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A Framework for IoT-based Products and Services Value Proposition

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Abstract

The Internet of Things (IoT) has the potential to help firms to innovate and to address new business opportunities. However, many companies face difficulties in developing value propositions for products and services based on this technology. Considering this, we aimed to answer the following research question: which elements need to be considered to develop value propositions for IoT-based products and services? We used the Design Science Research (DSR) method to answer this question through the creation and testing of a specific framework to support the development of this type of value proposition. The framework was evaluated by 31 academic experts and practitioners and applied to two real businesses. It considers critical elements related to the value proposition and the relations between the main architecture layers of the IoT (including capabilities and challenges), the different types of values that can be generated for different actors, as well as the strategic positioning of IoT-based products and services.

Keywords: Internet of Things, Value Proposition, Design Science Research.

A Framework for IoT-based Products and Services Value Proposition

1. Introduction

The Internet of Things (IoT) integrates the physical and the digital dimensions, and generates new business opportunities for organizations to leverage this technology and develop innovative products and services through the combination of sensors, ubiquitous connectivity, data, and analytics (De Cremer, Nguyen, & Simkin, 2017; Fleisch, Weinberger, & Wortmann, 2014). However, its adoption is still slow, requiring more proof of concept (Gartner, 2018). IoT presents several challenges that impact its widespread adoption (Hsu & Lin, 2018), such as security, privacy, storage, and use of data, the lack of usefulness of an intelligent object, among others. These challenges should be considered by organizations (Mani & Chouk, 2018).

The IoT can be used to create new business, products, and services, but requires new value propositions (Mani & Chouk, 2018). The value proposition is the presentation of the organization's products and services, identifying the values that they generate and for whom they are generated, being a fundamental factor in the adoption and intention to use IoT-based products and services (Hsu & Lin, 2018). Companies face a significant challenge to understand the potential and limitations of the IoT to generate appropriate value propositions.

In this sense, we assume that specific elements need to be considered to develop the value proposition for IoT-based products and services. Existing frameworks for value proposition are very generic (Bocken, Short, Rana, & Evans, 2013), lack empirical application due to their complexity (Den Ouden, 2012), focus only on the customer (Osterwalder, Pigneur, Smith, Bernarda, & Papadakos, 2014; Rintamäki, Kuusela, & Mitronen, 2007), or focus only on the strategy positioning (Anderson, Narus, & Van Rossum, 2006). There is a lack of studies in the literature proposing specific frameworks or models to support the value proposition for IoT-based products and services. Some references suggest using the Value Proposition Canvas from Osterwalder et al. (2014) or the Anderson et al. (2006) model, which have the limitations mentioned.

Therefore, this research aims to answer the following research question: *which elements need to be considered to develop value propositions for IoT-based products and services?* We used the Design Science Research (DSR) method to answer this question through the creation and testing of a specific framework (the artifact of the DSR) to support the development of this type of value proposition.

We developed the framework through a systematic literature review and the application of the Delphi technique with 52 IoT experts and the evaluation by: 25 of these experts; in a workshop with four academic experts; applied in two companies with real IoT-based products; and passed through a final analytical evaluation with two practitioners. The generated framework, called Value 4.0, is multidimensional and allows analyzing the IoT-based product and services considering several elements, distributed in three dimensions (*Actors, Perspective, Strategy*) and associated to a fourth one, specifically related to the IoT, encompassing the five IoT architecture layers (as proposed by Fleisch et al. (2014)), considering both the unique IoT capabilities that can transform traditional products into smart, connected devices, providing new types of services of aggregate value. Next sections, we presented this study.

2. Internet of Things (IoT)

The IoT aims to make traditional objects intelligent, enabling them to interact with each other or with people, seeing, hearing, "thinking" and performing tasks, share information and coordinate decisions across technologies such as devices, sensors, the Internet and applications (Al-Fuqaha, Guizani, Mohammadi, Aledhari, & Ayyash, 2015). In the IoT, objects are equipped with identification, localization, communication, and the capabilities of sensing, actuating, adapting to rules, connecting to networks, and processing data (Al-Fuqaha et al., 2015; Lin et al., 2017). These capabilities enable objects to communicate with each other and with other devices and services over the Internet, allowing them to be located, identified, and operated to achieve a specific purpose (van Deursen & Mossberger, 2018).

