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Research of the Internet of Things business models in Portugal

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NOVA Information Management School
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RESEARCH OF THE INTERNET OF THINGS BUSINESS MODELS IN PORTUGAL

by

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Dissertation submitted as partial fulfillment of requirement for the degree of Master in Information Management, Specialization in Information System Technologies.

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RESUMO

A Internet of Things (IoT) é um conceito que veio revolucionar como as “coisas” e as pessoas estão interligados atualmente. O impacto desta tecnologia na economia e na sociedade vai ser enorme e vai mudar a forma como efetuamos as nossas tarefas na vida quotidiana e empresarial. Este conceito foi criado quando a primeira comunicação entre máquinas foi conseguida. Com o avanço tecnológico foi possível desenvolver tecnologias cada vez mais avançadas, tendo como exemplo a IoT. Esta é composta por redes de sensores, objetos e pessoas. Como a IoT abrange vários setores de atividade e permite o desenvolvimento de aplicações muito diversas, não existe uma única arquitetura, mas várias. O tipo de arquitetura adotada depende do objetivo que o cliente ou o criador queiram, o que pretendem melhorar ou atingir ao desenvolver e implementar estas tecnologias. Normalmente o objetivo principal é tornar os processos o mais eficientes possível e recolher dados sobre vários parâmetros tais como, temperatura, trânsito, velocidade, utilização do produto, saúde, funcionamento de máquinas, entre outros. Este tipo de informação e tecnologia é de considerável importância para as empresas dado que as ajuda a posicionarem-se no mercado, melhorar a estratégia adotada, diferenciarem-se dos concorrentes, criar mais valor e impacto para os clientes e facilitar o processo de tomada de decisão. Para o cidadão, a IoT irá ajudá-los numa melhor interação com os serviços públicos e melhorar a qualidade de vida, por exemplo. Nesta dissertação é pretendido perceber o que é a IoT, as suas arquiteturas e vantagens e desvantagens aquando da adoção da mesma. Para além disso, também foi estudado o impacto criado pela IoT nas empresas, os seus modelos de negócio e os das empresas de maneira a perceber se se mantêm ou se sofrem alterações depois da introdução destas tecnologias e o impacto no mercado e na economia. O método usado para realizar este estudo foi a realização de entrevistas aplicadas a varias empresas com diferentes experiências na área e com um contacto mais direto com a IoT.

PALAVRAS-CHAVE

Economia; Empresas; Internet of Things; Internet; IoT; Modelos de Negócio; Tecnologia

ABSTRACT

The Internet of Things is a concept that is revolutionizing how “things” and people are interconnected nowadays. The impact it is going to create in the economy and the society is going to be immense and it will change the manner in which we do our personal and corporative daily tasks. This concept was created several years in the past when the first communication machine-to-machine was achieved and with time, the technology has been evolving to what we know as the “Internet of Things”. It is based on networks among sensors, things and people. As the IoT is so diverse, there is not a specific architecture, but several. Depends on the objective of the clients or developers, what do they want to improve or achieve by developing or implementing this technology. The main objectives are making processes as efficient as possible and gather data about several parameters such as, temperature, traffic, speed, product usage, health, machine functioning, among several others. This type of information and technology is very important for entities as it helps them positioning in the market, improve their strategy, differentiate from the competition, create more value, impact for the clients and in the decision making process. For the citizens, the IoT will help them to interact better with public services and increase their life quality, for instance. This dissertation attempts to understand what the IoT is, its architectures and the advantages and disadvantages that exist throughout its implementation. It was also investigated the impact the Internet of Things has in entities, its business models and the entities business models as well in order to understand if they remain the same or go through some changes after introducing these technologies in the entity, and the overall market and economic impact. The method used to obtain these results is based in interviews conducted to several enterprises with experience and direct contact with the IoT.

KEYWORDS

Business Models; Economy; Enterprises; Internet of Things; IoT; Internet; Technology

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LIST OF ABREVIATIONS AND ACRONYMS

GPS	Global Positioning System
IoT	Internet of Things
IP	Internet Protocol
LPWAN	Low Power Wide Area Network
NFC	Near Field Communication
RFID	Radio Frequency Identification
UAV	Unmanned Aerial Vehicle
WSN	Wireless Sensor Network

1. INTRODUTION

Due to the increasing fast-paced environment, we observe nowadays in technology development, it is almost mandatory for organizations and people adapt more quickly to that technology, so it can create a higher positive impact, create greater value and assist in our daily activities. According with Gartner's 2014 Hype Cycle for Emerging Technologies (Figure 1), the Internet of Things reached its peak as being one of the technologies that came revolutionize the routine for people and enterprises.

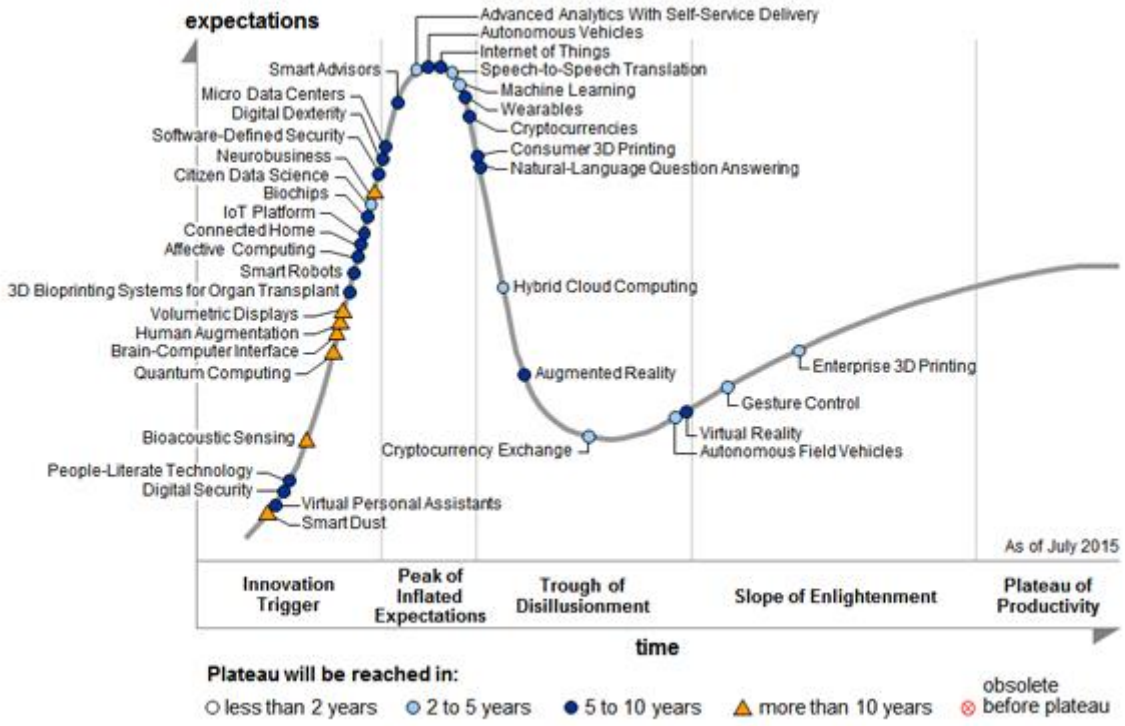

Figure 1 – Gartner's 2015 Hype Cycle for Emerging Technologies

The Internet of Things can be characterized as a dynamic network infrastructure among several components with the capability of self-configuring within certain standards and communication protocols. These are physical and virtual "things" that have their own identities, physical characteristics, and virtual qualities which use intelligent interfaces to be impeccably incorporated into the information network. This allows "things" to interact and communicate with each other, with respective surroundings through data exchange and information about their environment. This technology is also capable of, reacting to the information gathered and "deciding" what the best process is to adopt and trigger a more proper response to it. The technology is able to create new services, if necessary, without the direct human intervention. (CERP-IoT, 2009)

When the mentioned article was published, in 2009, Internet of Things did not have the popularity it has today. Many entities are reticent in adopting this kind of technology, since it is in the initial stages of development, even with the great interest coming from the technologists and programmers. These entities are mainly hesitant because there are many problems associated with the Internet of Things, including some reluctance in its utility. The reluctance is mainly caused by the

perception the market has concerning the weak security and lack of standards of this technology. (CERP-IoT, 2009).

