainty	Increasing the *cost*	Increasing the *cost*	Increasing the *cost* due to getting a license
	Revenue streams	Reducing the amount of *revenue*	Reducing the amount of *revenue*	Reducing the amount of *revenue*	Reducing the amount of *revenue*
Organization level	Key processes				
	Value configuration				
	Scope of management				
Resource level	Key resources				
7th component		Reducing *value capture*	Reducing *value capture*		

- Two uncertainties, security/privacy and immaturity, lead to a fall in customer perception of value, which in turn can affect the number of customers and the amount of revenue generated.
- The results of Tables 11, 12, 13 and 14 regarding the impact of four uncertainties on the value proposition component of the four proposed business models show that the greatest impact of these four uncertainties is conceivable on the value creation of ISPs based on *connectivity service providing* and then on *cloud service providing*. However, these four uncertainties have little effect on *technical solution providing* and *business solution providing*, which have a consulting nature. Based on the result, proposing connectivity S. P. and cloud S. P. seems infeasible at first glance, but on the one hand, the uncertainties raised are prob-

Table 13 The impact of the selected uncertainties on the components of the third of the proposed business models

Business model components		Selected uncertainties			
		Security and privacy	Immature technology	Interoperability	Regulation license
Market level	Customers	Reducing *market size*	Reducing *market size*	Reducing *market size*	Reducing growth rate
	Competitors	Reducing *market growth* and consequently, reducing *new entrants* and *competition*	Reducing *market growth* and consequently, reducing *new entrants* and *competition*	Increasing *competition* as a result of decreasing *coopetition*	Reducing *new entrants* and *competition* as a result of increasing entrance barriers
	Key suppliers				
Offering level	Value proposition	Connectivity service providing + Technical solution providing + Cloud service providing + Business solution providing			
	Cost structure	Increasing *cost* as a result of performing specific measures in order to harness this uncertainty	Increasing the *cost*	Increasing the *cost*	Increasing the *cost* due to getting a license
	Revenue streams	Reducing the amount of *revenue*	Reducing the amount of *revenue*	Reducing the amount of *revenue*	Reducing the amount of *revenue*
Organization level	Key processes				
	Value configuration				
	Scope of management				
Resource level	Key resources				
7th component		Reducing *value capture*	Reducing *value capture*		

able in nature, so their occurrence is not certain. On the other hand, connectivity S. P. and cloud S.P., according to three sources (Altmann 2000; European Commission 2016; GSMA 2016), are among the capabilities of ISPs; hence, ISPs are expected to be interested in using these capabilities in the field of IoT.

5 Discussion

Drawing on the research done by Frankenberger et al. (2013), this study used a four-stage BMI process to innovate the business model of ISPs driven by IoT. After implementing the three initial stages of the BMI process, four ISPs' business models

Table 14 The impact of the selected uncertainties on the components of the fourth of the proposed business models

Business model components		Selected uncertainties			
		Security and privacy	Immature technology	Interoperability	Regulation license
Market level	Customers	Reducing *market size*	Reducing *market size*	Reducing *market size*	
	Competitors	Reducing *market growth* and consequently, reducing *new entrants* and *competition*	Reducing *market growth* and consequently, reducing *new entrants* and *competition*	Increasing *competition* as a result of decreasing *coopetition*	
	Key suppliers				
Offering level	Value proposition	Technical solution providing + Cloud service providing Business solution providing			
	Cost structure	Increasing *cost* as a result of performing specific measures in order to harness this uncertainty	Increasing the *cost*	Increasing the *cost*	
	Revenue streams	Reducing the amount of *revenue*	Reducing the amount of *revenue*	Reducing the amount of *revenue*	
Organization level	Key processes				
	Value configuration				
	Scope of management				
Resource level	Key resources				
7th component		Reducing *value capture*	Reducing *value capture*		

related to the four ISPs' value creation ideas driven by the IoT were proposed. In the final stage of the BMI process, STA was used to determine the robustness of the proposed business model components drawing on Haaker et al. (2017).

Summarizing the results of STA showed that the greatest impact of the four uncertainties, affecting the ISPs' business in the IoT domain, is conceivable on value creation of ISPs driven by IoT based on *connectivity service providing* and *cloud service providing*. This undermines the justification of ISPs' value creation based on the two mentioned methods, which are part of the capabilities of today's ISPs. ISPs are also interested in using these two capabilities in the IoT domain. Evidence of this claim is the IoT solutions of the four largest ISPs in the world, which despite the mentioned uncertainties, have addressed value creation based on *connectivity service providing* and *cloud service providing* in the IoT domain, according to Table 15.

Table 15 Parts of IoT solutions of the world's four well-known ISPs

ISP's name	IoT solutions
Verizon	IoT connectivity service based on LPWAN https://opendevelopment.verizonwireless.com/content/dam/opendevelopment/pdf/news/11039964_SB_NB_IoT_tdciv.pdf Cloud service as IoT platform https://www.verizonwireless.com/support/verizon-cloud
Orange	IoT connectivity service https://www.orange-business.com/en/products/iot-managed-global-connectivity Cloud service included IoT platform https://www.orange-business.com/en/blogs/cloud-service-included-how-kerlink-successfully-deployed-iot-platform-avoiding-vendor-lock
Telefonica	Partnership in IoT network connectivity https://www.telefonica.com/en/web/press-office/-/telefonica-and-schindler-join-forces-to-provide-iot-connectivity-for-elevators-and-escalators-worldwide Join to the main IoT cloud providers https://iot.telefonica.com/en/search/q=IoT+cloud+provider
AT&T	Providing IoT connectivity service based on LTE-M and LPWAN https://www.business.att.com/categories/iot-networks.html Establishing IoT platform https://iotplatform.att.com

Nevertheless, to increase the validity of the ISPs'value creation based on the two mentioned methods, in the following, more evidence is presented about the validation of ISPs' value creation based on, first, *connectivity service providing,* and then, *cloud service providing*. Furthermore, the impact of IoT technology on the ISPs' business components is explained at the end of this section.

5.1 Validation of ISPs' value creation in the IoT domain based on *connectivity service providing*

More evidence about the value creation of ISPs (WA + FWA providers) based on connectivity service providing in the IoT domain is presented in this sub-section.

- According to Deloitte (2018) report,[9] there is no single version to meet the connectivity needs of IoT applications and related use-cases. Instead, different connectivity solutions from three types of WA, FWA and MWA are needed in accordance with specific features of each IoT use-cases such as required battery life, data rates, latency, mobility, range, and network cost.

[9] As well as Deloitte (2015) report.

- According to ITU (2016a) report based on Machina Research experts' predictions in 2015,[10] MWA technologies will provide only 50% of the connectivity required by the IoT domain by 2025. Therefore, WA + FWA providers play an important role in meeting the remaining 50% of the connectivity needed by this area.
- According to another report by ITU (2016b), connectivity service providers (e.g., ISPs) are a part of the IoT value chain, and their presence in this value chain is essential. In other words, to provide the connectivity needed by 90% of the rural population, 50% of home customers in developing countries, and 15% of home customers in developed countries to enter into the IoT domain, a vast range of WA, FWA and MWA technologies are required.
- Due to the four valuable characteristics of LPWAN technologies, including; low power consumption, low bit rate, long range, and low cost, they are considered a leading technology (Rebbeck et al. 2014), an ideal alternative (Queralta et al. 2019), and unique solution for meeting connectivity of the IoT domain (Naik 2018). Since, at present, only 20% of the world population is covered by LPWAN technologies, promotion and improvement of the IoT networks' connectivity infrastructure is still growing and is considered a good opportunity for value creation in this area (McKinsey 2018a). In this respect, Machina Research has predicted that by 2022 the number of LPWAN connections will reach 1.4 billion (GSMA 2017) and outnumber the connections related to 2G, 3G, and 4G technologies. Therefore, considering the ISPs' capability to create LPWAN technologies-based networks, their value creation based on *connectivity service providing* is logical and growing according to the mentioned research.

The evidence presented points to the fact that the IoT domain's connectivity requires ISPs' connectivity service providing based on WA and FWA technologies (scope of ISPs in this study), particularly LPWAN technologies.

To enhance the obtained results, in the rest of this sub-section, the value creation of WA + FWA providers based on *connectivity service providing* in the IoT domain is materialized.

According to McKinsey (2018a), the value creation of every business in each of the IoT usecases depends upon understanding the needs of that IoT usecase and adapting the business capabilities to meet those usecases needs. In this respect, the value creation of ISPs to provide IoT usecases connectivity solutions requires understanding the capability of ISPs in providing different connectivity solutions, identifying the connectivity needs of the IoT usecases, and mapping the capabilities with the identified needs.

To gain an understanding of the ISPs' capabilities in providing connectivity solutions and the advantages and limitations of their connectivity solutions in comparison to other connectivity solutions, the characteristics of different connectivity

[10] Source: IoT Global Forecast & Analysis 2015–2025, Machina Research, August 2016. Excludes consumer audio-visual applications).

solutions applicable in the IoT domain, based on the studies on IoT enabler technologies (third class of Table 1), are presented as follows.