To enable these capabilities, the IoT architecture involves several technology layers. Most references in the literature indicate at least three main layers (application, network, and perception). In contrast, others indicate more layers (service, middleware, business, among others) with different names and divisions (Al-Fuqaha et al., 2015; Da Xu, He, & Li, 2014; Hammoudi, Aliouat, & Harous, 2018). Despite the importance of these layers for the IoT functioning, Fleisch et al. (2014) indicate that an IoT-based product or service is not only composed of technology layers. The integration process between the physical and the digital layers is where new values are created, as demonstrated in Figure 1.

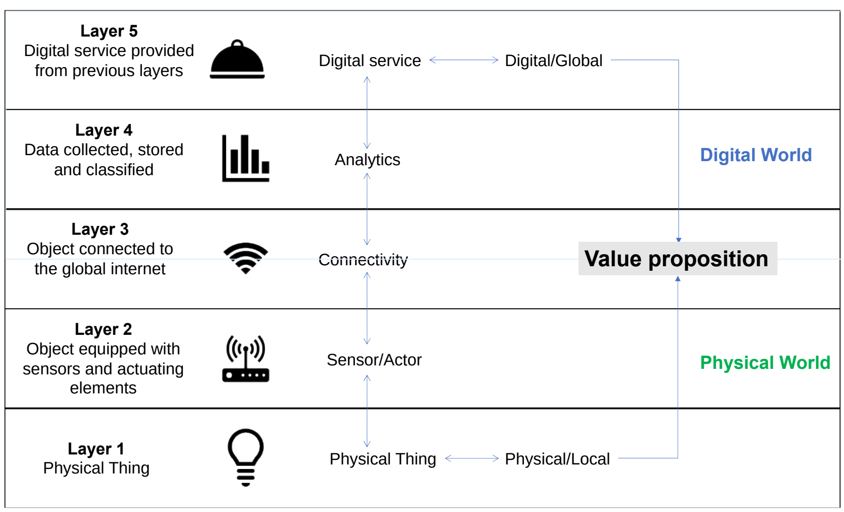

Figure 1: IoT layers
(Source: Fleisch et al., 2014)

IoT-based products and services depend on integrating all these layers to enable IoT capabilities (Fleisch et al., 2014) and applications, covering the most diverse areas and businesses. However, despite the capabilities and potentials of the IoT, it is still in an early stage of adoption, and it is necessary to overcome a set of barriers and challenges for its usage (Da Xu et al., 2014). The main challenges for IoT adoption include costs, hardware size and weight, power consumption, standardization, interoperability, availability, reliability, performance, scalability, size and storage (big data), security and privacy issues (Al-Fuqaha et al., 2015; Alioto & Shahghasemi, 2018; Hammoudi et al., 2018; Mani & Chouk, 2017). Many of these challenges were discussed by Atzori, Iera, and Morabito (2010) and continue to be presented in the most recent literature.

3. Value Proposition and the IoT

The value proposition concept has been widely used (Payne, Frow, & Eggert, 2017). The first definitions of value proposition present it as a combination of price and benefits to be delivered to target customers (Lanning, 1998). This definition received later contributions but remains related to a promise or statement about the products and services that a company offers, and the benefits and values that will be delivered to customers, and how it differs from competitors (Payne et al., 2017).

There are several frameworks of value proposition in the literature that apply to products and services in general (Anderson et al., 2006; Barnes, Blake, & Pinder, 2009; Bocken et al., 2013; Den Ouden, 2012; Kambil, Ginsberg, & Bloch, 1996; Osterwalder et al., 2014; Rintamäki et al., 2007). These frameworks indicate essential elements of the value proposition besides benefits and price, such as performance, risk, effort, customer roles (Kambil et al., 1996). They also indicate different dimensions of value (functional, economic, emotional, symbolic, and ethical values), extending the understanding of value beyond tangible elements (Rintamäki et al., 2007). Actors that can be impacted by the value proposition should be considered as well, such as stakeholders, the society, or the environment (Den Ouden, 2012). There is a need for continuous innovation in the value proposition integrating economic, social, and environmental aspects, as technology evolves in the IoT scenario.

