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What the white goods sector should understand in order to join the Internet of Things ecosystem in the connected home

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***Abstract*— The implications of the Internet of Things (IoT) regarding business can be observed under multiple perspectives. Some of these perspectives involve the development of new products, innovation, inter-firm collaboration or competition. However, in this research, the problem is analysed from the perspective of the IoT ecosystems in the connected home, which tries to identify the element structure in order to maximize the information value creation for the white goods sector. This document explores the evolution of the Internet of Things in the home with a business focus point in terms of information value. This is based on an extensive review of literature while analysing the phenomena incidence of industry and organizations. Likewise the challenges and opportunities that the household appliance companies represent are visualized, the business model framework is used in order to contextualize the problem, find a knowledge gap and integrate the stakeholders conceptions about the Internet of Things.**

***Keywords*— Internet of Things, White Goods, Ecosystem, Home, IoT**

I. Introduction

The scientific and technological knowledge is indispensable in order to boost the economic and social development of the countries. In this sense, science, technology and innovation have become necessary tools to transform productive structures [1]. In effect, the Information Technology and Communication (ICT) advancements contribute to competitiveness and productivity of the industry and organizations helping them to confront with current economic global obstacles [2].

Regarding emerging technologies, one of the most important ones is the Internet of Things [3], which can be defined as the articulation of sensors, transmitters, telecommunications and cloud computing technologies [4]; that is, this can be questioned if the data is collected by sensors and transmitted across different communications media in order to be sent to central Internet systems where they are later utilized for different purposes.

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In line with the above, advances the Internet of Things in the home can affect the white goods industry, in terms of the creation of new products or services, changes in the use of devices, the value chain or the behavior of consumers amongst other things. Understanding this phenomenon can allow companies to design strategies in the benefit of adapting and innovating, thus avoiding the decline of an important industrial sector and leveraging the endogenous development of loT solutions.

The methodology used in the construction of this document is based on a continuous improvement cycle, which leans on the framework reference of the book from Sampieri, et al. [5]. The use of this framework allows the detection of the major contributions, challenges, concerns and opportunities that the loT ecosystems in the connected home generates. The critical analysis is supported by the contrasting rigorous research of 44 authors, which complements the methodology.

In September 2014, the University of Harvard published the results of an investigation exploring the connection between the adoptions of new technologies (where the machine to machine or loT communications are found) and the business performance. One of the main conclusions in companies had to do with the fact that 54% of the companies listed as pioneers (those who invest and take advantage of opportunities generated by technology) have experimented with significant changes in their central business strategy or business models based on the adoption of new technologies; compared to 29% of the following companies and 10% in cautious companies [6].

According to the above, it is necessary for white goods companies to analyse the loT topic through the ecosystem lens, where the use of an open architecture is beneficial while integrating solutions for manufactured products by competing companies. One should understand that business models that are able to adapt accordingly to the context are motivators to design loT strategies for the connected home.

The document initially portrays the background, followed by an explanation of the strategy in finding scientific articles related to the Internet of Things topic for the Connected Home. The steps taken are shown at the point where search strings were used in the database and how were relevant records filtered for the topic in question. Subsequently the critical analysis of the documents is performed, taking us to the detection of the reasons why the Internet of Things for the Home must be a priority for the manufacturing companies of white goods.

II. Background Information

Before the birth of the loT concept as a tracking mechanism in the Procter & Gamble supply chain [7], the scientist Mark Weiser based his ubiquitous computing research, as he named it, the laying foundations for what would be "invisible" computers located in different places of our environment (ubiquitous). These would execute different functions in order to fulfill the promise to simplify household chores [8].

Currently the exploration of the integration in communication and computing environment for humans (also known as the ambient intelligence) specifically in the home is based on the concept of " smart home" [9]. The idea of a home connected to the Internet and with "smart" functions can be described as: "device ecosystem, home appliances and sub-systems, all interconnected and interacting between them" [3].

Meanwhile the loT ecosystem can be defined as a special type of business ecosystem made up of a group of companies of the ecosystem and individuals with their own socioeconomically environment, therefore establishing a bond between the home and the industry. The companies are then competing and cooperating by means of a common set of core assets related with the physical interconnection of the world of things and the virtual world of the Internet [10].

Similarly, white goods are found with in the household appliances that make up the loT ecosystem in the home, these which can be described as: major appliances used for the kitchen (refrigerator, stove or oven), cleaning (washer and dryer) or to the environmental comfort (such as air conditioners); in this research, the term white goods makes reference to products in the first group, specifically those which have a helping function in the chores related to the conservation or cooking of nourishment or food.