Nevertheless, IoT is considered as the technology that is going to make an enormous difference, transforming all sectors of activity and personal lives of its users in the next years. Such reasons are enough to justify the interest in wanting to understand the impact of the Internet of Things in our lives more clearly.

Thus, having as main subject the main business models, the objective of this research is to understand what the Internet of Things is, the business models for this technology, how is it going to change everything around us and what value it can create. Additionally, try to understand how it makes an impact socially and economically in the market and in the enterprise, how it can change the way companies work in Portugal, its advantages, disadvantages and the different applications in this area.

As for the personal point of view, this research is going to contribute for the development of new competencies regarding the acquisition of new knowledge about the Internet of Things, by understanding how it can be applied in enterprises business models. There will be also acquired more competencies about methodologies and development processes throughout the research work.

1.1. BACKGROUND MOTIVATION

The Internet of Things allows the possibility for many opportunities in new technological functionalities that influence the market structure by creating new competitive advantages and new threats to the business growth and development. With the Internet of Things almost everything can be connected among them based on different types of communication structures and can perform monitor, control, optimize and autonomous tasks where each one of these groups may depend on the previous one in order to exist. Having all this considered, this type of technology has innumerous applications possible and its even considered as a game changer in the digital era and technological evolution, some of these applications are in cities, agriculture, buildings, organizations, healthcare, transports and energy.(Heppelmann & Porter, 2014)

The more commonly known definition of business models is through (Timmers,1998) perspective, quoted by Glova, Sabol, & Vajda, (2014), that says it is a structural design of complex products, information and service flows intertwined with the actors and their respective roles, with the value created for all the individuals that are part of this design and its respective revenue source. However, in the opinion of these authors the business models concerning the Internet of Things can be considered as being a main component to connect the technical developments with its business perspective. One of the prime challenges in understanding the business prospective for IoT projects is observed in the incorporation of multiple types of businesses working in cooperative atmospheres, so it is an advantage to analyze the business systems of the companies and its stakeholders (Glova, Sabol, & Vajda, 2014).

This dissertation is going to explain and study similar situations and examples in detail throughout the next chapters. Most of the time companies do not know exactly what type of technology to

implement and how to apply it to maximize their processes and results. Given that the Internet of Things is an emergent technology, matters become more complicated since it is a very recent technology in its early stages of development, adoption and implementation, questioning its use, its profitability and its ability to create value for the company. To achieve this process and result improvement, having a clear vision of the projects so that stakeholders have a specific picture of projects economic and technologic results is of utmost importance.

Considering the situation we are currently living in Portugal, this research seeks to understand the current business models adopted, how could be the development, implementation and investment in the Internet of Things in Portugal in different areas of economy and different dimensions companies. As well as, the improvement it can bring for the business processes, the improvement in people's lives and in the public and private sector services, the kind of relatable technologies being used, as well as, its advantages, disadvantages and prospects concerning the IoT technology.

Regarding the application of this dissertation, it is possible to say that, since this paper is going to analyze the impact of Internet of Things in business, it is going to have a theoretical application that can be useful for the population in general, but it is going to focus in the business sector. The main concern about the Internet of Things is the focus on security, privacy and standards in the Internet of Things, since there is little development of this technology. Existing IoT solutions have serious security issues causing the adaptation and implementation to not be as successful as expected, at least for now. However, with further development and study of this technology, it is expected for security and related issues to be resolved.

This research will review existing knowledge about the subject in a global perspective, extend or create new knowledge on a local perspective, in this case about Portugal in the various economic sectors.

1.2. STUDY OBJECTIVES

Nowadays, we can perceive that most markets and society want more results, faster and with the best quality possible. With the constant increase and evolution of the technology, sometimes companies do not know which technology is better to adopt to improve their results internally and in the market they operate in at a reasonable cost, which leads to not having a precise decision and focus on a specific tool or process to achieve the expected result and objective.

Here the subject is how Internet of Things can improve business results through the business models available and how it can create value for the company as well as for the market. Having that in consideration, this paper is going to explore the main steps in development of the Internet of Things, its implementation and adoption and value created for the companies.

In order to fulfill this master thesis objective and purpose, the following specific objectives will be required to write the Internet of Things literature review:

- Study detailed analysis about what is the Internet of Things and its utility,
- Understand the current business model in the technology area,

• Study the Internet of Things scope in the several sectors of activity, in particular the potential,

• Define of study criteria,

• Define type of methodology adopted (for this study it was elaborated interviews to enterprises in the Internet of Things market),

• Define the development of the study, conclusions/recommendations analysis of the current situation in Portugal, concerning the Internet of Things market

• Make recommendations for future research topics.

1.3. DOCUMENT ORGANIZATION

The present dissertation is divided in three main parts that are going to be detailed in this chapter.

The first part, composed by Chapters 1 and 2, is the result of a thorough literature review and analysis about the topic of the Internet of Things in the context of business models. For this part were used most relevant and important articles about the subject in order to have a consistent basis for the research conducted during this dissertation, focusing more in the theoretical part of the Internet of Things.

In Chapter 1, is presented the introduction and contextualization of the topic, explaining the motivations that led to it, objectives and how the document is organized.

In Chapter 2, is presented the analysis of the Internet of Things setting at global and local level to the best of our knowledge considering that this subject is extremely broad and there are many topics that were not able to be mentioned in this dissertation.

In the second part of the document, composed by Chapter 3 and 4, will be defined the research methodology used to analyze the current situation in the Internet of Things environment through interview of start-up enterprises as well as larger enterprises and different entities in order to better understand their point of view. Based on that information, analyze the current situation and what might be the future of the Internet of Things in Portugal.

In Chapter 3, is presented a study of the different types of methodologies used to design a case study and the characterization of the case study.

In Chapter 4, is presented the interview guides used, the results from the interviews collected and global analysis of the research.

The third part, composed by Chapter 5, is presented the conclusions and future studies.

2. LITERATURE REVIEW

2.1. INTERNET OF THINGS CHARACTERIZATION

To characterize the Internet of Things, first we should define what it is. There are many definitions and it is a relatively old concept. According with the article “Internet of Things History” available in the website Postscapes (2016), the Internet of Things started taking form in the year 1832 when Baron Schilling in Russia created an electromagnetic telegraph. A year later, Carl Friedrich and Wilhelm Weber created their own code to communicate over a distance of 1200 meters within a city in Germany. From there, with time and development of new technologies in this area, was possible to evolve at an incredible pace into the technological revolution we observe nowadays (Postscapes, 2016).