The potential of the IoT to enable the creation of smart products opened a space for creating new value propositions. The combination of traditional products with the IoT capabilities provides new functions and benefits related to both the physical objects and the digital services associated with them (Fleisch et al., 2014). Nevertheless, it is fundamental to consider the IoT challenges in the value proposition. For instance, privacy and security risks may impact IoT adoption more than the price of the product or service (Hsu and Lin (2018).

Lindley, Coulton, and Cooper (2017) highlighted simplicity, versatility, and pleasure as characteristics to consider when developing devices based on the IoT. Fiore, Tamborrini, and Barbero (2017), in turn, noted that, despite the growing IoT market such as smart home solutions, the lack of perceived benefits, the high prices, and the concern for privacy are barriers for adoption. Mishra et al. (2016) emphasized that it is also necessary to consider the socio-organizational context, cultural, social, and cognitive forces in the process of adopting IoT-based solutions. In sum, the challenge is to develop value propositions that integrate all these points without losing focus (Hudson, 2017). It is necessary to understand the potential and challenges of the IoT to create a successful value proposition for IoT-based products and services (Kiel, Arnold, & Voigt, 2017).

However, few authors have explored the relation between IoT and value proposition. Hudson (2017) described the need to revise value propositions in the context of IoT according to the type of business model and the strategic positioning adopted by the organization, following Anderson, Narus and Van Rossum (2006) model. Previous research also highlighted the need for reviewing the value propositions for IoT-based products and services (Kamble, Gunasekaran, Parekh, & Joshi, 2019), citing some elements to be considered in this value proposition. However, they do not comment or detail these elements.

Thus, in this research, we sought to consolidate the knowledge of existing studies about the value proposition and the IoT and identifying which elements are necessary for the development of value propositions for IoT-based products and services, as detailed next.

4. Method

Design Science Research (DSR) is a method that supports and operationalizes research when the goal is to develop an artifact to solve a practical problem (Aken, 2004). This research followed the DSR approach by Peffers, Tuunanen, Rothenberger, and Chatterjee (2007), comprised of six steps of research: (1) problem identification and motivation, (2) definition of the objectives for a solution, (3) design and development, (4) demonstration, (5) evaluation, and (6) communication of results.

The first step was the **(1) problem identification and motivation**. It started with an exploration of the literature on IoT and value proposition. As a problem, we identified that it was not clear which elements should be considered to develop value propositions for IoT-based products and services. Also, the existing frameworks to support the value proposition development did not address the specificities and complexities of the IoT, such as the IoT capabilities and challenges.

Moving to the next step, **(2) definition of the objectives for a solution**, we envisioned a framework as a solution to support the development of value propositions for IoT-based products and services. This framework has the following objectives: (a) to support the creation of new value propositions for IoT-based products or services; (b) to support the revision of existing value propositions; (c) to help companies to consider the IoT capabilities and challenges when developing the value proposition; (d) it must be understandable, intuitive, easy to use, simple and, parsimonious (considering only essential elements to the value proposition).

With these objectives, the next step was **(3) design and development**. A systematic review of the academic and grey literature was conducted (in August 2018), searching for (a) "value proposition" and (b) "value proposition" AND "Internet of Things" OR IoT. After the analysis of results, we selected 449 academic studies related to value proposition (out of 1180 initial results), and 39 academic studies (out of 89 initial results) and 206 publications from the grey literature (out of 701 initial results) related to IoT and value proposition. All the references selected went through an open coding process with the help of ATLAS.ti in order to identify the elements that need to be considered for the development of value propositions for IoT-based products and services.