- Connectivity solutions based on the *cellular network*: The advantages of the technologies in this group, such as 2G, 3G, and 4G LTE(Long Term Evolution), include high bandwidth, broad coverage, high availability, and high reliability. However, two features of these technologies, namely the high cost and high power consumption, have caused them not to be considered ideal choices for providing connectivity in the IoT domain (McKinsey 2018a). The newly emerging technology of this group, 5G, despite advantages like energy efficiency (Zhang et al. 2016), high data exchange speed, low delay, broad coverage, and high reliability (Li et al. 2018), is faced with numerous challenges, e.g., scalability (Modieginyane et al. 2018; Ndiaye et al. 2017), interoperability (Elkhodr et al. 2016; Ishaq et al. 2013), security and privacy (Girson 2017), and lack of compatibility (Li et al. 2018).
- Connectivity solutions based on LPWAN technologies: The technologies of this group, like Sigfox, LoRaWAN (Long Range Wide Area Network), NB-IoT(Narrow Band Internet of Things) (Mermer and Zeydan 2017; Sinha et al. 2017), are used extensively due to the characteristics including; long transmission ranges[11] (Centenaro et al. 2016), low energy consumption[12] (Patel and Won 2017), low-cost deployment[13] (Raza et al. 2017) and the capability to transmit a few tiny messages per day in a long radio range specific to the IoT network (Mekki et al. 2018).
- Connectivity solutions based on other connectivity technologies are; (1) Unlicensed short-range connectivity, i.e., BLE (Bluetooth Low Energy), Z-Wave, Zigbee, and Wi-Fi which is not possible due to the failure to meet the long transmission range need of the IoT applications (Mekki et al. 2018), (2) Extraterrestrial-based connectivity solutions, including satellite and other microwave technologies, with low-to-medium bandwidth, high range, and medium-to-high reliability and availability features. The high cost of this group of technologies has led to their niche role in providing the connectivity required by the IoT domain. They are solely used when there is no access to cellular and fiber networks (McKinsey 2018a), and (3) Deep fiber solution[14] which is mostly used in the backhaul section of the network (not the last mile). Its advantages are reliability and robustness, ease of installation, ability to connect to existing infrastructure, and efficient use of space. Hence, according to the two different reports of Deloitte (2017a, b), deep fiber development (in the backhaul section of the network) is a prerequisite for 5G development. The development of 5G, as an IoT enabler, will further the growth and maturity of IoT technology; therefore, deep fiber development directly leads to the development of 5G and indirectly

[11] Up to 40 km in rural and up to 10 KM in urban areas.

[12] Maximum battery life of 10 years.

[13] Less than 5 dollars for each device and less than 1 dollar for an annual subscription of each device.

[14] Means using fibre infrastructure close to the end customers; it doesn't mean deploying fibre deeply.

increases IoT's growth and maturity. Accordingly, in the US and developed countries, the focus on developing deep fiber solution has been doubled.

The three groups of unlicensed short-range connectivity, LPWAN connectivity, and deep fiber connectivity solutions are related to the scope of ISPs in this study from among the connectivity solution groups discussed. Therefore, the ISPs' capability to provide connectivity solutions is in line with the technological characteristics of these three solutions.

Due to the general requirements of IoT use-cases, i.e., long communication range, very low energy consumption (extended battery life), and cost-effectiveness (Mekki et al. 2018; Naik 2017; Naik et al. 2016; Naik and Jenkins 2016), it can be concluded that simultaneous coverage of all the mentioned requirements is only possible by LPWAN and 5G technologies (McKinsey 2018a). Since extensive access to 5G technology is not possible by 2023 (McKinsey 2018a), the annual economic interests projected for the IoT[15] require that investments in this area are not postponed to the extensive use of 5G (McKinsey 2018a). In this situation, the best alternative to meet the needs of IoT usecases is using LPWAN Technologies. It is expected that by 2022, most IoT applications use LPWAN-based connectivity solutions (McKinsey 2018a).

The obtained results point to the high capabilities of LPWAN technologies in meeting the connectivity needs of the IoT. This refers to the high capability of the ISPs in meeting the connectivity requirements of this area. Hence, it can be argued that there are ample value creation opportunities in this area for the ISPs. Although LPWAN technologies are regarded as proper alternatives for meeting the connectivity needs of the IoT usecases, not all LPWAN technologies, including LoRaWAN, SigFox, and NBIoT, are appropriate for different IoT usecases; because each type of LPWAN technologies is different in eight aspects, namely quality of service, battery life, latency, scalability, payload length, range, deployment model, and cost (Mekki et al. 2018a). Therefore, to describe the appropriate IoT usecases of each of the three LPWAN technologies more accurately, these eight aspects are compared in Table 16.

After describing the characteristics of each LPWAN technology, this study focuses on identifying the specialized requirements of each IoT use-cases. Identification of each IoT usecase's specialized requirements depends upon the mastery of all usecases in the IoT domain. In the statistics provided by IoT Analytics (2018), obtained from the analysis of 1600 real IoT projects, top ten usecases[16] were introduced that have been investigated in this study for identifying the requirements of IoT usecases. Obviously, for meeting the connectivity requirements of some of them, including *connected cars*, *smart supply chain,* and *smart health* high range of mobility is required; hence their connectivity requirements will not be met by WA + FWA providers.

[15] $3.9 trillion to $11.1 trillion by 2025.

[16] Including; *Smart city*, *Connected industry*, *Connected buildings*, *Connected car*, *Smart energy*, *Connected health*, *Smart supply chain*, *Smart agriculture*, *Smart retail* and others.

Table 16 Describing the characteristics of LPWAN technologies

	SigFox	LoRaWAN	NBIoT	Optimal technology
Quality of service (Mekki et al. 2018)	License-free sub-GHz bands, hence low QoS	License-free sub-GHz bands, hence low QoS	Licensed spectrum and LTE-based synchronous protocol optimal for QoS	NBIoT
Battery life (Oh and Shin 2016)	End-devices are in sleep mode, which reduces the amount of consumed energy; Battery life is high	End-devices are in sleep mode, which reduces the amount of consumed energy; Battery life is high	End-devices are in sleep mode, but synchronous communication and QoS handling consumes additional energy	SigFoX and LoRa
Latency (Mekki et al. 2018)	–	Class C of LoRa has low latency connectivity	Low latency connectivity	NBIoT and Class c of LoRa
Scalability (Mikhaylov et al. 2016)	High scalability	High scalability	Very high scalability	NBIoT and then, LoRa
Payload length (Mekki et al. 2018)	Data transmission up to 12 bytes	Data transmission up to 243 bytes	Data transmission up to 1600 bytes	NBIoT
Range (Sinha et al. 2017)	At least 40 km	At most 20 km	At most 10 km	SigFox
Deployment model (Mekki et al. 2018)	Public network operation	Public network operation + Local network deployment	Public network operation	LoRa
Cost (Mekki et al. 2018)	Low cost	Low cost	Higher cost than SigFox & LoRa	SigFox and LoRa

In order to accurately determine the type of LPWAN technology appropriate for each of the remained applications, the identified specific requirements of these applications were mapped with the capabilities of each of the three LPWAN technologies according to Table 17. So, Table 17 shows the position of using each of the three LPWAN technologies in the IoT use-cases.

As mentioned before, the scope of ISPs in this study is WA + FWA providers. Accordingly, as setting up two networks based on SigFox and LoRaWAN, which are based on *base station*, is the specialty of the ISPs in this study, setting up a network based on NBIoT technology, due to its dependence on LTE infrastructure, is not within the scope of the ISPs of this research and is considered a subset of cellular technologies (Mekki et al. 2018) and the specialty of MNOs.

Hence according to Table 17, value creation of the ISPs in the scope of this research, based on connectivity service providing, is only possible through creating a specific network of IoT based on each of the two SigFox and LoRaWAN technologies in IoT use-cases of *smart agriculture*, *asset tracking and status monitoring*, *pallet tracking for logistics*, *smart building*, and *smart cities*.

It should be mentioned that LPWAN technologies, like other technologies, have a life cycle and gradually lose their freshness, become saturated, and may be replaced by new technologies. However, according to two different reports published by McKinsey (2018a, b), connectivity providing based on LPWAN technology not only is a growing field in itself, but its growth leads to the growth of IoT technology. Therefore, value creation based on this method can be a good option to maintain and develop the business and income attractiveness of WA + FWA providers in the IoT domain. The two reports revolved around the following issues:

- The expected market share of the telecom industry in the field of IoT by 2025 (McKinsey 2018b)[17] and the role of providing connectivity required by IoT in the growth of this technology.[18]
- High capabilities of LPWAN technologies in simultaneously covering all connectivity requirements of the IoT domain,[19] alignment of the IoT growth with LPWAN Tech growth[20] and growing coverage of LPWAN technologies (McKinsey 2018a).[21]

At the end of this subsection, it should be noted that among all components related to the value creation of ISPs based on *connectivity service providing* in the first three proposed business models (Figs. 3, 4, 5), the type of technology used is effective on only three components: *key resources*, *cost structure,* and *key suppliers*. According to the suggestion of the selected experts, these three components were

[17] Total available market for IoT technology by 2025 in Telecom industry could be up to 55 $B.

[18] The IoT is also benefiting from infrastructure improvements that have enhanced connectivity.

[19] LPWAN fills an unmet need in IoT connectivity.

[20] IoT grows in tandem with LPWA.

[21] By 2022, we expect that most IoT applications will use LPWA networks.