In 1999, Kevin Ashton may have been the first to create and use the term Internet of Things when referring to Internet-connected sensors, devices and citizens (Hernandez-Bravo & Carretero, 2014).

As stated previously there are many definitions written on scientific articles and websites, there is a general idea of what it is. Depending on the perspective, there may be small differences but they do not change the core definition. The main idea of the Internet of Things is defined as a network infrastructure of objects, sensors and people connected among themselves and the Internet with the capability of interacting with each other and their surroundings.

One of the main characteristics of the IoT is the heterogeneity. Some applications have characteristics specific for certain domain, while others contain characteristics that apply to several different domains and it is scalable. Both of these main characteristics constitute an obstacle to the development and creation of solutions, as it requires many different architecture suiting each application and different names, address/paths, code mapping services and types of communication (Borgia, 2014).

The IoT will help to minimize costs, optimize operational costs and the ability to function without any human intervention. The objects by themselves should have some self-capabilities that would allow them to have a high level of configuration autonomy, organization, adaptation to several environments and exchange massive amounts of data which can be used by third parties. Nonetheless, security is one of the prime concerns when it comes to technology, the Internet of Things should assure the security of the environment applied towards the communications and authentications of the service, the integrity of data and users privacy as well as the reliability of the environment. (Borgia, 2014).

The main components in the Internet of Things network allow diverse forms of communication technologies; this causes the need of developing several communication protocols that can interact with and manage core networks when it has a great number of devices connected to the same access point. Besides this feature, it also requires a good level of consistency of communication in different operating environments, for instance, mobility and quality of channels. As such, it is of high importance to support continuous mobility and to function more proficiently, simultaneously, in environments made by immobile or reduced mobility devices. Overall, the IoT environment involves devices with partial resource needs, having certain specifications in order to save energy, reducing its consumption. One way of guaranteeing security for this technology is to ensure the communication

protocols are extremely robust to network attacks in order to protect the integrity of communications, to ensure anonymity of the user and identify unusual events. Because of the vast number of applications of the Internet of Things in many different sectors, the interoperability between them becomes difficult to achieve, making this one of the main challenges in the IoT development process (Borgia, 2014).

To overcome that situation, the solution is to find a good network architecture. In this type of technology, it would be more suitable to use a hierarchical type because it fulfills most of the IoT requirements by guaranteeing high quality connectivity between innumerous devices and a better administration of the enormous amount of network traffic. As the IoT functions with more than just the network, during the development of the systems that are going to integrate the network, it is necessary to consider addressing and naming the objects so we can identify them in the network. Although this characteristic is aimed to the IP based networks and RFID environments, at the date of the article analyzed, solutions of the same kind (addressing and naming) for the sensors and other type of devices still have not been found. Most of the Internet of Things objects are mobile, but to a certain degree (Borgia, 2014).

It is also significant to find means to manage the mobility for all the objects efficiently, usually resorting to IPv6 mobile technology where permanent or temporary addresses are assigned depending on if it is a fixed or mobile object. An object that is positioned in certain area that is not covered by this technology can be detected by accessing the location of the group of objects which it is part of. However, this method does not give the accurate location of the object (Borgia, 2014).

The Internet of Things is considered a universal technology and gathers and provides data in real time through wireless networks and devices about the surroundings introduced in, through RFIDs sensors, whether it is in an inside/outside environment. Considering this, the authors defend that the IoT technology has no physical limits because any object connected to a certain network can become part of the Internet of Things (Yang, Yang, & Plotnick, 2013).

Since the architecture of a system or technology also helps to define what it is and its characteristics, this document is going to make a brief approach concerning that matter within the sphere of research. In the Internet of Things, there are two types of characteristics that should be considered in its architectures framework. Some of the functional characteristics of things are performance, accuracy, reliability, availability and time response. The non-functional characteristics mentioned are trust, users experience, motivations and expectations. Other factors to have in consideration are mechanisms that allow real time adaptation through analyzing the map of networks any given time, perceive events and generating actions across the map regarding those events (Kyriazis & Varvarigou, 2013).

The characteristics of the Internet in general as well as for the Internet of Things are described by the variety of services supported by them. Most of the Internet centered services target user is the human being. Some examples of that situation are email, online chat, and video and file transfer, among others. In the Internet of Things, most of the interaction between smart things is with themselves, i.e between with other computers and with the Internet. In this case, users are more involved with technology when it comes to decision making (Fleisch, 2010).

The IoT can reach a pervasive connection between objects, automatic gathering and processing of information in real time and ubiquitous computing, overpowering the lack of connection between real world objects and digital ones. Lou, Liu, Zhou, & Wang (2011) write about their perspective regarding the technology necessary to make an IoT solution work. One of the technologies is the Information Perception Technologies, which delivers the identification of things and the environment surrounding them. These technologies are the Radio Frequency Identification (RFID) that allows each object to have their own identifier and is able to be scanned wirelessly from the distance. For this type of technology and for the IoT to function, additional systems, such as, identity management, identity encryption, authentication management and several others are required in order to identify and track of distinct objects. The wireless sensor networks (WSN) are systems that are self-configuring, -networking, -diagnosing and self-repairing, making them very useful in the surroundings monetarization and surveillance. With the arrival of the Internet of Things there has been some developments in order to combine sensors with RFID to improve the collection of more information about the surrounding environment and conditions of the objects (Lou, Liu, Zhou, & Wang, 2011).

Other technology that makes the IoT possible, is multi-network fusion technologies where different objects and devices are interconnected through various networks, as for example, wireless and mobile networks, which is the essence of the Internet of Things (Lou, Liu, Zhou, & Wang, 2011).

In addition, the other component that constitutes the IoT are pervasive computing technologies, these are considered to increase integration of information and communication technologies in citizens' lives, environments, computing, communication and user interface. It allow everything to communicate, exchange and process information (Lou, Liu, Zhou, & Wang, 2011).

The constituents of this technology present their own characteristics in several domains that characterize the essential features, the characteristics shared by the all objects, the characteristics of autonomous things and the characteristics of things with self-control and replication capabilities (CERP – IoT, 2009).

Some of the essential characteristics of things are that the things/objects can be virtual or real in nature and they can have their own identification, making it possible for them to be identified automatically. This will allow things to exchange information and if necessary to be deterministic. Some objects also might have more than one identification and virtual address in order to take part in different contexts with different functions. With the identification(s), an object can have specific characteristics for each identification, life history, identification track, flow pattern through the real world and the interactions with other objects. Another of the basic characteristics of things is the respect to the privacy and security of other things and people that interact with them; objects use protocols in order to communicate between them and the infrastructure they are implanted in and are able to exchange information between physical, digital and virtual worlds (CERP – IoT, 2009).

The characteristics that apply to every object in IoT are that they can have sensors embedded in them in order to communicate with the environment and the objects can contest with other things for resources, services and can trigger selective pressure. In the social characteristics present in all things, they can start communication by themselves, create groups and networks and interconnect with other things, computing devices and people. As for the characteristics in autonomous things, they create tasks independently, detect and select patterns from the surroundings or learn from other objects and some can make their own decisions based on their reasoning capabilities and

analytics. The objects with the capability of self-replication or control can create, manage or destroy other objects (CERP – IoT, 2009).