III. Methodology and Results

An initial Google search regarding the definition on the Internet of Things gives 242 million results; the first 100 represent more than 30 different definitions for this concept. Initially, a strategy was designed for the development of a list with keywords, definitions and terminology that allowed for performing adequate literature.

This allowed for the beginning of the literature review, to be centred on identifying classical and conceptual articles for the Internet of Things. In order to reach this, Scopus, ISI Web of Science and Scholar databases were selected, by which different inquiries were performed to identify the authors, definitions and publication trends. In this regard, one can infer that according to Figure 1 since 2011 a sustained increase is observed regarding articles published on the IoT subject.

Consequently, a 6 step process was designed in order to identify classical and conceptual articles supported by a software designed at Universidad Nacional de Colombia called My Tree Of Science; Robledo-Giraldo, et al. [11] who support this search methodology by applying the graph theory. The scientific literature was reviewed through the National System of Libraries of the Universidad Nacional de Colombia, which reviews databases with more than 10.000 science indexed international magazines. The sequential execution of activities is shown below:

1) 2664 articles were filtered applying the search filters (Internet and "thing"); the use of the special character * allow it to include in the search words such as everything and things.
2) The search is organized by relevance. With the use of ISI Web of Science algorithms in order to generate a base ranking the amount of times the criteria search is found in an article.
3) The first 300 results are exported to a flat file (the amount of records determine the methodology regarding the computation restrictions in the algorithms).
4) As with the previous file, the software was fed in http://mytreeofscience.com, which is an intelligent tool for the selection of scientific articles.
5) In this way 83 articles were obtained and revised through the DOI code in doi.org.
6) The documents collected were organized in the EndNote (Thomson Reuters) software for the administration of bibliographical references, for its revision and interpretation.

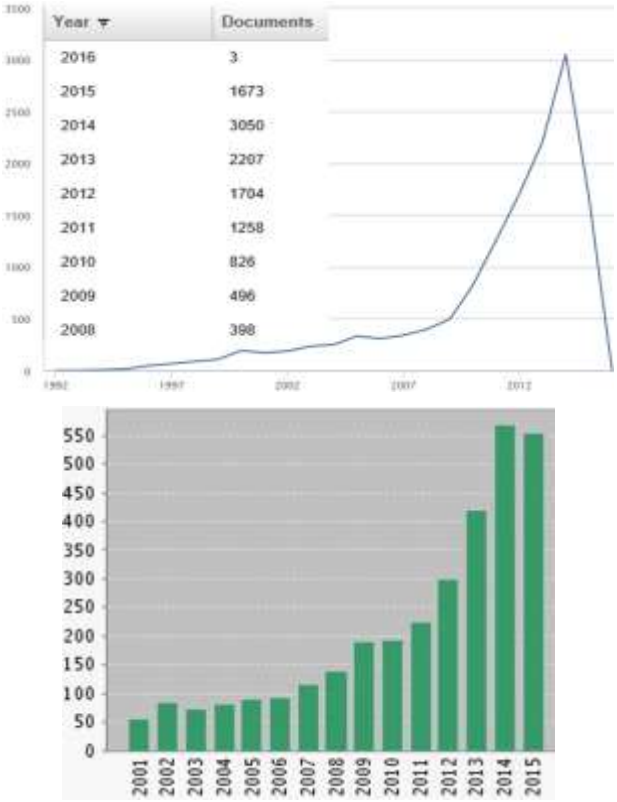

Figure 1. Publication per Year ISI Web of Science & Scopus.

Finalizing this step, a list of terms was developed and ideas were structured regarding the state of the art of loT and its evolution. The following step was to design a strategy in order to find relevant information that allows the understanding of what are the challenges and opportunities for electrical appliance companies in the Internet of Things era? In this sense, the search is then based on two different inquiries that should integrate the most relevant

technological and business aspects of loT in the home. Each one is explained bellow:

The first inquiry is the revision of literature called technology or that of practical use. Scientific articles relevant to the loT application in the home are searched. In this way the conclusion was made that terminology as intelligent home, ubiquitous computing, smart living and ambient intelligence must be in the construction.

The second tries to find the industries and is based on the perspectives on which the phenomenon is being studied, making it crucial to design the inquiry incorporating the business models concept [12]. Understanding this research, as a conceptual tool allows one to express logic by means of how a company tries to generate money [13].