Table 17 Mapping between the LPWAN technologies and the selected IoT applications

Selected IoT applications	The requirements of selected IoT applications	LPWAN technologies characteristics	Mapping result
1. Smart energy (Smart metering) (Andreadou et al. 2016; McLoughlin et al. 2015)	Frequent communication Low latency High data rate No need for low energy consumption neither long battery lifetime	Comparing with the charctristics in Table 16	Best choice: NBIoT
2. Smart agriculture (Charania and Li 2020; Queralta et al. 2019)	Long battery life of sensors devices Update sensed data a few times per hour *Most farms don't access to LTE cellular infrastructure		Best choice: SigFox + LoRa
3. Connected industry (Lubrano et al. 2020; Mekki et al. 2018, 2019; Patel and Won 2017; Queralta et al. 2019)	3–1 Manufacturing automation segment requires (Mekki et al. 2018; Morel et al. 2019): Real-time machinery monitoring, so frequent communication High quality of service		Best choice: NBIoT
	3–2 Asset tracking and status monitoring require (Lubrano et al. 2020; Queralta et al. 2019): Low-cost sensors Long battery lifetime High network control		Best choice: SigFox + LoRa
	3–3 Pallet tracking for logistics requires (Mekki et al. 2019; Patel and Won 2017): Low device cost Battery lifetime Reliable mobile communication *Most stations don't access to LTE cellular infrastructure		Best choice: SigFox + LoRa
4. Smart building (Havard et al. 2018; Nanni et al. 2017)	Low cost Long battery lifetime No need for high-quality service or frequent communication		Best choice: SigFox + LoRa
5. Smart retail (Retail point of sales terminals) (Adapa et al. 2020; Saarikko et al. 2017)	Guaranteed quality of service No constraint on battery lifetime (have a continuous electrical power source) A strong requirement of low latency		Best choice: NBIoT
6. Urban areas and smart cities (Ismagilova et al. 2019; Queralta et al. 2019)	Power efficiency Ease of deployment Scalability		Best choice: SigFox + LoRa

explained in general and regardless of the type of technology used so that the three business models can be used for all industry level ISPs (with the same capabilities as ISPs in this study, even with different technological focus). At this stage of the research, based on the results of materializing the value creation of ISPs based on *connectivity service providing* in the IoT domain, the three components can be explained in more detail in the instance level (the usecase level of the IoT domain) according to Table 18.

5.2 Validation of ISPs' value creation in the IoT domain based on cloud service providing

In this subsection, more evidence for the value creation of ISPs based on *cloud service providing* in the IoT domain is presented.

- Accenture's (2019) report states that the logical solution of Telcos(Telecom companies) for the optimal use of IoT technology-based opportunities is that they first focus on their key capability, connectivity service providing, and then, being

Table 18 Explaining the details of the three components of ISPs BM based on connectivity service providing

	Key resources	Cost structure	Key suppliers
SigFox	IoT network equipment (SigFox base stations + End devices) Required spectrum license (Spectrum license free) Backhaul transmission media IoT connectivity experts Network operation experts Supplier management	IoT network equipment cost (SigFox base station & end devices cost + Deployment cost per SigFox base station) Annual spectrum license cost (Spectrum license free) Backhaul transmission media IoT solution experts and other skilled forces cost Maintenance and operation cost Supplier management cost	IoT network equipment suppliers (SigFox base station and end devices suppliers) Backhaul transmission media suppliers Software developer Sale agencies
LoRaWAN	IoT network equipment (LoRa base stations + End devices) Required spectrum license (Spectrum license free) Backhaul transmission media IoT connectivity experts Network operation experts Supplier management	IoT network equipment cost (LoRa base station & end devices cost + Deployment cost per LoRa base station) Annual spectrum license cost (Spectrum license free) IoT solution experts and other skilled forces cost Maintenance and operation cost Supplier management cost	IoT network equipment suppliers (LoRa base station and end devices suppliers) Backhaul transmission media suppliers Software developer Sale agencies

known in an ecosystem of partners, use their existing infrastructures for delivering cloud computing services with low latency and high quality of service in the IoT domain -alone or in partnership with platform players. Then, they can focus on offering value-added services based on data analytics in the IoT domain.
- According to Deloitte's (2015) report, the complete realization of IoT-based opportunities depends on the value creation of businesses based on the information about their products and services' performance. In this regard, there are valuable opportunities for connectivity service providers (such as ISPs); instead of focusing solely on connectivity service providing for creating and communicating information, they can focus on *cloud service providing* for aggregating and analyzing information through a partnership or acquiring platform providers.
- Based on ITU's (2018) report, two value creation methods in the IoT ecosystem are 1) network providing and 2) network providing and platform providing together. Value creation based on the second method becomes possible through a partnership with platform providers or acquiring them.

The evidence presented from accredited sources like Accenture, Deloitte, and ITU points to the validity of value creation of ISPs in the IoT ecosystem based on *cloud service providing* after focusing on their key capability, *connectivity service providing*.

5.3 Elaborating on the impact of IoT on the ISPs' business models components

In order to elaborate on the impact of IoT on the ISPs' business model components, this sub-section focuses on comparing the ISPs' business model components driven by IoT in this study and the current ISPs' business model components (Hanafizadeh et al. 2019). Obviously, the accumulation of reliable results hinges on choosing the same scope of focus in the two types of business models in question. Due to the focus area of Hanafizadeh et al. (2019) in elaborating on the current business model of ISPs, i.e., *connectivity service providing*, among the four business models driven by IoT (see Figs. 3, 4, 5, 6), only the first three proposed models related to the value creation of ISPs in the IoT domain based on *connectivity service providing* were addressed. According to the explanations given in the integration stage of the BMI process, the components of each of the three mentioned models were explained in the same way based on *connectivity service providing*.

Therefore, to explain the impact of IoT on ISPs' business model components in the specified scope, the components of the three proposed business models based on *connectivity service providing* (Figs. 3, 4, 5) were recorded in the middle column of Table 19 (second column). The components of the current business model of ISPs based on Hanafizadeh et al. (2019) were recorded in the third column of Table 19. Peer-to-peer comparison between the components was performed based on Hedman and Kalling's ontology.

As shown by Table 19, the impact of IoT technology on the components of ISPs' business model can be explained as follows:

Table 19 The comparison between the components of the current business model of ISPs (Hanafizadeh et al. 2019) and IoT driven ISPs' business model

Business model components		The components of IoT driven ISPs BM	The components of current ISPs BM
Market level	Customers	B2C (End users) B2B	B2C (End users) B2B (Network operators + other ISPs)
	Competitors	Other ISPs Mobile operators New entrants	Other ISPs Mobile operators New entrants
	Key suppliers	IoT network equipment suppliers Backhaul transmission media suppliers Software developer Sale agencies	Equipment suppliers Infrastructure Suppliers Application suppliers Sales agencies *Network operators* *Content providers*
Offering level	Value proposition	Connectivity service providing in IoT domain	Broadband internet access
	Revenue streams	Subscription fee per connected device Usage-based fees per send & receive a message	Subscription fee Traffic volume selling (Pay per use) *Flat rate* *Traffic agreement with other ISPs*
	Cost structure	IoT network equipment cost Annual spectrum license cost Backhaul transmission media cost IoT skilled forces cost *Maintenance & operation cost* *Supplier management cost*	Network equipment cost Annual license cost Transmission media cost Skilled forces

Table 19 (continued)

Business model components		The components of IoT driven ISPs BM	The components of current ISPs BM
Activity and organization level	Key processes	FAB IoT network design and development and deployment Partner management ability Supplier relationship management Customer relationship management	FAB
	Value configuration	Value shop + value network	Value shop + value network
	Scope of management	Focus on value creation and business components configuration surveillance	Focus on value creation and business components configuration surveillance
Resource level	Key resources	IoT network equipment Backhaul transmission media IoT and network skilled forces Required spectrum license	Network equipment Transmission media IP skilled forces Required license
7th component		Value capture surveillance	Value capture surveillance

- IoT Technology will not change the following components of ISPs' business model driven by IoT: *customer segment*, *competitors*, *value configuration*, the *scope of management*, *longitudinal dimension,* and *value proposition*; it is noteworthy that despite the same scope selection, in the ISPs' business model driven by IoT, connectivity service providing between things is focused upon.
- The key processes component of ISPs' business model driven by IoT also requires other items such as *IoT network design, development and deployment*, *partner management capability*, *supplier relationship management*, *customer relationship management*, and the *key processes* of the current business model, *FAB processes*.
- The *maintenance and operation cost* items, as an enhancing service, are added to the cost structure component of the ISPs' business model driven by IoT in addition to the items in the current business model.
- Usually, the two items of flat rate and traffic agreement with other ISPs incorporated in the current business model will not be considered in the revenue stream component of the business model of ISPs driven by IoT.
- The types of items characterized in the key resource component are the same in the two current and innovated business models. The sheer difference is related to the nature of the equipment required by the business model driven by IoT, specific to IoT technology.
- Regarding the comparison of the key suppliers' component across the two current and business models driven by IoT, it is noteworthy that, in the innovated business model, in addition to providing communication service, operation and maintenance of the customer network are also offered as an enhancing service, so there is usually no need for the partnership of network operators and content providers.

6 Conclusion

The purpose of this study was to explain the new logic of ISPs (WA+FWA providers) under the influence of IoT technology to elaborate on their value creation in the IoT domain. To this aim, we first focused on identifying the value creation method of ISPs in the IoT domain. Accordingly, based on the research in IoT, various value creation methods in the IoT domain were identified in the form of NPD and BMI (Cortimiglia et al. 2016; Fleisch et al. 2015). As a result of comparing the two methods, it was found that not only is BMI operating profit margin growth more than five times the NPD, but also BMI is a driver of competitive advantage in business (McGrath 2010; Teece 2010), while the NPD does not necessarily lead to sustainable competitive advantage (Pohle and Chapman 2006). Therefore, in this study, to elaborate on the value creation of ISPs in the IoT domain, was focused on BMI implementation driven by IoT in the ISPs' business context. To this aim, among the various procedures of BMI implementation, this study focused on the implementation of a four-step process of BMI based on Frankenberger et al.'s (2013) study. Due to the importance of evaluation of the proposed business model(s) as a part of the BMI process, in enhancing their credibility and robustness in the IoT domain (Bouwman et al. 2009, 2012; Tesch 2016), in the final stage of the BMI process in this study, the STA method based on Haaker et al.'s (2017) study was used.