The Internet of Things architecture as in most of other complex technologies requires a middleware. In this case, the smart middleware would permit the formation of a dynamic map of the things from the real world into the virtual world with the support of exceptionally accurate temporal and spatial resolution and by merging the characteristics of pervasive sensor networks and other identifiable objects. In the IoT the responses and messages between objects and the interface need to be consistent among them so that the virtual world can be understandable, simplifying the interoperability (CERP – IoT, 2009).

A few other characteristics related with the connectivity in the IoT technologies are performance, reliability, robustness, flexibility, range, power requirements, data output, costs and licensed or unlicensed field (Biggs, Garrity, LaSalle, & Polomska, 2016).

2.2. INTERNET OF THINGS ECONOMIC IMPACT

According with this study concerning the economic impact and considering some factors already mentioned before, interoperability is undoubtedly an important component in the Internet of Things functioning and maximization of value. Business to business applications will have a greater economic impact than consumer applications. This value can be exponentially increased by connecting two types of IoT applications among each other. With the Internet of Things it will be possible to create new business models and different forms of competition equally in the companies that use, develop and supply this technology. The Mckinsey & Company (2015) report say, one of the interesting factors is that the interoperability creates 40% of the total value generated. Without the advantages of the interoperability, the maximum value of applications Internet of Things could reach would be 7 trillion dollars per year by 2025. Whereas if it has those advantages considered, the highest value reached would be 11 trillion dollars per year total (Figure 2) (McKinsey Global Institute, 2015)

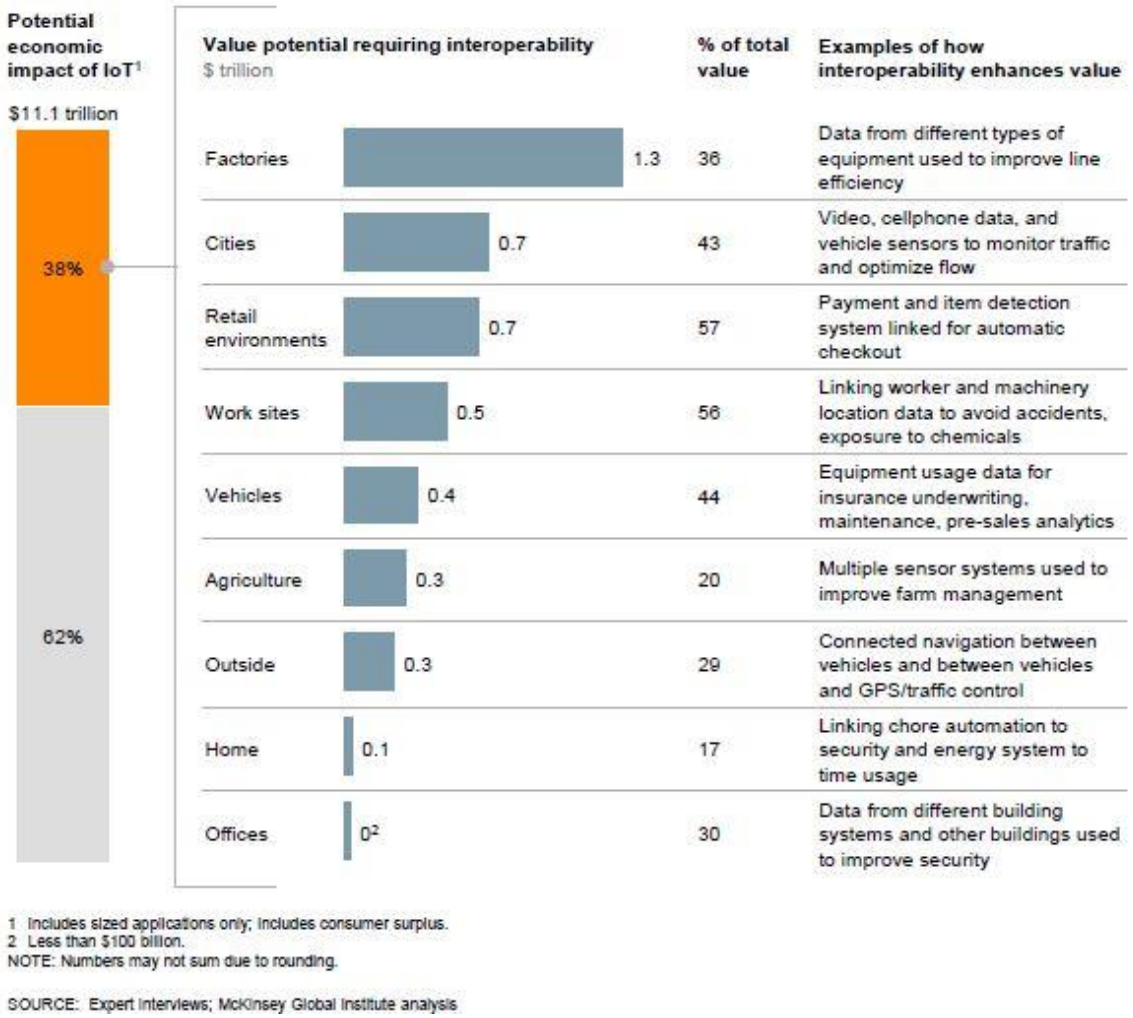

Figure 2– Economic Impact with IoT interoperability, McKinsey Global Institute, 2015

Among the several sectors, the ones requiring a higher amount of interoperability are the construction and oilrig sectors. In the construction sector, the value created by interoperability in worksites reaches approximately 60%. An offshore oilrig needs several thousands of sensors which gather data to monitor their systems or machines. For example, sensors monitor performance and

according with that data it could schedule maintenance when it presents abnormal values (McKinsey Global Institute, 2015).

During the research for the current report in analysis, was observed that of most data gathered and analyzed was not being used to its entire extent. This also creates several barriers to the organization in technical and commercial areas, and the lack of knowledge about this technology is another factor that makes users slightly reluctant about its utilization and implementation (McKinsey Global Institute, 2015).

In the next decade, most developed countries will experience a greater economic impact in the application of IoT, compared to those that are less developed , with estimates stating that 38% of the annual economic impact is in developing countries and 62% in the most developed countries. However, this is observed because the more advanced countries require larger value in deployment due to the high costs (McKinsey Global Institute, 2015)

There are some factors to be considered when comparing different types of countries and economies. The ones that that have more income, investments and spending possibilities can return a higher value from this technology than those countries with less economical possibilities. Also depending on the geography, the IoT can be applied in certain sectors more than others. For instance, it could be applied to areas that need improvement in which we can maximize results in different parts of the world such as maximizing productivity, profit and quality of life for its citizens, consequently increasing the economic impact in them (McKinsey Global Institute, 2015).

Although the IoT applications for consumers are commonly mentioned in the media channels because of the most recent innovative solutions such as, self-driving cars and different type of monitoring systems, McKinsey Global Institute have a different opinion. The business-to-business applications are the ones that hold greater value. This is mostly true in working sites such as oil and gas and constructions sites, where they have no direct impact on the consumers. This could lead to the creation of many opportunities for technology providers, and it could change considerably the competition leading to the creation and adoption of new business models in business-to-business activities. In an improved perspective about the impact between business-to-business and business-to-consumer situations, the authors of this report estimated that 69% of the prospective value of IoT applications by users would come from primary users, which are business-to-business organizations. In the optic of the buyer, 79% of the value obtained would be created when a business acquires an Internet of Things application or service. Over two thirds of the value created by the use and implementation of IoT would be from factories, worksites and offices (McKinsey Global Institute, 2015).