Computing sciences have made great advances in the recent years. Not only have they generated new fields of research, they have also allowed the rebirth of the home as an object of study for the scientific community. It is being transformed into a place where technology plays a very important role. The proposal of scientists and researchers for the home is the creation of an intelligent environment, which is adapted to the needs, tastes and interests of the people living inside them facilitating their daily chores.

The exploration and integration of communications and computing in people´s environment is also known as the Ambient Intelligence, which supports the sensor advances, sensor networks, ubiquitous computing and artificial intelligence [14].

With these clear concepts the inquiry is developed where all the scientific articles on the loT topic are gathered and they focus on the home. As an application, and according to the above point this schematic way can be seen in Figure 2. The result of the search can bring the articles found in the intersection between the two areas of knowledge.

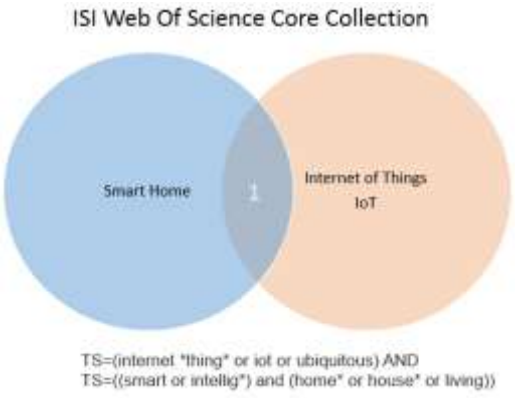

Figure 2. Inquiry Internet of Things – Smart Home

A total of 490 articles were exported to Microsoft Excel in order to filter the content. The criteria used was, the relevance to the topics for the research and to the amount of citations (at least 3 citations), thus resulting in 25 articles.

It is important to mention that the same inquiry was executed in the Scopus database generating 458 records, these were compared to the results in the Web of Science without encountering any additional articles included in the revision.

As the interpretation of the scientific literature advances, new authors of well-known trajectory appear on the loT topic and articles not found in initial inquiries. It was necessary to identify the most important authors by topics in order to improve the quality of the obtained publications. The result of this compilation is shown below:

TABLE I. RELATION OF AUTHORS IOT – HOME

Categories	Authors
Internet of Things	(Ashton, 2009), (ITU Strategy and Policy Unit, 2005), (Welbourne et al., 2009), (Miorandi, Sicari, De Pellegrini, & Chlamtac, 2012), (Karimi & Atkinson, 2013), (Guillemin & Friess, 2009), (Gershenfeld, Krikorian, & Cohen, 2004), (Gaglio & Lo Re, 2014), (Bassi & Horn, 2008), (Atzori, Iera, & Morabito, 2010; Yan, Zhang, Yang, & Ning, 2008), (Gubbi, Buyya, Marusic, & Palaniswami, 2013), (Borgia, 2014)
Ubiquitous Computation & Ambient Intelligence	(Weiser, 1991), (Zelkha, Epstein, Birrell, & Dodsworth, 1998), (Friedewald, Vildjiounaite, Punie, & Wright, 2007), (Cook, Augusto, & Jakkula, 2009), (Guo, Zhang, Wang, Yu, & Zhou, 2013)
Smart Home or Connected	(Raji, 1994), (Vassileva, Odlare, Wallin, & Dahlquist, 2012), (Solaimani, Keijzer-Broers, & Bouwman, 2013), (Saint, 2015), (Balta-Ozkan, Boteler, & Amerighi, 2014), (Chan, Esteve, Escriba, & Campo, 2008), (De Silva, Morikawa, & Petra, 2012), (Ehrenhard, Kijl, & Nieuwenhuis, 2014), (Kirkham, Armstrong, Djemame, & Jiang, 2014), (Peine, 2008), (Perera, Zaslavsky, Christen, & Georgakopoulos, 2014)

Lastly, the table II was designed based on the map method [5] allowing to organize information that is extracted and collected from inquiries and executed in the database. This map integrates the concepts, dimensions, methods and models found in the literature review.

TABLE II. LITERATURE MAP INTERNET OF THINGS – CONNECTED HOME

Definitions & Concepts	Dimensions
Internet of Things Ubiquitous Computation & environmental ambient Smart or connected Home	Technological Platform Security Energy Savings Standards Information Value Loop Wireless Sensor Networks Architecture Home automation Health care Activity recognition
Measurement	**Models**
Algorithmic complexity measurements Quality metrics of software and hardware	Normally are used project management for the development of solutions in hardware and software Software development models

The second inquiry was designed to find scientific articles relating the Internet of Things with business models for companies. In this area of the revision the articles extracted from the inquiry of the Web of Science database were not relevant from the business standpoint. For this reason the Google Scholar database was selected for the research. After the inquiry, 199 records were obtained and

filtered with the criteria of the date of publication, thus being executed from the year 2013 and generating 60 results.