Besides the systematic literature review, we applied the Delphi technique (Linstone & Turoff, 2011) to gather the views of experts on value proposition and the IoT. We conducted two rounds of Delphi. In the first round, a questionnaire was sent to 52 IoT experts around the world, asking which elements should be considered to generate value propositions for IoT-based products/services. The answers gathered in the first Delphi round also went through an open coding process of the elements that need to be considered to generate a value proposition for IoT-based products/services. We identified 99 elements in total (experts plus the literature), including elements to generate a value proposition in general and also elements related to the IoT layers, capabilities, and challenges. We grouped and organized these elements (considering different dimensions), as will be detailed in the Research Results section.

The next phases of the DSR were **(4) demonstration** and **(5) evaluation**. The first version of the framework was presented to the 52 experts participating in the Delphi, through the second round of this technique. In total, 25 of the 52 experts evaluated the framework. The evaluation was performed via an online questionnaire. The criteria adopted to evaluate the artifact (framework) were: functionality; utility; completeness; usability, or ease of use; fit with the organization flexibility; and parsimony (Prat, Comyn-Wattiau, & Akoka, 2015; Venable, Pries-Heje, & Baskerville, 2016). The online questionnaire contained (a) a 5-points Likert scale (Strongly disagree to Strongly agree) evaluating the framework according to these criteria; (b) a 5-points Likert scale (Not important to Very important) to assess the importance of each one of the elements of the framework and (c) one open questions asking for suggestions and improvements. Based on the evaluation by the Delphi experts, we made several improvements in the framework. After these adjustments, we submitted the second (improved) version, named "Value 4.0", to a new demonstration and evaluation rounds: a group of academic experts (from the university in which the study was conducted); in real-life applications by two companies, with the participation of their owners; and two practitioners. We present the details of the four rounds of evaluations of the framework in Table 1.

Evaluation	**Type**	**Mode**	**Date**	**Duration**	**Participants**
1st: Analytical	IoT's experts (2nd round of Delphi)	Online – web questionnaire	Apr 14, 2019 to May 13, 2019	29 days (10 min. average per answer)	25
2nd: Experimental (artificial)	Workshop with academic experts	Face-to-face meeting	June 26, 2019	85 min.	4
3rd: Observational	Case 1 - Company A	Online work session - Skype	June 24, 2019	50 min.	1
	Case 2 - Company B	Online work session - Skype	June 11, 2019	50 min.	1
4th: Analytical	Practitioner 1	Face-to-face meeting	June 5, 2019	1h30min	1
	Practitioner 2	Face-to-face meeting	Jul 10, 2019	54 min.	1
Total				**579 min**	**33**

TABLE 1: Rounds of evaluation of the artifact

We analyzed the answers to the individual questionnaires using descriptive statistic techniques (frequency, mode, averages). The answers to the open questions and discussions (which were recorded and transcribed) were saved in the ATLAS.ti database. We analyzed the content of these answers via open codification to identify the necessary improvements in the artifact, as well as to identify qualitative aspects of the artifact evaluation.

5. Research Results

The systematic literature review and the expert's answers in the first round of Delphi allowed us to identify 99 elements to be considered in the value proposition for IoT-based products and services. These elements were reviewed, eliminating redundancies, resulting in a total of 67 elements grouped into three dimensions identified in the most cited value proposition frameworks found in the academic literature.

The first dimension, *Actors*, defines to whom the generated value can be created, who is impacted by it, or can co-create the value (Bocken et al., 2013; Den Ouden, 2012). These actors can be: (1) clients, whether in their roles as a buyer, consumer, user, co-creator or transferor of value; (2) the organization itself, including its employees; (3) ecosystem actors - involving stakeholders, partners, suppliers, government and others; (4) society; (5) environment; (6) bystanders - who are people indirectly impacted (positively or negatively) by the IoT-based product or service (Ferneley & Light, 2008); and (7) other objects.

The second dimension, *Perspectives*, is related to the type of value being generated or delivered. We identified the following perspectives: environmental or ecological, economic or financial, functional, psychological or emotional, social or symbolic, regulation, and political (Den Ouden, 2012; Rintamäki et al., 2007). In this dimension, we identified 54 (out of the 67 elements) that were grouped to create a more parsimonious framework and distributed within the five levels. This perspective is strongly related to the third dimension of the framework, *Strategy*, which refers to the value proposition positioning type.