Having in consideration these percentages and estimations, the IoT market will be worth approximately 2 trillion dollars per year by the year of 2025, coming from several companies that develop and create Internet of Things technology or deliver services such as system design and implementation. In this type of environment, it is going to be the software and services suppliers that will retain most of the generated value over time (around 60% to 80% of the revenues). Since the IoT technology is going to be mostly used for specific ends and for very different sectors, it needs a common foundation, depending on the various sectors, it may also require a customization for each sector and enterprise (McKinsey Global Institute, 2015).

The implementation of the Internet of Things focus in nine main areas (humans, home, retail environments, offices, factories, worksites, vehicles, cities and outside), the Internet of Things will help increase the value of the assets where it is applied, it will have a global value of 4 trillion to 11 trillion dollars yearly. Considering the estimations, the largest impact will be in the factories, hospitals, farms and manufacturing sites. This is where it can reach around 4 trillion dollars per year which is about one third of the global estimated. The other settings returning more value are cities and humans with the increased value of roughly 1.6 trillion dollars yearly. The smallest settings are the offices have an increased value of 150 billion dollars (Figure 3) (Mckinsey & Company, 2015).

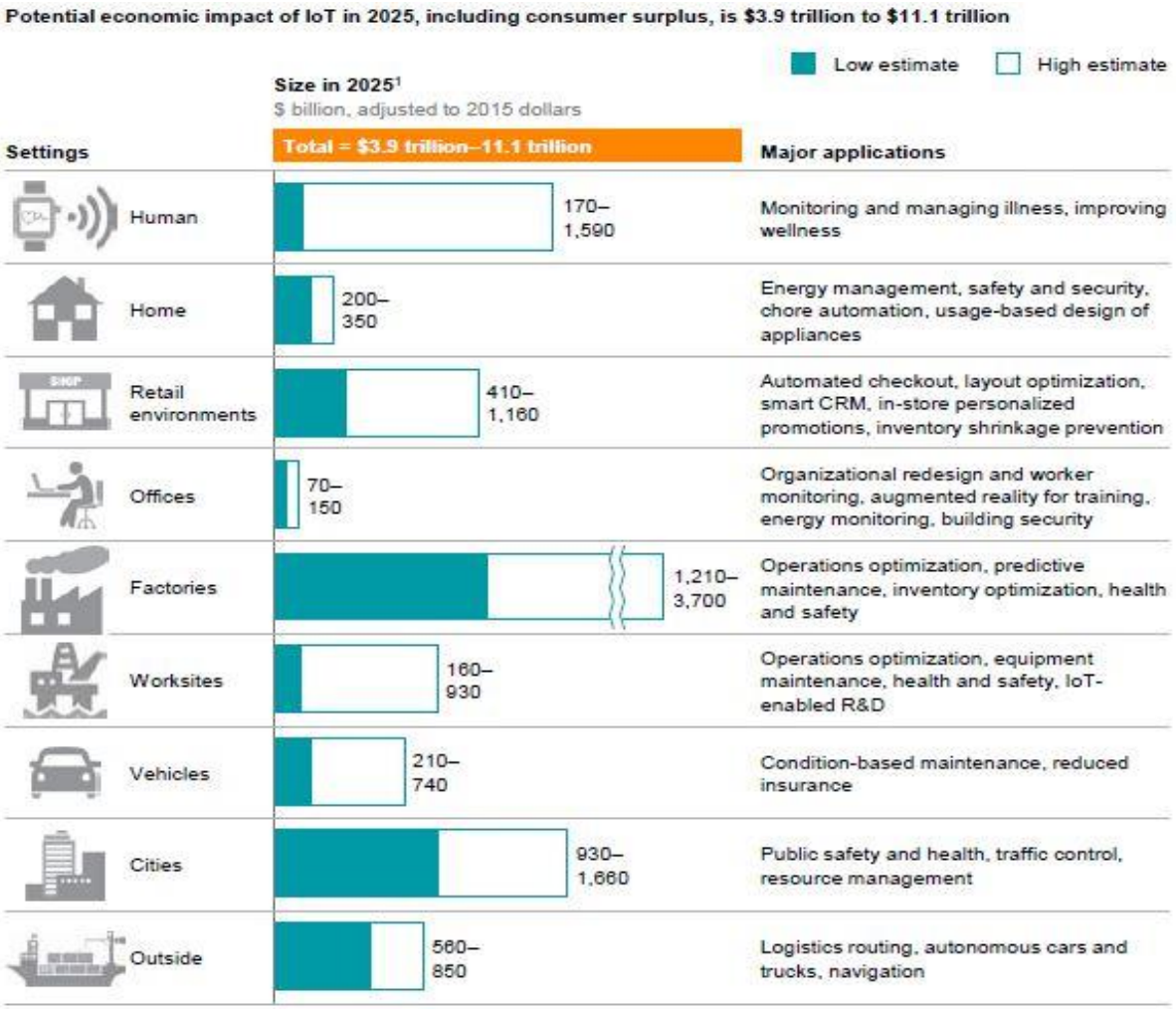

Figure 3 – Potential economic impact of IoT in 2025, McKinsey Global Institute, 2015

2.3. INTERNET OF THINGS TECHNOLOGIES

In the human setting, IoT applications are focused on the human body, which is divided in to two categories: human health and fitness and productivity growth. The applications can also help the professionals (doctors, trainers, among others) with the decision-making process and health monitoring of patients, athletes and citizens in general. This area can have an impact from 160 billion dollars to nearly 1.5 trillion dollars per year, being that the majority of this value is from the IoT devices, that are applied to monitoring and treating illnesses, particularly chronic diseases (McKinsey Global Institute, 2015).

There are three categories of IoT devices applied to human health which can be wearable either worn or carried; they are implantable, injectable or ingestible. Some examples of these types of categories are micro sensors and Nano robots, which are small dimension smart devices that are to be inserted, injected or swallowed. Information for non-wearable measurements and monitoring devices, which transfer data about a human being's health periodically without the device being necessarily attached permanently, can be gathered via Wi-Fi or Bluetooth. The IoT implemented in the treatment of chronic diseases can help patients have better and effective care with fewer complications. Additionally, the tests and exams executed in the hospital would only be able to provide the results in that moment of that exam. In contrast to the sensors and Nano robots we can have data in real time and in a continuous form in order to analyze the progression or regression of the disease and adjust the treatment accordingly. This technology will help to ensure that the patient is adopting the specified treatment to assist doctors with monitoring of the patient. Furthermore, this report estimates that IoT applications may decrease the costs of care for chronic patients by 10% to 15%. In order to improve and monitor wellness, wearable technology has been used, chiefly in more developed countries with a high level of adhesion. This technology has an estimation of increasing more than 60% per year. It can also help people improve their health, sleep and productivity. For example, fitness trackers have a wide range of varieties: it can calculate the distance made during an exercise, measure heart beats, breathing, calories consumed and give recommendations for future workouts (McKinsey Global Institute, 2015).