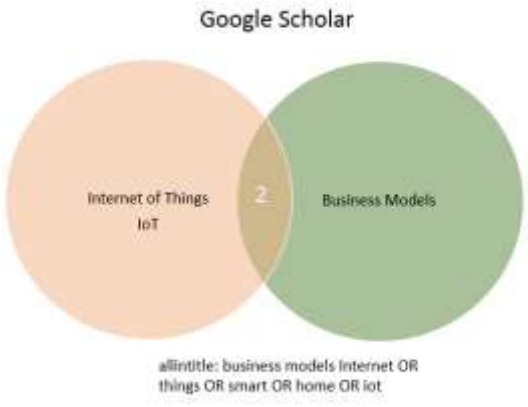

Figure 3. Inquiry Internet of Things – Business Models

Given that from the business perspective the state of practice is fundamental in order to understand the business vision phenomenon, a diagram of news monitoring was designed around the Internet of Things. During the first months of the year 2015 a compilation of additional information sources supported the application Flipboard.com, based on the topic "trend studies, value creation and state of practice¨, this is summarized in table III:

TABLE III. IOT – HOME AUTHOR RELATION

Categories	Authors
First Mover Advantage	(Harvard Business Review Analytic Services, 2014)
Business models and Internet of Things	(Fleisch, Weinberger, & Wortmann, 2014; Turber, vom Brocke, Gassmann, & Fleisch, 2014), (Leminen, Rajahonka, Westerlund, & Siuruainen, 2014), (Sundmaeker, 2010; Westerlund, Leminen, & Rajahonka, 2014), (Want, Schilit, & Jenson, 2015), (Rong, Hu, Lin, Shi, & Guo, 2015)
Design of the Business models:	(Zott & Amit, 2010),(Chesbrough, 2010),(Osterwalder & Pigneur, 2011), (Weiller, Shang, Neely, & Shi, 2015), (Teece, 2010; Zoet, Smit, & de Haan, 2014)
Smart - connected products	(Atzori, Iera, & Morabito, 2014), (Allmendinger & Lombreglia, 2005), (Kortuem, Kawsar, Fitton, & Sundramoorthy, 2010), (Meyer, Främling, & Holmström, 2009), (Want, Weiser, & Mynatt, 1998), (Porter, 2014)
Public policies and legal area	(Weber & Weber, 2010)
Trend Studies- Value Creation – State of Practice	(Deloitte, 2015), (MCkinsey, 2015), (Accenture, 2014), (Tata Consulting, 2015), (IDC, 2015), (Cisco, 2014), (The Economist, 2013)

The concept, dimension and method table results can be seen bellow:

TABLE IV. LITERATURE MAPPING INTERNET OF THINGS – SMART HOME

Definitions & Concepts	Dimensions
First Mover Advantage IoT Business models Business model design Smart – connected products Public Policies – Legal Trend Studies	Business IoT As a force for Change Competition Innovation Business procedures Integration (cooperation & acquisitions) Multisectoral Services Trend Analysis Business indicator Opportunities & Challenges Value Creation
	Barriers to adoption Concerns Interoperability Legal Regulation Smart Product Design Stakeholders Consumers User Companies of IoT Technology Suppliers Government (policy Makers) Employees
Measurement	**Models**
Usually expert interviews (Delphi method), structured surveys and focus groups	Business Model Innovation Ecosystem business models for IoT Business Model Canvas Lean Canvas

IV. Discussion

In 2005, the United Nations first mentioned the term "Internet of Things", in a report published by the International Telecommunication Union (ITU) [15], this report outlined the opportunities available to connect new devices to the Internet, while largely explaining the applications that can have the RFID (Radio Frequency Identification) in this matter, in addition to analysing the ethical and privacy information challenges, concluding with opportunities for world development.

On the other hand, some researchers define the global sector of the white goods as moderately dynamic where competition takes place through prices and whose technology in production is mature. In this regard, companies have perfected techniques of flexible manufacturing with the help of computers in order to reduce the costs of production. Likewise their concerns are centered on products that aiming for energy savings and environmental friendliness. "The industry leaders of the white goods sector have prospered achieving an economy of scale, better distribution channel control and simple innovation" [16].