To implement the stages of the BMI process, secondary data extracted through descriptive analysis (Smith and Firth 2011) from the studies conducted on the IoT and BMI, primary data obtained through interpretative analysis (Schmidt 2004) from the interviews with the experts, and the results of technical reports of accredited source like ITU, Accenture, Deloitte, and Mckinsey were used.

As a result of performing the BMI process integrated with the STA, driven by the IoT in the ISPs' business context, four new ideas for value creation of ISPs driven by the IoT were identified at the output of the ideation stage of the process. Four business models for ISPs in the IoT domain based on the four proposed ideas were explained at the output of the integration stage of the process. In the fourth stage of the process, the evaluation stage, the robustness of the components of the four proposed business models based on the STA method was examined, which indicated that there were doubts in justifying the value creation of ISPs in the IoT domain based on *connectivity service providing* and *cloud service providing*. Therefore, after completing the BMI process, based on reliable sources, first, validation of the ISPs' value creation based on *connectivity service providing* as well as materializing their value creation based on this method at the instance level (IoT use-cases level) were focused upon. Then, the value creation of ISPs based on *cloud service providing* was addressed. At the end of the research, the impact of IoT on the business model components of ISPs was explained.

The present study's achievement is proposing four business models for ISPs (WA + FWA providers) driven by IoT, which means the new logic of their business in this technology. The findings of this study can help deepen the ISPs managers' anticipation and identification of the opportunities based on IoT technology (Moqaddamerad et al. 2017). As a result, they can re-perceive and respond to IoT-based opportunities in a novel way (Patel 2016). In turn, responding to them helps its rapid growth, facilitates and accelerates taking its personal advantages[22] (Chui et al. 2010) and corporate advantages[23] (Sundmaeker et al. 2010).

On the other hand, given the dearth of research on IoT (Patel 2016), BMI (Schneider and Spieth 2013), and BMI driven by IoT (Wirtz et al. 2016) domains, BMI implementation driven by IoT in the ISPs' business context can make a great contribution to the scholarship (Veit et al. 2014), provide a starting point for further studies in identifying value creation methods in other businesses in the telecom industry and even other industries influenced by this technology.

The scarcity of practical knowledge in both IoT and BMI domains was one of the limitations of this study. The most significant challenges and limitations of the present research are the limited background of studies in both areas and the experts' disagreement over the responses to the interview questions and seeking to reach a final consensus among them. Ensuring the validity of the proposed business models is another limitation of this research.

22 Including the improvement of the individuals' lifestyle due to the optimal control of their daily lives.

23 Including the optimization of the processes, intelligent management of the products, and increasing the scalability and efficiency of the business.

Quantifying the STA method by adding quantitative assumptions and assigning quantitative value to the elaborated uncertainties, which is a way of boosting the reliability and validity of the components of the proposed business model in IoT, can be considered a research avenue. Furthermore, materializing the proposed business models of this research based on *connectivity service providing* at the instance level or IoT use-cases level for other industry-level ISPs outside the scope of this research with a different technological focus is recommended as another research avenue. Besides, the choice of basic theories in the field of IoT can also be considered an important pivotal theme for future research direction. The reason is that in this study, in explaining two components of the proposed business models, including key resources and value configuration of key processes, only two basic theories of RBT and VCT were used, respectively, depending on the nature of the problem, the nature of the IoT technology and the evidence available in the secondary data. There is no doubt that IoT technology also provides the foundation for other basic theories, such as information sharing. Accordingly, the choice of other basic theories whose assumptions come a step closer to realization under the influence of IoT technology can be the focus of future research.

Appendix 1

The direct result of content analysis based on Atlas-Ti software related to IoT domain is presented on Fig. 7.

The direct result of Atlas ti related to the *family members of the mentioned codes in IoT domain*, is presented as follows:

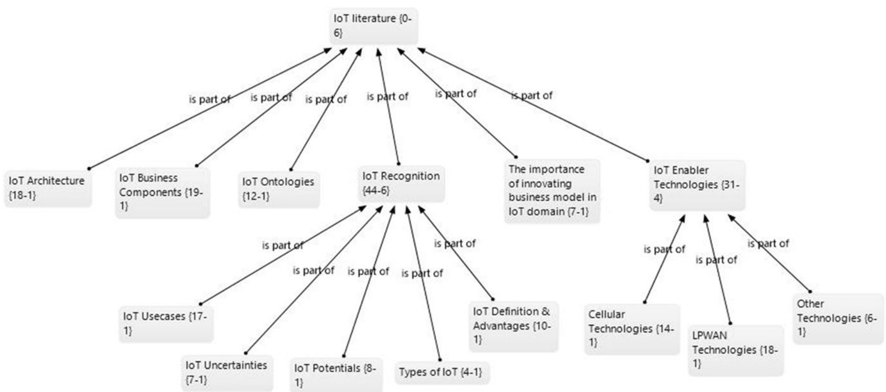

Fig. 7 Segmentation of the IoT studies into fourteen different codes

Primary Doc Families

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Primary Doc Family: Cellular Technologies

Primary Documents (14):
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[P 3: Akpakwu et al., 2017.pdf]
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[P86: Girson, 2018 .pdf]
[P93: McKinsey, 2018.pdf]
[P113: Rahimi et al., 2018.pdf]

Primary Doc Family: IoT Architecture

Primary Documents (18):
[P 1: Abreu et al., 2017.pdf]
[P 6: Atzori et al., 2010.pdf]
[P 7: Atzori et al., 2012.pdf]
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Quotation(s): 0

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Quotation(s): 0

Primary Doc Family: IoT Uncertainties
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[P99: Morel et al., 2019.pdf]
[P103: Nanni et al., 2017.pdf]
[P105: Patel & Won, 2017.pdf]
[P106: Queralta et al., 2019.pdf]
[P109: Saarikko et al., 2017.pdf]
[P111: Woo et al., 2015.pdf]

Primary Doc Family: LPWAN Technologies
Primary Documents (18):
[P81: Andreadou et al., 2016.pdf]
[P83: Centenaro et al., 2016.pdf]
[P87: GSMA, 2017.pdf]
[P93: McKinsey, 2018.pdf]
[P95: Mekki et al., 2018.pdf]
[P97: Mermer & Zeydan, 2017.pdf]
[P98: Mikhaylov et al., 2016.pdf]
[P100: Naik & Jenkins, 2016.pdf]
[P101: Naik et al., 2016.pdf]
[P102: Naik, 2017.pdf]
[P103: Nanni et al., 2017.pdf]
[P104: Oh & Shin, 2016.pdf]
[P105: Patel & Won, 2017.pdf]
[P106: Queralta et al., 2019.pdf]
[P107: Raza et al., 2017.pdf]
[P108: Rebbeck et al., 2014.pdf]
[P109: Saarikko et al., 2017.pdf]
[P110: Sinha et al., 2017.pdf]

Primary Doc Family: Other Technologies
Primary Documents (6):
[P 5: Andrews et al., 2014.pdf]
[P64: Shariatmadari et al., 2015.pdf]
[P85: Deloitte, 2017.pdf]
[P93: McKinsey, 2018.pdf]
[P95: Mekki et al., 2018.pdf]
[P113: Rahimi et al., 2018.pdf]

Primary Doc Family: The importance of innovating business model in IoT domain
Primary Documents (7):
[P17: Chan, 2015.pdf]
[P30: Ghanbari et al, 2017.pdf]
[P60: Raza-Ullah & Bengtsson, 2014.pdf]
[P61: Ritala et al., 2013.pdf]
[P71: Turber & Smiela, 2014.pdf]
[P73: Westerlund et al, 2014.pdf]
[P92: Lucero, 2016.pdf]

Primary Doc Family: Types of IoT
Primary Documents (4):
[P 8: Bandyopadhyay& Sen, 2011.pdf]
[P22: Da Xu et al., 2014.pdf]
[P53: Palattella, et al, 2016.pdf]
[P54: Palattella, et al., 2014.pdf]

Appendix 2

The direct result of content analysis based on Atlas-Ti software related to BMI domain is presented on Fig. 8.