One of the emergent technologies which is going to disrupt how we function and improves employees' productivity, besides the Internet of Things is augmented reality. This generates graphics and provides assistance in performing a task in real time in the workers field of vision through goggles or electronic glasses. It can be helpful in circumstances where analyzing is needed before performing the task and for recently new employees as a tool to perform a more complex task. Another types of applications for productivity improvement is to use the Internet of Things to observe the good governance and functioning of an organization. This is achieved by conducting sporadic assessments, wherein its results will determine which departments or areas need improvement or are giving better results than expected. The IoT technology ensures that the results will be more reliable compared to a direct employee survey. This is due to the, use of badges, cameras, sensors and GPS such that the employers can have a better perspective of the employees performance and outcomes. However this type of monitoring can raise enormous resistance to its' implementation due to the lack of privacy this type of management causes. In the safety area, the IoT assists in avoiding accidents by using sensors that detect when a person approaches a dangerous area or controls the exposure to hazardous chemicals and radiations. This kind of system it reduces considerably possible illnesses, injuries and death in the workplace. The estimation about the

economic impact of IoT in employees' productivity can be from 150 billion dollars to 350 billion dollars per year (McKinsey Global Institute, 2015).

When it comes to IoT home applications, most of the solutions for this area are mainly for security and automation of domestic tasks. Even though this technology will not have as much impact as its applications in factories, it will probably change how users will interrelate in their work environments and households. The smart technology for homes can work autonomously; doing tasks automatically such as cleaning, preparing food to a certain point and gardening; all of which can reduce the amount of work at home by 17% (McKinsey Global Institute, 2015).

With the support of internet connections, sensors and computing power, some machines can start to predict what the homeowner needs using the data gathered about their daily routine through usage of information about choices and decisions recurrences, from there the machines can set themselves to do the tasks automatically. The energy in houses can be managed and controlled through sensors; smart thermostats that detect when the owners are not in the house and regulate the temperature to conserve energy, for instance. Other sensors can manage, provide and analyze information about utilities and appliances in general. Taking in to further consideration the devices and solutions applied for this purpose tends to be cheaper since there will be a high demand. Besides being implemented to utilities, the IoT can be implemented, in the security of the house concerning burglaries, fire, and possessions impairment (McKinsey Global Institute, 2015).

2.4. Internet of Things Business Models

In order to succeed, due to the fast-paced technology market, companies adopt business models which they find most suitable for their type of business environment internally and externally. This includes the approach adopted by having taken into account all the procedures and department organization in the company, from the employees to the final consumer (Glova, Sabol, & Vajda, 2014).

There is not a general definition of business models. Due to the many definitions existent, it is difficult to determine the nature and constituents of a good model. There is also some confusion with business model and concepts such as "strategy, business concept, revenue model and economic model" as they can be assumed as being the same. Based on various definitions of business models, the authors identified three categories; economic, operational and strategic, each one with their own specific set of variables. In certain way, it is organized as a hierarchy, going from the economic level to the strategic level. The business model can be defined based only on the entity's economic model. The business model helps making specific decisions. It is a form of organizing and defining fundamental decisions in the beginning of the life of an enterprise. Business models support the entrepreneurial exploration. It represents a strategic outline for hypothesizing a value-based project. The framework created by the author, emphases the user of such framework to "design, describe, categorize, critique and analyze a business model" for any kind of company. Frameworks are used to support a strategic guideline for the company to manage itself. If there are some components missing in the framework, the model adopted can be difficult to understand and to proceed with the path they want to follow, leading to an unbalanced situation among the decision areas and the

operational areas. Rules are also taken into consideration in the business models so that it is more comprehensible (Morris, Schindehutte, & Allen, 2005).

Business models can be divided in two types of categories. The first category is the value model, which is directed for value creation methods by detecting new and emerging opportunities, find and apply better strategy in the market for the enterprise that may lead to the restructuration of the enterprise infrastructure or not, so it can have as many benefits as possible in those types of prospects. The second category is process modelling, which is applied to model the corporations' business processes. These allow an architectural analysis and summary of the employment of business strategies in recognized enterprise infrastructures. The main obstacle for the Internet of Things plans in understanding the business potential, is its' assimilation of several businesses working in cooperative environments. There are many IoT projects without a defined development line and a doubt in the profitability for most of the project ideas. While considering new ubiquitous computing development, the main difficulty is to combine it with new value intention in such a manner that the pioneering idea is understandable to the investors. Business models are necessary in order for entrepreneurs to analyze and create their own valuation of the economic and technological viability point of view. For the research conducted by Glova et al. (2014), the method used was the e3.model value with three perspectives: the value perspective, the business process perspective and the information systems perspective. Here all the situations in these three fields explored, analyzed and compared among themselves. At the end of these process see if the idea is profitable, the decision making in the enterprise occurs, otherwise this type of flow is stopped or restarted again (Glova et al., 2014).

Applying a value based model in the Internet of Things environment using this methodology allows the detection of new value solutions and likewise it can provide a better exemplification of how the development of new value objects can bring new participants into the business structure that is working to increase sustainability and performance of the model (Glova et al., 2014).

Smart and connected devices can give a different power to the customer because they allow a better understanding of its' real performance, permitting the customer choosing one entity over another. Some customers are not completely comfortable with the concept of product usage data, leading to the decrease of confidence on the manufacturers for "advice and support". However, the ownership models, "product as a service" business model, can provide more power to the buyers by decreasing the costs of changing to a new manufacturer. Furthermore, this type of model allows users to pay only for the quantity used of the service. Technology (smart and connected systems), similar or with a service based business model can lead to the fast emergence of new firms and an increase in the competition, which can redesign competition environment and industry borders (Heppelmann & Porter, 2014).

Business models are an important crucial part for augmented dispersion of innovation. The term business model can cause some confusion with the idea of strategy and revenue methods. However according to the authors, when talking about business models the principal idea of it is that, it is not a strategy but rather a conciliation of different strategy constituents (Schief & Buxmann, 2012). (Morris et al., 2005) quoted by the authors came to the conclusion that the business models must contemplate various factors, being them the value offer, the customer, internal procedures and aptitudes, how the firm generates money, its' competitive strategy and growth objectives. (Kontio et

al., 2005) quoted by (Schief & Buxmann, 2012) have a different perspective of what makes a business model in accordance to the opinion that it is based around the customers and different sections description, service and product availability (meaning what services and products the firm can deliver), distribution model and associates the revenue model. On the other hand other views include (Rajala,2007), quoted by (Schief & Buxmann, 2012), wherein business models have the following concepts of offering, revenue model, connections and management mind-set (Schief & Buxmann, 2012).

After the analysis of the several types of business models in order to build a framework for their research, Schief & Buxmann (2012), come to the conclusion that a framework for business models helps the company reach decisions and foresee the business model life cycle including periods of specification, improvement, alteration, review and restructuring necessary during that cycle. Johnson, M.W. et al. (2008), quoted by Schief & Buxmann (2012), are of the opinion that the goals achieved in the digital economy depend on the business model adopted (Schief & Buxmann, 2012).

Although the article analyzed is more focused on software industry, having in consideration the characteristics and nature of the Internet of Things, the structured line of thought in the article elaborated by (Schief & Buxmann, 2012) regarding business models, can be also applied to the Internet of Things. Even though software in general and Internet of Things have their own differences, the IoT is also part of the digital economy.