Similarly, household appliances can be considered a classic product of low technology (in contrast for example with consumer electronic products) developed by companies who deal in a mature market with little drive in scientific advancement [17]. However, in the recent years of the Internet of Things revolution, new problems have been raised with relation to the above. Porter and Heppelmann [12] argue that the competitive environment is changing thanks to IoT therefore white goods companies should take note and adapt their products and/or services.

In this regard, the rapid development in the Internet of Things has generated interest from digital companies (such as Google, Apple and Amazon) thanks to the advances of Big Data and the cost reduction of sensors for the development products and services around the home ecosystem. This interest could trigger a severe test in the business models of companies in general with consequences that are still difficult to predict. However, in order to extrapolate some instances in the application of IoT one can observe the automobile industry on behalf of Google and watches on behalf of Apple thus providing an idea of what is to come.

The application ranges of the Internet of Things (loT) are very broad [18], and can be seen in smart cities [19], in wearable technology, in industrial Internet [20] and in smart homes [9]. However the scientific work in each one of the topics has focused on technological aspects, generating problems such as closed loT architectures and typically digital ecosystems with little or no interoperability between its components.

Meanwhile, in the global context, large corporations are found immersed in competition in order to take advantage of science and technology upon the development of new products. This situation is reflected in the formation of alliances between companies[1], looking for the definition of standards and new applications of the researches around IoT in the technological field. This has exerted pressure on companies that for different reasons do not belong to any alliance. After all these types of clubs are a source of information and a laboratory of practices that allow a better understanding of the loT phenomenon.

Regarding the adoption of the Internet of Things in industry and organizations, one can infer according to the revision, that the topic has been hardly investigated in white goods companies and its associated ecosystems. In this regard, some researchers argue that the gap in loT between the technological industry and manufacturing is increasingly narrow to the point that the separation between them, is only a concern of the past [12]. With this in mind, it is safe to say that the manufacturing companies find the need to understand how to develop the construction capabilities of software in order to successfully incorporate this in the hardware they build. Thanks to the convergence between the physical products and the digital services a diagram that combines these two elements is possible today [21].

Additionally, TATA consultancy services [22] published a report analysing how companies on a global level are using the Internet of Things. One of the findings relates the technological loT adoption in Latin America, which is the lowest compared to North America, Europe and Asia Pacific. Worth highlighting is the importance loT has in the home through the application for the reduction of energy consumption, health care and security.

According to the above, the impact on traditional product design has not wasted any time. According to Porter and Heppelmann [12], smart products create a dilemma for white goods manufacturers due to the long life span of their products. Consequently these business models such as: companies must take "product as a service", "shared products" or hybrid diagrams into consideration. Moreover, Iansiti and Lakhani [23] insist on the need to apply digital lenses to existing products in order to take advantage of the ubiquity. In this regard, Atzori, et al. [24] restate that loT requires the knowledge of the construction of complex services of added value through the cooperation of social media objects. That is to say that electrical appliances must go far beyond intelligent products and more towards the level of social objects.

From the revision of literature one can conclude that the electrical appliance industry is mentioned in general terms by Fleish, Guillemin & Porter [12, 21, 25]. Basically commenting in an applied prospective that the changes in business models can be presented in this economic sector.

Recent studies performed by consultancy companies show a more detailed view regarding the application of the Internet of Things in the home. In the case of MCKinsey Global Institute [26], the topic is treated through the generation of economic value for companies while a study made by the Consumer Electronic Association (CEA) analyses, amongst other things, the state of the actual smart devices market for the home in the United States and how the companies adapt their business models to new challenges [27].

One can say, therefore, that the loT is in a "birthing" stage where the scientific and practical levels are laying the foundation for a value proposition regarding new products and services as well as the best way of client delivery [28]. In this regard the necessity for the industry and organizations to comprehend the functionality of IoT ecosystems and the interoperability of all its components is manifested [29]. It is important to remember that according to Chen, et al. [30], the information can happen in different places, things, companies, industries and different regions or countries. The application models can change from closed to open and can be constructed in loT systems resulting in different industries.

This could explain the position of Westerlund, et al. [31] regarding the research in loT with nearly an absent focus of the ecosystems. That is why they anticipate in their analysis that the promoters of shared value are crucial for the creation of win-win ecosystems. Similarly, other researchers add that it is necessary to generate value, create innovation and make money [32]. Moreover, Tafti, et al. [33] argue that an ecosystem can cooperate as well as compete to increase the efficiency and improve the business performance.

v. Challenges and Future Research Perspectives

According to MCKinsey Global Institute [26], in as much as the loT adoption increases in the homes, consumers can ask for additional characteristics in electrical appliances beyond their reliability. This represents a unique opportunity for white goods manufacturers allowing them to offer services through electrical appliances. In this way, the information becomes a new asset for organizations and enables the creation of value.