The direct result of Atlas ti related to the *family members of the mentioned codes in BMI domain*, is presented as follows:

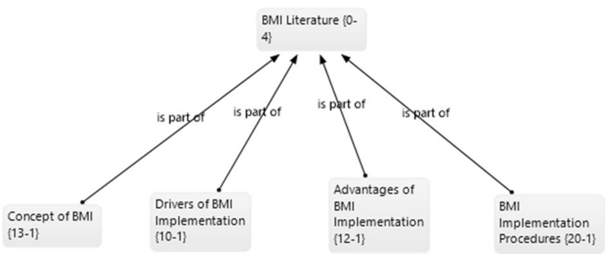

Fig. 8 Segmentation of the BMI studies into four different codes

Primary Doc Families

HU: BMI Literature_ Atlas ti- Final Version
File: [D:\thesis\The results of Atlas ti\BMI Literature_ Atlas ti- Final Version.hpr7]
Edited by: Super
Date/Time: 2020-10-27 00:36:29

Primary Doc Family: Advantages of BMI Implementation
Primary Documents (12):
[P 1: Baden-Fuller & Morgan, 2010.pdf]
[P 3: Björkdahl, 2009.pdf]
[P 8: Casadesus-Masanell & Ricart, 2010.pdf]
[P10: Chesbrough & Rosenbloom, 2002.pdf]
[P11: Chesbrough, 2007.pdf]
[P13: Comes & Berniker, 2008.pdf]
[P22: McGrath, 2010.pdf]
[P24: Mitchell & Coles, 2003.pdf]
[P25: Pohle & Chapman, 2006.pdf]
[P27: Sun et al., 2012.pdf]
[P28: Teece, 2010.pdf]
[P32: Venkatraman & Henderson, 2008.pdf]

Primary Doc Family: BMI Implementation Procedures
Primary Documents (20):
[P 2: Bilgeri et al., 2015 .pdf]
[P 4: Bouwman et al., 2009.pdf]
[P 5: Bouwman et al., 2012.pdf]
[P 6: Burkhart et al., 2011.pdf]
[P11: Chesbrough, 2007.pdf]
[P12: Chesbrough, 2010.pdf]
[P14: Cortimiglia et al., 2016.pdf]
[P15: De Reuver et al., 2013.pdf]
[P17: Frankenberger et al., 2013.pdf]
[P18: Haaker et al., 2017.pdf]
[P28: Teece, 2010.pdf]
[P30: Tesch, 2016.pdf]
[P31: Veit et al., 2014.pdf]
[P43: Tesch et al., 2019.pdf]
[P46: Amit & Zott, 2012.pdf]
[P47: Cavalcante, 2014.pdf]
[P48: Demil et al., 2015 .pdf]
[P49: Giesen et al., 2007.pdf]
[P50: Laudien & Daxböck, 2016.pdf]
[P51: Wirtz et al., 2016 .pdf]

Primary Doc Family: Drivers of BMI Implementation
Primary Documents (10):
[P 7: Calia et al., 2007.pdf]
[P 8: Casadesus-Masanell & Ricart, 2010.pdf]
[P 9: Casadesus-Masanell & Zhu, 2013.pdf]
[P10: Chesbrough & Rosenbloom, 2002.pdf]
[P11: Chesbrough, 2007.pdf]
[P14: Cortimiglia et al., 2016.pdf]
[P19: Keskin et al., 2016.pdf]
[P26: Sorescu et al., 2011.pdf]
[P29: Tesch et al., 2017.pdf]
[P33: Whitmore et al., 2015.pdf]

Primary Doc Family: The Concept of BMI
Primary Documents (13):
[P 8: Casadesus-Masanell & Ricart, 2010.pdf]
[P 9: Casadesus-Masanell & Zhu, 2013.pdf]
[P12: Chesbrough, 2010.pdf]
[P16: Demil & Lecocq, 2010.pdf]
[P20: Landau et al., 2016.pdf]
[P21: Lindgardt et al., 2009.pdf]
[P23: Mitchell & Coles, 2004.pdf]
[P24: Mitchell & Coles, 2003.pdf]
[P28: Teece, 2010.pdf]
[P34: Zott & Amit, 2010.pdf]
[P35: Abdelkafi et al., 2013.pdf]
[P41: Schneider & Spieth, 2013.pdf]
[P42: Skarzynski & Gibson, 2008.pdf]

Appendix 3

Glossary of terms

BLE	Bluetooth low energy
BMD	Business model development and business model design
BMI	Business model innovation
CIoT	Consumer IoT
CRM	Customer relationship management
D2D	Device to device
eTOM	Enhanced telecom operation map
FAB	Fulfillment, assurance, billing
FWA	Fixed wireless access
HetNet	Heterogeneous network
ICT	Information and communication technologies
IIoT	Industrial IoT
IoT	Internet of things
ISPs	Internet service providers
LoRaWAN	Long range wide area network
LPWAN	Low power wide area network
LTE	Long term evolution
MCC	Mobile cloud computing
MEC	Mobile edge computing
MNO	Mobile network operators
MTC	Machine-type communication
MWA	Mobile wireless access
NBIoT	Narrow band internet of things
NPD	New product development
QoS	Quality of service
RBT	Resource based theory
S.P	Service providing
SSIM	Spectrum sharing and interference management
STA	Stress testing approach
TCI	Telecommunication company of Iran
Telcos	Telecom companies
TIC	Telecommunication infrastructure company
VCT	Value configuration theory
WA	Wired access
WNFV	Wireless network function virtualization
WSDN	Wireless software-defined networks

References

Abdelkafi N, Makhotin S, Posselt T (2013) Business model innovations for electric mobility—What can be learned from existing business model patterns? Int J Innov Manag 17(01):1340003

Abreu DP, Velasquez K, Curado M, Monteiro E (2017) A resilient Internet of Things architecture for smart cities. Ann Telecommun 72(1–2):19–30

Accenture (2019) Felix Bengelsträter Felix Frohböse Karin Lupsa-Henel. https://www.accenture.com/_acnmedia/pdf-97/accenture-the-internet-of-things-for-telcos

Adapa S, Fazal-e-Hasan SM, Makam SB, Azeem M, Mortimer G (2020) Examining the antecedents and consequences of perceived shopping value through smart retail technology. J Retail Consum Serv 52:101901

Agiwal M, Roy A, Saxena N (2016) Next generation 5G wireless networks: a comprehensive survey. IEEE Commun Surv Tutor 18(3):1617–1655

Akpakwu GA, Silva BJ, Hancke GP, Abu-Mahfouz AM (2017) A survey on 5G networks for the Internet of Things: communication technologies and challenges. IEEE Access 6:3619–3647

Akyildiz IF, Nie S, Lin SC, Chandrasekaran M (2016) 5G roadmap: 10 key enabling technologies. Comput Netw 106:17–48

Altmann J (2000) A reference model of internet service provider businesses. In: Proceedings of the 3rd international conference on telecommunication and electronic commerce (ICTEC2000), November 2000

Amit R, Zott C (2012) Creating value through business model innovation. MIT Sloan Manag Rev 53(3):41–49

Andersson P, Mattsson LG (2015) Service innovations enabled by the "internet of things." Imp J 9(1):85–106

Andreadou N, Guardiola MO, Fulli G (2016) Telecommunication technologies for smart grid projects with focus on smart metering applications. Energies 9(5):375

Andrews JG, Buzzi S, Choi W, Hanly SV, Lozano A, Soong AC, Zhang JC (2014) What will 5G be? IEEE J Sel Areas Commun 32(6):1065–1082

Atzori L, Iera A, Morabito G (2010) The Internet of Things: a survey. Comput Netw 54(15):2787–2805

Atzori L, Iera A, Morabito G, Nitti M (2012) The social internet of things (SIoT)–when social networks meet the internet of things: concept, architecture and network characterization. Comput Netw 56(16):3594–3608

Baden-Fuller C, Morgan MS (2010) Business models as models. Long Range Plan 43(2–3):156–171

Bandyopadhyay D, Sen J (2011) Internet of things: Applications and challenges in technology and standardization. Wirel Pers Commun 58(1):49–69

Beretta R (1996) A critical review of the Delphi technique. Nurse Res 3(4):79–89

Bilgeri D, Wortmann F (2017) Barriers to IoT business model innovation. This study is supported by the Bosch IoT Lab at the University of St. Gallen. https://aisel.aisnet.org/wi2017/track09/paper/2/

Bilgeri D, Brandt V, Lang M, Tesch J, Weinberger M (2015) The IoT business model builder. A White Paper Of the Bosch IoT Lab in collaboration with Bosch Software Innovations GmbH Google Scholar.

Björkdahl J (2009) Technology cross-fertilization and the business model: the case of integrating ICTs in mechanical engineering products. Res Policy 38(9):1468–1477

Böhle F (2011) Management of uncertainty—a blind spot in the promotion of innovations. In: Jeschke S, Isenhardt I, Hees F, Trantow S (eds) Enabling innovation. Springer, Berlin, pp 17–29

Bouncken RB, Gast J, Kraus S, Bogers M (2015) Coopetition: asystematic review, synthesis, and future research directions. RMS 9(3):577–601

Bouwman H, De Reuver M, Solaimani S, Daas D, Haaker T, Janssen W, Walenkamp B (2012) Business models tooling and a research agenda. First 25:1–28

Bouwman H, Ter Doest H, van der Duin P (2009) Developing new business models for intermediaries in the insurance sector. Int J Manag Pract 3(3):263–276

Brad BS, Murar MM (2014) Smart buildings using IoT technologies. Stroitel'stvo Unikal'nyh Zdanij i Sooruzenij 5(20):15–27

Bucherer E, Uckelmann D (2011) Business models for the internet of things. In: Uckelmann D, Harrison M, Michahelles F (eds) Architecting the internet of things, pp 253–277

Buntz B (2015) Top 10 reasons people aren't embracing the IoT. Internet of Things Institute. https://www.Ioti.Com/iot-trends-and-analysis/top-10-reasons-people-aren-t-embracing-iot. Accessed 20 May 2017. [Google Scholar]

Burkhart T, Krumeich J, Werth D, Loos P (2011) Analyzing the business model concept—a comprehensive classification of literature. In: ICIS 2011 Proceedings, Paper 12

Burkitt F (2014) A strategist's guide to the internet of things. Strategy + Bus 43(2–3):2–12

Burmaoglu S, Saritas O, Kıdak LB, Berber İC (2017) Evolution of connected health: a network perspective. Scientometrics 112(3):1419–1438

Calia R, Guerrini F, Moura G (2007) Innovation networks: from technological development to business model reconfiguration. Technovation 27(8):426–432

Camponovo G, Pigneur Y (2003) Business model analysis applied to mobile business. ICEIS 4:173–183