The innovation brought by the Internet of Things to the companies can be separated into four levels. Using IoT technology as a business innovation tool for diagnostic purposes only would be level zero. Automation exclusively without changing the business processes would be the equivalent to level one. Level two already uses the technology in a more direct manner, using IoT to increase business process' efficiency. For instance, instead of having a clerk operating the checkout system it would be faster having a RFID-enabled self-checkout at a store or another type of service, which requires customers to scan items. Level three business innovations already integrates IoT technology in their products in which they can install microcomputers or sensors in order to gather data about what the consumer is using that product, how often is it being used, in what way and also to measure the resources used by that product. Level four of business innovation, is the highest level in business innovation because companies use IoT to change their business model, this is so it has a complete perceptibility of their products such that enterprises can adopt the option of renting the product using the pay-per-use method instead of selling it, for instance (Fleisch, 2010).

There is an absence of specific business models for each of the Internet of Things layer (sensing, network and applications) and understanding of how these layers interact among themselves. The effective value delivered by the IoT remains unanswered. The main advantages for companies to implement structured and focused business models particularly when this technology is emerging are that, it can help companies to be the first to easily adapt externally and internally to the market with the IoT ascension and take higher gain from the opportunities in this field. Sun, Yan, Lu, Bie, & Thomas(2012) say with support on literature that the more appropriate business model in this technology would have emphasis in:

- The customers, focus on which are the target customers , their location and if their behaviors and preferences have changed,

- The markets, focus on if they have altered in any way and if market repositioning is required,
- The channel, focus on what is the best channel to provide their products and/or services,
- The infrastructure, focus on who are the companies' main partners, main activities and available main resources,
- The value offered to the customer,
- The revenue and cost focus on the difference in amount generated respectively.

There are many ways of representing business models at an enterprise and industrial level. The principles for the enterprise level are the Value Chain, the Strategy Map, the Four Box Business Model and the Business Model Canvas. More oriented for the industry sector are the Five Forces, the Value Net, Supply Chain and Business Model Environment. Although the models value chain and business model canvas are the ones most commonly applied in academic and practical situations (Sun, Yan, Lu, Bie, & Thomas, 2012).

Sun, Yan, Lu, Bie, & Thomas (2012) adopted and applied the DNA model for the Internet of Things where it stands for the design that targets the "how" question; necessities that concern the question "what" and the aspirations covenant to the question "why" which refers to the ends to be achieved. The other two concepts refer to the means to achieve that end. For this type of model the authors say it has a direct input-processing-output relationship and also it facilitates the understanding of planning, analysis and design throughout the various sectors (Sun, Yan, Lu, Bie, & Thomas, 2012).

The IoT, in this case using RFIDs business model must have some essential features. For example it should be incremental. The architecture technology should register entities involved in the business as the model succeeds, or having an enrollment list since the beginning would also be very helpful. It should be scalable, where the many integrant companies would play numerous of different roles and would have a reuse of the architecture on a different purpose (Villanueva, Villa, Moya, Santofimia, & Lopez, 2012).

The majority of the enterprises that participated in the research conducted by The Economist Intelligence Unit (2013) say they pretend to implement IoT in the company in some manner. For now, the investment is quite low, but very probable to increase depending on the stages of implementation of the technology. Furthermore, it is still undefined how the most successful business models will be like and the majority of the companies are of the opinion that if one of them is slow to implement the Internet of Things, will not keep up with the competition in the market. Another impediment for the implementation of IoT is the lack of employees with enough knowledge and skills to work and take as much advantage as possible from it. To resolve this situation, enterprises are training staff and searching for IoT aptitude, while others resort to hiring consultants or third party experts in order to create and gather knowledge and detect effective business models. It is expected that the IoT makes available new revenue opportunities for already existing products and services, stimulate new working habits or business processes and modify existing business models or strategies. From the study done by the authors, 9% of the senior managers say the IoT would not have any major influence in how their business is managed. There is not a specific way of knowing what business models will provide the best adaptation and results in the Internet of Things,

this answer can be obtained just by trying different types of business models (The Economist Intelligence Unit, 2013).

The Internet of Things can deliver potential for business renovations, although many of them are yet to be discovered and explored. When it comes to technology, especially the more disruptive ones, businesses (and people) need to adapt in order to thrive. It is required to innovate business models. This may imply a complete change in their current business model. By innovating and focusing on new opportunities type of tactics, a company can individualize itself from the competitors launching a competitive advantage and profit for being the first to take the first step. When a model is weakened, it is very difficult to try to strengthen it once again. It would be best to use business model innovation to emerge in new markets. For a business model to be innovative it has to change one or more key elements in its business model as well as their interrelations. The result from these modifications can give origin to a business model that can cumulatively progress or it can be a completely different type of business model. Such as it happened when the Internet appeared, that several traditional businesses were replaced by online shopping and services, others were solely built online and were able to achieve success and now with the ever-present access to information and mobility, these companies have adapted to that situation providing new products and services (Bucherer & Uckelmann, 2011).

This type of progresses in the market it is also expected to happen with the Internet of Things, where new businesses models based on this technology, may substitute the traditional models in the same way as the Internet did. One of the biggest features that make Internet of Things to create value and consequently value proposition is that it will create an enormous quantity of information using physical devices, meaning that exponentially information that is more detailed will be available. It can create new scenarios of value proposition as product related information to the customer or billings according with the usage of a service. Some of the features about the value proposition offered by the IoT are the high detail information to a level that can give a new dimension of clarity and insight about something. It can provide very accurate information and from various sources, suitability of information, access real time and older data for business analysis along with business intelligence for a higher level of management, intelligent decision making based on real time events, mobility and price transparency (Bucherer & Uckelmann, 2011).

Bucherer & Uckelmann (2011) explain some examples of business models, being them the platform as a service, information service provider and the integration of end-users and business analysis and decision making. In the platform as a service model, IoT offers a wide variety of scenarios. In the example provided by the authors, sensors permit the tracing of a product and current position, the condition the product is in or its parts consequently giving the support and maintenance necessary, if there is anything broken after its usage, the practical example given by the authors was from a rent-a-car store. As for the information service providers, the IoT is applied by associating information to a product while sharing easily information for other parties, in particular if there are billing abilities are added as main function. The example given for this situation is a manufacturer company since it requires much information about the parts it is using to produce its final product, this allows a much better flow of information and in a short period of time (Bucherer & Uckelmann, 2011).

The end-user involvement in IoT will connect the users to the lifecycle of the product. The market that can most take advantage from this situation are the business-to-consumers companies. Through

the Internet of Things it can be collected specific information concerning the product itself and its features, with the addition of the possibility of automatically accessing the unique identification with the utilization of Near Field Communication (NFC), bar code reading software, image use and sound recognition. The example mentioned in the article is a supermarket where customers can insert more information about a product and give it a classification, for that it may be necessary for the user to make a profile, in that way the company can track its preferences and product visualizations giving the possibility for them to make suggestions. In the business analysis and decision making example, IoT can provide real time information and analysis prospects for supply chains and product processes. This data can be retrieved from smart objects present in the company or anywhere in the Internet of Things, for instance, the agile type of management requires greatly these kind of information obtained in real time (Bucherer & Uckelmann, 2011).