On the other hand, the need for maturity in loT solutions indicates that many of the available data of different

[1] Some of them are: Allseen Allianse, Open interconnect consortium, Thread Group & Internet of Things consortium

industries and organizations are not utilized and do not generate value. This is the case of the petroleum sector where 300.000 sensors are installed in pipelines of which only 1% of collected data is used only with a specific monitoring focus. [26].

Likewise, the difficulty to describe, predict and exploit data poses additional challenges. In fact a fundamental problem in areas such as the home is learning the event representations and activities of multiple levels of complexity [19]. In the same way Chen, et al. [34], indicates how difficult it is to extract knowledge from great volumes of information.

It can be inferred then that in the Latin American context, loT is in the initial stages of development therefore relevant studies are not yet available on the subject. However, we can argue that the search for new development sources has presented additional challenges in the industry. These have tried to overcome with the incorporation of new technology in business processes despite the limited advances in competitiveness and innovation [35].

In the same way, the governments of different countries are racing in order to take advantage of opportunities generated around the loT [36]. They try to promote endogenous development solutions and stimulate competition of the local industry. The main challenge for the government has to do with data, the use and the administration of what is generated by loT solutions in the home. These require a solid legal framework allowing innovation and technological advancements. This topic is argued amongst the scientific field [37, 38]. However the government practices are reactive to the challenges they represent.

Additionally, various economic sectors participate in the loT ecosystem of the home. With regard to the preparation of food, the incorporation of producers, electrical appliance manufacturers, kitchen utensils, supermarkets, companies in the energy sector, gas and water that supply public services, as well as technological companies have started developing applications. An example of this is the home food delivery. These aspects allow to wager on the development and innovation of products and services for the home.

According to this, the increase of connected devices to the Internet allows for the assumption of the development for solutions for a connected home and may increase importantly in the following years. Recently the consulting company of investigation in technology, Gartner, produced a report where it predicts that in 2017, 45% of connected devices to the Internet can be in the homes [39]. Thus manifesting the importance of the home regarding other category applications on the Internet of Things.

In the Latin American context, the Internet of Things is in its early stages of development; however, according to International Data Corporation, IDC Predictions Team-Latin [40], by the end of 2015 291 million Internet-connected devices are expected in the region, 20% more than in 2014; IDC also predicts that more than half of the companies in 2015 will develop initiatives on this subject, some of which are in the public sector, which is interested in solutions for smart cities, transportation, vehicle traffic management, public safety, only to name a few topics.

VI. Conclusions

The broad range of options provided by the Internet of Things has allowed the public and private sectors of different countries to focus their efforts in order to take advantage of the research in this field. At the same time, by trying to improve competition or designing new products and services to solve the problems of the community, the industry and the organizations. Even though the Internet of Things is a technological trend that is revolutionizing the world, it is estimated that in 2025 it can generate 350 trillion dollars for business only in home chores alone [26]. Barriers exist preventing consumers from early adoption but also paradigms that prevent companies from developing products and services to take advantage of these new opportunities existing.

It is clear then that great challenges exist for companies of electrical appliances. The vision of the ecosystem makes it necessary to break paradigms. For example, the collaboration of competitors should be looked at in order to develop collaborative solutions, standards or open type architectures. In the same way, understanding that the business models have an expiration date is one of the motivations to adapt [41]. Given that the advances of the Internet of Things are placing pressure on companies to reinvent themselves.

Moreover, the focus on creating value through information has been limitedly studied. Recently Delloite [42] disclosed a study that analyses the creation and capture of the value of loT solutions. Becoming increasingly aware that companies need to adopt such a focus and control the flow of information. Likewise the need is detected to use the data effectively not just for monitoring and control but also to take them to levels of optimization or prediction [26], through which information generates value.

In the area of the Internet of Things research topics can be found concerning topics such as: energy savings, home activity recognizance, smart cities, remote control and other topics that have allowed the evolution of the concept and its application [43]. However an aspect that can be differential in loT studies are those who look not only to technology but also to the social utility. Such as the researcher Cristine Hine who suggest that the changing factor is not the technology in itself but the use and the construction which surrounding it [44].

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