Casadesus-Masanell R, Zhu F (2013) Business model innovation and competitive imitation. The case of sponsor-based business models. Strateg Manag J 34(4):464–482

Casadesus-Masanell R, Ricart J (2010) From strategy to business models and onto tactics. Long Range Plan 43(2):195–215

Cavalcante SA (2014) Designing business model change. Int J Innov Manag 18(02):1450018

Centenaro M, Vangelista L, Zanella A, Zorzi M (2016) Long-range communications in unlicensed bands: the rising stars in the IoT and smart city scenarios. IEEE Wirel Commun 23(5):60–67

Chan HC (2015) Internet of things business models. J Serv Sci Manag 8(04):552

Chang BY (2011) Business process management of telecommunication companies: fulfillment and operations support and readiness cases. Int J Future Gener Commun Netw 4(3):73–86

Charania I, Li X (2020) Smart farming: agriculture's shift from a labor intensive to technology native industry. Internet Things 9:100142

Chesbrough H (2007) Business model innovation: it's not just about technology anymore. Strategy Leadersh 35(6):12–17

Chesbrough H (2010) Business model innovation: opportunities and barriers. Long Range Plan 43(2–3):354–363

Chesbrough H, Rosenbloom RS (2002) The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies. Ind Corp Chang 11(3):529–555

Cho JY, Lee HS, Lee BG (2015) Connectivity issues on IoT business-the Korean case of smart home network. In: The second international conference on electrical, electronics, computer engineering and their applications (EECEA2015), vol 120

Christensen CM, Bartman T, Van Bever D (2016) The hard truth about business model innovation. MIT Sloan Manag Rev 58(1):31

Chui M, Löffler M, Roberts R (2010) The Internet of Things. Mckinsey quarterly, cisco system no. 2. pp 70–79

Comes S, Berniker L (2008) Business model innovation from strategy to execution. Springer, Berlin Heidelberg, pp 65–86

Conti M, Dehghantanha A, Franke K, Watson S (2018) Internet of Things security and forensics: challenges and opportunities. Future Gener Comput Syst J 78(2):544–546

Cortimiglia MN, Ghezzi A, Frank AG (2016) Business model innovation and strategy making nexus. Evidence from a cross-industry mixed-methods study. R&D Manag 46(3):414–432

Coucheney P, Maillé P, Tuffin B (2014) Network neutrality debate and ISP inter-relations: traffic exchange, revenue sharing, and disconnection threat. NETNOMICS Econom Res Electron Netw 15(3):155–182

Coze JCL (2005) Are organisations too complex to be integrated in technical risk assessment and current safety auditing? Saf Sci 43(8):613–638

Da Xu L, He W, Li S (2014) Internet of things in industries: a survey. IEEE Trans Ind Inf 10(4):2233–2243

Deloitte (2015) The IoT and the new role for network service providers-Iot-telecom-en-160211.pdf. Michael Raynor, Philip Wilson. https://www2.deloitte.com/content/dam/Deloitte/cn/Documents/technology-media-telecommunications/deloitte-cn-tmt-beyond-the-dumb-pipe

Deloitte (2017a) Communication Infrastructure Upgrade; the need for deep fiber. Dan Littmann, Craig Wigginton, Phil Wilson. https://www2.deloitte.com/content/dam/Deloitte/us/Documents/

Deloitte (2017b) Dan Littmann, Jack Fritz. https://www2.deloitte.com/us/en/pages/consulting/articles/communications-infrastructure-upgrade-deep-fiber-imperative.html

Deloitte (2018) Erik Bookholt, Bruno Marques Pires, Florian Berg. https://www2.deloitte.com/content/dam/Deloitte/de/Documents/technology/Connectivity-in-IoT-deployments-Deloitte.pdf

De Reuver M, Bouwman H, Haaker T (2013) Business model road mapping: a practical approach to come from an existing to a desired business model. Int J Innov Manag 17(01):1340006
Demil B, Lecocq X (2010) Business model evolution: in search of dynamic consistency. Long Range Plan 43(2–3):227–246
Demil B, Lecocq X, Ricart JE, Zott C (2015) Introduction to the SEJ special issue on business models: business models within the domain of strategic entrepreneurship. Strateg Entrep J 9(1):1–11
Desai P, Sheth A, Anantharam P (2015) Semantic gateway as a service architecture for iot interoperability. In 2015 IEEE international conference on mobile services (MS), pp 313–319
Dijkman RM, Sprenkels B, Peeters T, Janssen A (2015) Business models for the Internet of Things. Int J Inf Manag 35(6):672–678
Domingo MC (2012) An overview of the Internet of Things for people with disabilities. J Netw Comput Appl 35(2):584–596
El Sawy OA, Pereira F (2013) Business modelling in the dynamic digital space. An ecosystem approach. Springer, Heidelberg
Elkhodr M, Shahrestani S, Cheung H (2016) The internet of things: new interoperability, management and security challenges. [Online]. https://arxiv.org/abs/1604.04824
European Commission (2016) https://www.ec.europa.eu/2016/digital-single-market/en/actors-broadband-value-chain
Fan PF, Zhou GZ (2011) Analysis of the business model innovation of the technology of internet of things in postal logistics. In: 2011 IEEE 18th international conference on industrial engineering and engineering management, pp 532–536. IEEE
Fleisch E, Weinberger M, Wortmann F (2015) Business models and the internet of things. In: Podnar Žarko I, Broering A, Soursos S, Serrano M (eds) Interoperability and open-source solutions for the internet of things. Springer, Cham, pp 6–10
Frankenberger K, Weiblen T, Csik M, Gassmann O (2013) The 4I-framework of business model innovation: a structured view on process phases and challenges. Int J Prod Dev 18(3/4):249–273
Fransman M (2010) The new ICT ecosystem: implications for policy and regulation. Cambridge University Press
Fugl KL (2015) Business model framework proposal for internet of things. Copenhaguen Business School, Frederiksberg
Ghanbari A, Laya A, Alonso-Zarate J, Markendahl J (2017) Business development in the Internet of Things: a matter of vertical cooperation. IEEE Commun Mag 55(2):135–141
Ghezzi A (2012) A proposal of business model design parameters for future internet carriers. In: International conference on research in networking. Springer, Berlin, pp 72–79
Giesen E, Berman SJ, Bell R, Blitz A (2007) Three ways to successfully innovate your business model. Strategy Leadersh 35(6):27–33
Girson A (2017) IoT has a security problem-will 5G solve it. Available on line 15 Jan 2018], https://www.wirelessweek.com/article/2017/03/iot-has-securityproblem-will-5g-solve-it
Gubbi J, Buyya R, Marusic S, Palaniswami M (2013) Internet of Things (IoT): a vision, architectural elements, and future directions. Futur Gener Comput Syst 29(7):1645–1660
Gupta S, Drave VA, Bag S, Luo Z (2019) Leveraging smart supply chain and information system agility for supply chain flexibility. Inf Syst Front 21(3):547–564
GSMA (2016) Mark Page, Christophe Firth and Colin Rand. https://www.GSMA.com/2016/05/The-internet-Value-Chain
GSMA (2017) https://www.gsma.com/newsroom/press-release/low-powerwide-area-networks-lead-iot-connections-2022/SophieWaterfield
Haaker T, Bouwman H, Janssen W, de Reuver M (2017) Business model stress testing: a practical approach to test the robustness of a business model. Futures 89:14–25
Hallowell MR, Gambatese JA (2010) Qualitative research: application of the Delphi method to CEM research. J Constr Eng Manag 136(1):99–107
Hanafizadeh P, Hatami P, Bohlin E (2019) Business models of Internet service providers. NETNOMICS Econom Res Electron Netw 20(1):55–99
Havard N, McGrath S, Flanagan C, MacNamee C (2018) Smart building based on Internet of Things technology. In: 2018 12th International conference on sensing technology (ICST), pp 278–281. IEEE
Hedman J, Kalling T (2003) The business model concept: theoretical underpinnings and empirical illustrations. Eur J Inf Syst 12(1):49–59