These three dimensions (*Actors*, *Perspectives* and *Strategy*) were associated to a fourth one, specifically related to the IoT, encompassing the five IoT architecture layers (as proposed by Fleisch et al. (2014) as demonstrated in Figure 1: (1) physical object; (2) sensor/actant; 3) connectivity; (4) analytics and (5) digital architecture service. This dimension considers the unique IoT capabilities that can transform traditional products into smart and the challenges related to the IoT, such as the security of the data pervasively collected.

The conceptualization that served as the basis for the generated framework is depicted in Figure 2. A conceptualization is a "semantic structure which encodes the implicit rules constraining the structure of a piece of reality" (Giaretta & Guarino, 1995, p. 6). The novelty of this conceptualization relies on the consideration of unique features of the IoT and how it can create different types of value for different actors, resulting in specific strategic positioning.

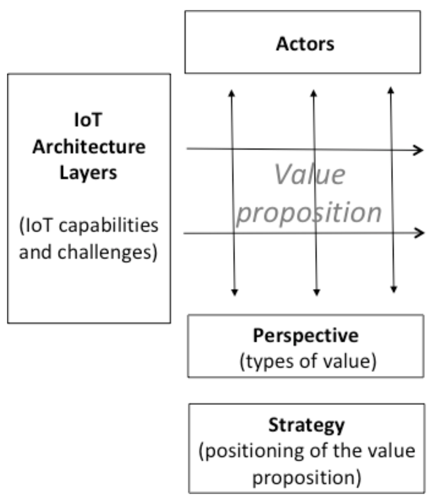

Figure 2: The conceptualization – foundations for the artifact (framework)

(Source: developed by the authors)

Considering this conceptualization, we created one version of the framework that was evaluated by 25 IoT experts in the second round of Delphi. Based on the expert's feedback, we adapted the framework and submitted them to three more different evaluations. The framework new version was named as "Value 4.0" (in reference to the industry 4.0). We submitted its second version to three new evaluation rounds: experimental, observational, and analytical, as already detailed in the methods section, Table 1. t

Overall, all participants rated the framework positively, they agreed that the framework is able to support the development of value propositions for IoT-based products/services, differs positively from other frameworks with a similar purpose, is easy-to-use, has the adequate number of elements (without excess), and is intuitive. The framework helped them to think about new elements that are not considered in other frameworks and helped to identify opportunities for the current value proposition. In sum, the second version of the artifact (Value 4.0) received positive evaluation results and suggestions for minor revisions. The final version of the framework is presented in Figure 3.