Holler J, Tsiatsis V, Mulligan C, Avesand S, Karnouskos S, Boyle D (2014) From machine-to-machine to the internet of things: introduction to a new age of intelligence. Elsevier, ISBN 978- 0-12-407684-6
Hsieh HF, Shannon SE (2005) Three approaches to qualitative content analysis. Qual Health Res 15(9):1277–1288
Huotari K, Hamari J (2012) Defining gamification: a service marketing perspective. In: Proceeding of the 16th international academic MindTrek conference, pp 17–22
IoT Analytics (2018) https://iot-analytics.com/top-10-iot-segments-2018-real-iot-projects/PadraigScully
ITU (2012) Recommendation ITU-T Y.2060. Series Y: global information infrastructure, internet protocol aspects and next-generation networks. https://www.itu.int/rec/T-REC-Y.2060-201206-I
ITU (2016a) What you need to know about IoT wide area networks; How to choose the right WAN technology for the Internet of Things. https://www.itu.int/dms_pub/itu-r/md/16/rsg1sg5iot16/inf/R16-RSG1SG5IOT16-INF-0011!N2!PDF-E.pdf/
ITU (2016b) Internet of things: overview & policy and regulatory enablers. ITU Asia-Pacific Centre of Excellence. https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/SiteAssets/Pages/Events/2016/Dec-2016-IoT/
ITU (2018) In: Internet of things in trade facilitation UNECE UN/CEFACT conference, Geneva, 24 April 2018. Overview of the ITU-T standardization activities related to the Internet of Things. Marco Carugi. https://www.unece.org/fileadmin/DAM/cefact/cf_forums/2018_Geneva/PPTs/IoT_PPTs/03/
Ishaq I, Carels D, Teklemariam G, Hoebeke J, Abeele F, Poorter E, Demeester P (2013) IETF standardization in the field of the internet of things (IoT): a survey. J Sens Actuator Netw 2(2):235–287
Ismagilova E, Hughes L, Dwivedi YK, Raman KR (2019) Smart cities: advances in research—an information systems perspective. Int J Inf Manag 47:88–100
Janasz K (2009) Ryzyko i niepewność w gospodarce–wybrane aspekty teoretyczne. Studia i Prace Wydziału Nauk Ekonomicznych i Zarządzania 14:87–98
Ju J, Kim MS, Ahn JH (2016) Prototyping business models for IoT service. Procedia Comput Sci 91:882–890
Kelly MB (2003) Report: the telemanagement forum's enhanced telecomoperations map (eTOM). J Netw Syst Manag 11(1):109–119
Keskin T, Tanrısever F, Demirkan H (2016) Sustainable business models for the Internet of Things. ORMS Today, public article, 43(1). Online: https://www.informs.org
Khan R, Khan SU, Zaheer R, Khan S (2012) Future internet: the internet of things architecture, possible applications and key challenges. In: 2012 10th International conference on frontiers of information technology, pp 257–260. IEEE
Krafft J (2010) Profiting in the info-coms industry in the age of broadband: lessons and new considerations. Technol Forecast Soc Chang 77(2):265–278
Künsemöller J, Zhang N, Soares J (2013) ISP business models in caching. In: 2013 IEEE 29th international conference on data engineering workshops (ICDEW), pp 279–285. IEEE
Landau C, Karna A, Sailer M (2016) Business model adaptation for emerging markets: a case study of a German automobile manufacturer in India. R&D Manage 46(3):480–503
Landeta J (2006) Current validity of the Delphi method in social sciences. Technol Forecast Soc Chang 73(5):467–482
Laudien SM, Daxböck B (2016) The influence of the industrial internet of things on business model design: a qualitative-empirical analysis. Int J Innov Manag 20(8):1640014-1–28
Leminen S, Westerlund M, Rajahonka M, Siuruainen R (2012) Towards IOT ecosystems and business models. In: Internet of things, smart spaces, and next generation networking, pp 15–26. Springer, Berlin
Leminen S, Rajahonka M, Westerlund M (2015) Ecosystem business models for the Internet of Things. Internet of Thingsinland F 35(January):10–13
Li H, Xu ZZ (2013) Research on business model of Internet of Things based on MOP. In: International Asia conference on industrial engineering and management innovation (IEMI2012) proceedings, pp 1131–1138. Springer, Berlin
Li S, Da Xu L, Zhao S (2015) The internet of things: a survey. Inf Syst Front 17(2):243–259
Li S, Da Xu L, Zhao S (2018) 5G Internet of Things: a survey. J Indus Inf Int 10:1–9
Lindgardt Z, Reeves M, Stalk G, Deimler MS (2009) Business model innovation. When the game gets tough, change the game. The Boston Consulting Group, Boston
Liu L, Jia W (2010) Business model for drug supply chain based on the internet of things. In: 2010 2nd IEEE international conference on network infrastructure and digital content, pp 982–986. IEEE

Lubrano F, Sergi D, Bertone F, Terzo O (2020) Multi-network technology cloud-based asset-tracking platform for IoT devices. In: Conference on complex, intelligent, and software intensive systems. Springer, Cham, pp 344–354
Lucero S (2016) IoT platforms: enabling the Internet of Things. White paper
Luchs M, Swan K, Creusen M (2015) Perspective: a review of marketing research on product design with directions for future research. J Prod Innov Manag 33(3):320–341
Manyika J, Chui M, Bisson P, Woetzel J, Dobbs R, Bughin J, Aharon D (2015) Unlocking the potential of the internet of things. McKinsey Global Institute
Massa S, Testa S (2011) Beyond the conventional-specialty dichotomy in food retailing business models: an Italian case study. J Retail Consum Serv 18(5):476–482
Matias J, Garay J, Toledo N, Unzilla J, Jacob E (2015) Toward an SDN-enabled NFV architecture. IEEE Commun Mag 53(4):187–193
McGrath RG (2010) Business models: a discovery driven approach. Long Range Plan 43(2–3):247–261
McKenna H, Hasson F, Smith M (2002) A Delphi survey of midwives and midwifery students to identify non-midwifery duties. Midwifery 18(4):314–322
McKinsey (2018a) The future of connectivity: Enabling the Internet of Things. https://www.mckinsey.com/featured-insights/internet-of-things/our-insights/the-internet-of-things-how-to-capture-the-value-of-iot
McKinsey (2018b) What's new with the Internet of Things. https://www.mckinsey.com/featured-insights/internet-of-things/our-insights/the-internet-of-things-how-to-capture-the-value-of-iot
McLoughlin F, Duffy A, Conlon M (2015) A clustering approach to domestic electricity load profile characterization using smart metering data. Appl Energy 141:190–199
Mekki K, Bajic E, Chaxel F, Meyer F (2018) Overview of cellular LPWAN technologies for IoT deployment: Sigfox, LoRaWAN, and NB-IoT. In: 2018 IEEE international conference on pervasive computing and communications workshops (percom workshops), pp 197–202. IEEE
Mekki K, Bajic E, Chaxel F, Meyer F (2019) A comparative study of LPWAN technologies for large-scale IoT deployment. ICT Express 5(1):1–7
Mermer GB, Zeydan E (2017) A comparison of LP-WAN technologies: An overview from a mobile operators' perspective. In: 2017 25th Signal processing and communications applications conference (SIU), pp 1–4. IEEE
Metallo C, Agrifoglio R, Schiavone F, Mueller J (2018) Understanding business model in the Internet of Things industry. Technol Forecast Soc Change 136:298–306
Mikhaylov K, Petaejaejaervi J, Haenninen T (2016) Analysis of capacity and scalability of the LoRa low power wide area network technology. In: European wireless 2016; 22th European wireless conference, pp 1–6. VDE
Miorandi D, Sicari S, De Pellegrini F, Chlamtac I (2012) Internet of things: vision, applications and research challenges. Ad Hoc Netw 10(7):1497–1516
Mitchell DW, Bruckner Coles C (2004) Establishing a continuing business model innovation process. J Bus Strateg 25(3):39–49
Mitchell DW, Coles C (2003) The ultimate competitive advantage of continuing business model innovation. J Bus Strateg 24(5):15–21
Modieginyane KM, Letswamotse BB, Malekian R, Abu-Mahfouz AM (2018) Software defined wireless sensor networks application opportunities for efficient network management: a survey. Comput Electr Eng 66:274–287
Moore JF, Curry SR (1996) The death of competition. Fortune 133(7):142
Moqaddamerad S, Ahokangas P, Matinmikko M, Rohrbeck R (2017) Using scenario-based business modelling to explore the 5G telecommunication market. J Futures Stud 22(1):1–18
Morel G, Pereira CE, Nof SY (2019) Historical survey and emerging challenges of manufacturing automation modeling and control: a systems architecting perspective. Annu Rev Control 47:21–34
Naik N (2017) Choice of effective messaging protocols for IoT systems: MQTT, CoAP, AMQP and HTTP. In: 2017 IEEE international systems engineering symposium (ISSE), pp 1–7. IEEE
Naik N (2018) LPWAN technologies for IoT systems: choice between ultra-narrow band and spread spectrum. In: 2018 IEEE international systems engineering symposium (ISSE), pp 1–8. IEEE
Naik N, Jenkins P (2016) Web protocols and challenges of web latency in the web of things. In: 2016 Eighth international conference on ubiquitous and future networks (ICUFN), pp 845–850. IEEE
Naik N, Jenkins P, Davies P, Newell D (2016) Native web communication protocols and their effects on the performance of web services and systems. In: 2016 IEEE international conference on computer and information technology (CIT), pp 219–225. IEEE

Nanni S, Benetti E, Mazzini G (2017) Indoor monitoring in Public Buildings: workplace wellbeing and energy consumptions An example of IoT for smart cities application. Adv Sci Technol Eng Syst 2(3):884–890
Ndiaye M, Hancke G, Abu-Mahfouz A (2017) Software defined networking for improved wireless sensor network management: a survey. Sensors 17(5):1031
OCDE O (2015) Digital economy outlook 2015. Paris of things. Technol Innov Manag Rev 4(7):5–14
Oh SM, Shin J (2016) An efficient small data transmission scheme in the 3GPP NB-IoT system. IEEE Commun Lett 21(3):660–663
Osterwalder A, Pigneur Y, Oliveira MAY, Ferreira JJP (2011) Business Model Generation: a handbook for visionaries, game changers and challengers. Afr J Bus Manag 5(7):22–30
Palattella MR, Thubert P, Vilajosana X, Watteyne T, Wang Q, Engel T (2014) 6tisch wireless industrial networks: determinism meets ipv6. In: Giancarlo F, Antonio L (eds) Internet of Things. Springer International Publishing, pp 111–141
Palattella MR, Dohler M, Grieco A, Rizzo G, Torsner J, Engel T, Ladid L (2016) Internet of things in the 5G era: enablers, architecture, and business models. IEEE J Sel Areas Commun 34(3):510–527
Patel A (2016) Gaining insight: re-thinking at the edge. Technol Forecast Soc Change 107:141–153
Patel D, Won M (2017) Experimental study on low power wide area networks (LPWAN) for mobile Internet of Things. In: 2017 IEEE 85th vehicular technology conference (VTC Spring), pp 1–5. IEEE
Pohle G, Chapman M (2006) IBM's global CEO report 2006: business model innovation matters. Strategy Leadersh 34(5):34–40
Pöhls HC, Angelakis V, Suppan S, Fischer K, Oikonomou G, Tragos EZ, Mouroutis T (2014) RERUM: Building a reliable IoT upon privacy-and security-enabled smart objects. In: 2014 IEEE wireless communications and networking conference workshops (WCNCW), pp 122–127. IEEE
Powell C (2003) The Delphi technique: myths and realities. J Adv Nurs 41(4):376–382
Qin Q, Yu H (2015) Research on the internet of things business model of telecom operators based on the value net. Manag Eng 21:8–12
Qin Z, Denker G, Giannelli C, Bellavista P, Venkatasubramanian N (2014) A software defined networking architecture for the internet-of-things. In: 2014 IEEE network operations and management symposium (NOMS), pp 1–9. IEEE
Queralta JP, Gia TN, Zou Z, Tenhunen H, Westerlund T (2019) Comparative study of LPWAN technologies on unlicensed bands for M2M communication in the IoT: beyond LoRa and LoRaWAN. Procedia Comput Sci 155:343–350
Rahimi H, Zibaeenejad A, Safavi AA (2018) A novel IoT architecture based on 5G-IoT and next generation technologies. In: 2018 IEEE 9th annual information technology, electronics and mobile communication conference (IEMCON), pp 81–88. IEEE
Rai A, Tang X (2014) Research commentary—information technology-enabled business models: a conceptual framework and a coevolution perspective for future research. Inf Syst Res 25(1):1–14
Raju A, Gonçalves V, Lindmark S, Ballon P (2012) Evaluating impacts of over subscription on future internet business models. In: International conference on research in networking. Springer, Berlin, pp 105–112
Raza-Ullah T, Bengtsson M, Kock S (2014) The coopetition paradox and tension in coopetition at multiple levels. Ind Mark Manag 43(2):189–198
Raza U, Kulkarni P, Sooriyabandara M (2017) Low power wide area networks: an overview. IEEE Commun Surv Tutor 19(2):855–873
Razian M, Fathian M, Buyya R (2020) ARC: anomaly-aware Robust Cloud-integrated IoT service composition based on uncertainty in advertised quality of service values. J Syst Softw 164:110557
Rebbeck T, Mackenzie M, Afonso N (2014) Low-powered wireless solutions have the potential to increase the m2m market by over 3 billion connections. In: Analysys Mason, London, UK
Ritala P, Agouridas V, Assimakopoulos D, Gies O (2013) Value creation and capture mechanisms in innovation ecosystems: a comparative case study. Int J Technol Manage 63(3–4):244–267
Saarikko T, Westergren UH, Blomquist T (2017) The Internet of Things: Are you ready for what's coming? Bus Horiz 60(5):667–676
Sadowski B, Nomaler O, Whalley J (2016) Technological diversification of ICT companies into the Internet of things (IoT): a patent-based analysis. https://hdl.handle.net/10419/148701
Sarasvathy SD (2001) Causation and effectuation: toward a theoretical shift from economic inevitability to entrepreneurial contingency. Acad Manag Rev 26(2):243–263

Saunders M, Lewis P, Thornhill A (2009) Research methods for business students, 5th edn. Prentice-Hall, Essex
Schmidt C (2004) The analysis of semi-structured interviews. In: Flick U, Kardorff E, Steinke I (eds) A companion to qualitative research. Sage, London, pp 253–258
Schneider S, Spieth P (2013) Business model innovation: towards an Integrated future research agenda. Int J Innov Manag 17(1):1340001-1–34
Series M (2015) IMT vision–framework and overall objectives of the future development of IMT for 2020 and beyond. Recommendation ITU, 2083-0. Services, Co-created effective, agile, and trusted eServices, pp 133–147
Shariatmadari H, Ratasuk R, Iraji S, Laya A, Taleb T, Jäntti R, Ghosh A (2015) Machine-type communications: current status and future perspectives toward 5G systems. IEEE Commun Mag 53(9):10–17
Shi Z, Liao K, Yin S, Ou Q (2010) Design and implementation of the mobile internet of things based on td-scdma network. In: 2010 IEEE international conference on information theory and information security (ICITIS), pp 954–957. IEEE
Shrimali G (2010) Competitive resource sharing by Internet service providers. NETNOMICS Econom Res Electron Netw 11(2):149–179
Sinha RS, Wei Y, Hwang SH (2017) A survey on LPWA technology: LoRa and NB-IoT. Ict Express 3(1):14–21
Skarzynski P, Gibson R (2008) Innovation to the core: a blueprint for transforming the way your company innovates. Harvard Business Press
Smith J, Firth J (2011) Qualitative data analysis: the framework approach. Nurse Res 18(2):52–62
Sorescu A, Frambach RT, Singh J, Rangaswamy A, Bridges C (2011) Innovations in retail business models. J Retail 87:S3–S16
Sun Y, Yan H, Lu C, Bie R, Thomas P (2012) A holistic approach to visualizing business models for the internet of things. Commun Mob Comput 1:1–7
Sundmaeker H, Guillemin P, Friess P, Woelfflé S (2010) Vision and challenges for realising the Internet of Things. Clust Eur Res Proj Internet Things Eur Comm 3(3):34–36
Tan L, Wang N (2010) Future internet: the internet of things. In: 2010 3rd International conference on advanced computer theory and engineering (ICACTE, 5, V5-376. IEEE
Teece DJ (2010) Business models, business strategy and innovation. Long Range Plan 43(2–3):172–194
Tesch JF (2016) Discovering the role of scenario planning as an evaluation methodology for business models in the era of the Internet of Things (IOT). In: Twenty Fourth European conference on information systems (ECIS) (p. ResearchPaper175)
Tesch JF, Brillinger AS, Bilgeri D (2017) Internet of things business model innovation and the stage-gate process: an exploratory analysis. Int J Innov Manag 21(05):1740002
Tesch JF, Tesch R (2019) Business model innovation in the era of the internet of things. Springer, Berlin
Tseng ML, Tan RR, Chiu AS, Chien CF, Kuo TC (2018) Circular economy meets industry 4.0: Can big data drive industrial symbiosis? Resour Conserv Recycl 131:146–147
Turber S, Smiela C (2014) A business model type for the internet of things. In: Proceedings of the European conference on information systems (ECIS) 2014, pp 1–10
Turber S, von Brocke J, Gassmann O, Fleisch E (2014) Designing business models in the era of Internet of things. Towards a reference framework. In: Tremblay TMC, VanderMeer D, Rothenberger M, Gupta A, Yoon V (eds) Advancing the impact of design science: moving from theory to practice. Springer, Miami, pp 17–31
Vaismoradi M, Jones J, Turunen H, Snelgrove S (2016) Theme development in qualitative content analysis and thematic analysis. J Nurs Educ Pract 6(5):100–110
Veit D, Clemons E, Benlian A, Buxmann P, Hess T, Kundisch D, Leimeister JM, Loos P, Spann M (2014) Business models. Bus Inf Syst Eng 6(1):45–53
Venkatraman N, Henderson JC (2008) Four vectors of business model innovation: value capture in a network ERA. In: Pantaleo D, Pal N (eds) From strategy to execution. Springer, Berlin, pp 259–280
Westerlund M, Leminen S, Rajahonka M (2014) Designing business models for the Internet of things. Technol Innov Manag Rev 4(7):5–14
Whitmore A, Agarwal A, Da Xu L (2015) The Internet of Things—a survey of topics and trends. Inf Syst Front 17(2):261–274
Wirtz BW, Pistoia A, Ullrich S, Göttel V (2016) Business models: Origin, development and future research perspectives. Long Range Plan 49(1):36–54

Woo S, Jo HJ, Lee DH (2015) A practical wireless attack on the connected car and security protocol for in-vehicle CAN. IEEE Trans Intell Transp Syst 16(2):993–1006

Wortmann F, Flüchter K (2015) Internet of things. Bus Inf Syst Eng 57(3):221–224

Wu M, Lu TJ, Ling FY, Sun J, Du HY (2010) Research on the architecture of Internet of Things. In: 2010 3rd International conference on advanced computer theory and engineering (ICACTE), 5, V5-484. IEEE

Yousuf T, Mahmoud R, Aloul F, Zualkernan I (2015) Internet of Things (IoT) security: current status, challenges and countermeasures. Int J Inf Secur Res (IJISR) 5(4):608–616

Yue H, Guo L, Li R, Asaeda H, Fang Y (2014) DataClouds: enabling community-based data-centric services over the Internet of Things. IEEE Internet Things J 1(5):472–482

Yunus M, Moingeon B, Lehmann-Ortega L (2010) Building social business models: lessons from the Grameen experience. Long Range Plan 43(2–3):308–325

Zhang D, Zhou Z, Mumtaz S, Rodriguez J, Sato T (2016) One integrated energy efficiency proposal for 5G IoT communications. IEEE Internet Things J 3(6):1346–1354

Zhou J, Leppanen T, Harjula E, Ylianttila M, Ojala T, Yu C, Yang LT (2013) Cloudthings: a common architecture for integrating the internet of things with cloud computing. In: Proceedings of the 2013 IEEE 17th international conference on computer supported cooperative work in design (CSCWD), pp 651–657. IEEE

Zott C, Amit R (2010) Business model design: an activity system perspective. Long Range Plan 34(2–3):216–226

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