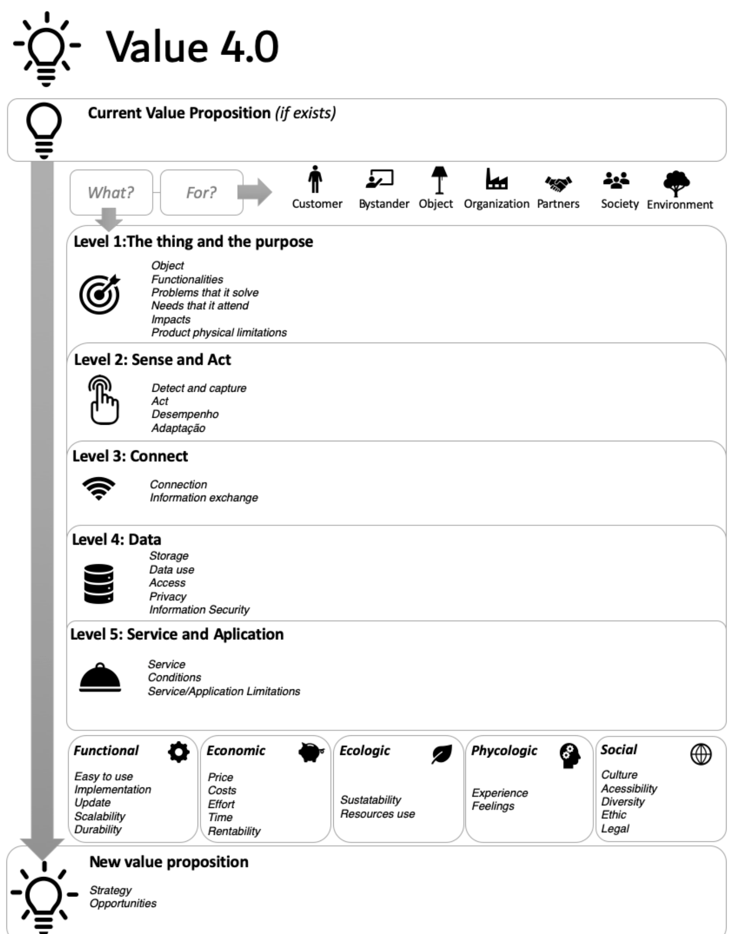

Figure 3: Value 4.0 Framework – final version
(Source: developed by the authors)

6. Discussion

The literature review and analysis, together with the views of IoT experts in the Delphi, has indicated several elements to be considered in the development of the value proposition for IoT-based products and services. These elements encompassed different types of value for different actors, interconnected with the levels of the IoT architecture and the correspondent capabilities and challenges of this technology. We inserted these elements into the framework and refined it, considering the results of the four rounds of evaluations.

Besides identifying the essential elements to be considered, the development process of this framework suggests implications for the design of artifact that address the same class of problems: supporting the development of value propositions for IoT-based products and services.

First, it is vital to consider the core elements presented by pre-existing frameworks that are already widely tested and widespread in the literature, which apply to products and services in general. However, the research data confirmed that these generic frameworks ignore specific IoT-related elements (such as the capabilities and challenges) that are present in the proposed artifact.

Second, the generated framework considers value proposition not only from a customer perspective (as happens in the most generic value proposition frameworks, for example, Osterwalder et al. (2014), quite cited in the literature) but from other actors, such as the society, the organization itself or bystanders. These other actors deserve consideration in the context of products and services created based on the IoT. For example, Klein, Sørensen, de Freitas, Pedron, and Elaluf-Calderwood (2020) examined challenges faced in the development of Google Glass (a smart product). These challenges are related to controversies on privacy and use of data, involving not only the users of Glass but also people around those users (bystanders) and societal aspects as a whole.

As a third implication, research results emphasize the need for a value proposition framework easy to use, objective, and intuitive. However, these characteristics are more difficult to achieve when there are a large number of elements that need to be considered in different dimensions related to the value proposition. The aggregation of similar elements and the care with the layout and visual components (levels and intersection of dimensions, uses of icons, layout) are suggested for the design of similar artifacts.

After taking these design implications into account, we consider that the framework application process was satisfactory, as participants rated it positively regarding its functionality, utility, completeness, usability, suitability for the organization, flexibility, and parsimony. Besides, the participants agreed the framework presents the elements needed to develop value propositions for IoT-based products and services.

Final Remarks

We used the Design Science Research (DSR) as the method to answer this question through the creation and testing of a specific framework (the artifact of the DSR) to support the development of this type of value proposition. The assessment of the framework by academics and practitioners and its application in real business has shown that it can help to identify opportunities in existing value propositions or generate new ones.

In addition to core elements that are usually presented in the value proposition literature for products and services in general, we identified the need to consider specific elements related to the IoT to generate appropriated value propositions in this context. The conceptualization (Figure 2) that grounded the developed framework and the elements of the value proposition can be considered as the main theoretical contribution of this article. The discussion in the previous section points to implications for the design of similar artifacts.

The final version of the framework, called Value 4.0 (Figure 3), is the main practical contribution of the study. The framework can be used as a support tool for creating value propositions for IoT-based products and services by companies, entrepreneurs, inventors, and managers, helping them to reflect on this process and identifying opportunities in their current value proposition (if any) and in new value propositions. Besides, this framework can help companies to leverage the potential of the IoT and minimize the risk of innovating with this technology.

As future research, the final version of the framework presented here can be applied in new cases, with different product types, at different stages of product development, and in different sectors and company sizes. New applications can help to refine the framework and to understand if some elements can be removed, inserted, changed, or better grouped. Evaluating the value perception (by different types of actors) of IoT-based products and services is also an important topic for future research.

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