In this case, the authors take for example an intelligent truck, in which the truck could exchange information in real time with the IoT in the tracking and condition monitoring of the cargo. Besides all these type of opportunities and certain advantages of the IoT, it will take some time for the end users to adapt to this new technology and it is still is far from its full potential. If some of its technical problems are overcome, the Internet of Things and new business models can give win-win situations for all stakeholders (Bucherer & Uckelmann, 2011).

The value creation in IoT cannot be maximized if we focus in the particular layers that constitute IoT in an intangible application, the value in this kind of technology, having as an example a LED light bulb, starts by the physical thing, then the sensor, the connectivity, the analytics and in last the digital service. These layers cannot be independent from each other and the flow between all of them is bi directional. (Fleisch, Weinberger, & Wortemann, 2014)

IoT solutions with more value do not acquire it by just adding more layers, but instead make the integration possible spreading to the physical devices. The manner the hardware is made is in great part influenced by the consequent digital levels/components. If each layer is individualized it will be very difficult to create digital services, considering the development of the IoT era, it is necessary the hardware to be built having into account the interconnections with the Internet solutions. An analysis involving the study of several business models conducted by the authors, return two business models, the digitally charged products which contains six components that associates both digital sensor based and physical products in order to create a whole hybrid and align it with new value proposals. The six components mentioned for this business model are the physical freemium, the digital add-on, the digital lock-in, the product as point of sale, the object self-service and the remote usage and condition monitoring. The sensor as service is a recent and powerful concept, as such it is going to be considered as a business model (Fleisch, Weinberger, & Wortemann, 2014).

The physical freemium, is a physical asset vended jointly with a free digital service. For example digital installations or maintenance and anomalies instructions that come together with the physical product without additional expenses, an example for this case is an intelligent alarm that has many sensors and cameras and warns the user in case of irregularities for free(Fleisch, Weinberger, & Wortemann, 2014).

The digital add-on is a type component in which a customer purchases a physical object at a reasonable price, then according with the necessity, the customer can acquire digital services at a higher price, and the example given is the configuration of the automobile performance software.

The digital “lock in” component merely needs that the original components are compatible with the digital system, the example are the Gillette where, for instance, its razor blades can only use razors from the same brand. Essentially, digital “lock in” in physical products is a sensor based and digital systems agreement arranged to use limit compatibility, avoid reproductions and safeguard warranties (Fleisch, Weinberger, & Wortemann, 2014).

The product as a point of sale component is where the products themselves become a mean to direct the consumer to sites of digital sales or marketing services related to that product, it can be accessed with smartphones and identification technology by scanning the product with a camera, usually from the smartphones. The component object self-service uses the aptitude to autonomously make orders on the internet, in this case the example is when a heating system is lower than a certain level on oil, it automatically can order more. In the remote usage and condition monitoring component, smart devices can convey information about their situation and its surroundings in real time, which allows to detect errors before something happens and monitor the conditions of consumables and inventory, usually this kind of system is expensive but with the IoT growth these systems will become more affordable (Fleisch, Weinberger, & Wortemann, 2014).

The sensor as a service business model is an overall idea of using the sensor data collected, processed and selling it for a fee among subsections, the treatment and usage of this kind of data is not developed the same way it was for just one application, in this scenario it has to be done for a numerous of applications. In opposite to the digitally charged products, this model focuses more specifically in the data and not so much the data generating products and services (Fleisch, Weinberger, & Wortemann, 2014).

After analyzing the point of view from these authors, it is possible to say since the Internet of Things is a relatively new technology, it still has not been reached a consensus about a unique business model or which one is the best for a specific situation, and probably never will be just one model. This is due to the IoT being very diverse and the possibility of being applied in so many distinct sectors, which one with its most appropriate type of business model. Although there are as well some features in common among most of the perspectives studied in this document, the IoT business models involve the usage of data gathered by the several constituents of the system in order to achieve faster and better results, efficiency, effectiveness and customer satisfaction and targeting.

2.5. CHARACTERIZATION OF THE PRIMARY, SECONDARY AND TERTIARY SECTORS IN PORTUGAL

After doing an analysis of the Internet of Things, what it is and the type of implementation and management the companies have towards this technology in general, we need to analyze the main sectors in Portugal where the IoT could be mostly used in our condition. In order to do that we will investigate the situation of the industrial, commercial and services sectors. The articles used and consulted concern the data from (INE I.P, 2015) Statistical Yearbook Portugal 2014 since the information for 2015 was not available at the time of elaboration of this document.

Primary Sector

According with reports also elaborated Statistic Portugal (2014) for the analysis of the primary sector in Portugal, this sector is represented by the agriculture, fisheries and forestry, being that there are two reports, one for agriculture and forestry and other one for fisheries. In the agriculture, it was observed an increase in the production comparing to previous years in the agricultural year of 2013/2014 essentially in the winter cereals, potatoes, vegetables and certain fruits such as peaches, plum and citrus. The olive for olive oil production and processed tomatoes did not reach the expected results as opposite to the products mentioned before, registering a decrease of 33,5% in the olive oil production (INE I.P, 2015).

The animal production in 2014 presented a growth of 1,8% in meat production, mainly in pig and poultry; likewise, the same situation was detected in the milk, eggs and dairy processed products. In the cattle and goats production there was a diminution and the sheep production remained the same level as the previous year (INE I.P, 2015).

Particularly in the pig sector, there was a raise of 4,2% in the meat and livestock production due to a European welfare regulation regarding gestating pigs. Furthermore, the production costs dropped because the costs of input materials also decreased, turning the animal feed prices similarly lower. The increment in the number of laying hen livestock and improvements made to the infrastructures led to the escalation of the eggs for consumption by 5,2% and the milk production augmented 8,2%. The fall in cereal prices influenced positively the annual return, making the year 2014 more productive than the year before (INE I.P, 2015).

In 2014 the output price index of agricultural goods decreased 6,0%, it increased to 5,7% in 2013, the main products that contributed for this scenario were potatoes, forage plants, fresh vegetables , other animals and pigs. The price index of goods and services expended in agriculture declined by 2,4% because of the price index of fertilizers and soil improvers, energy and lubricants and animal feeding. For the price index of goods and services that contribute to agricultural investment showed an increase of 2.3%, from the augment of prices index in machinery, transport equipment and other type of equipment. The agricultural income decreased by 3,0% comparing to 2013, regardless of the reduction in agricultural labor input. The behavior of the income redirects the evolution of Gross Value Added (GVA), it was -3,2%, and on other subsidies on production, this was -4,2%. To the GVA decrement, from the nominal perspective, the main responsible was the negative variation in the agricultural production (-3,5%) balanced with the reduction in intermediate consumption (-3,7%). From the real perspective, the GVA rose by 3.2% (INE I.P, 2015).

In forestry the GVA improved by 6,0% in volume and 8,7% in value in 2013, comparing to 2012, maintaining the growing tendency since 2009. In order to achieve these results, the production of wood, which raised by 6,7% and cork (increased by 6,0%) were a determining factor. The production increase of these materials was due to favorable changes in both volume and price. Furthermore, 2013 registered an augment in volume of forestation that provides a regular income (more 14,9%) because of eucalyptus replanting (INE I.P, 2015).

The Statistics Portugal report states that the trade balance deficit of agriculture and agro-food products was 3,2 million euros. The importation of these type of products in 2014 decreased 4,3% in comparison to 2013 and exports increased more 4,7% (INE I.P, 2015).

As for product suppliers Spain is Portugal's main supplier in agriculture and agro foods totalizing 48,7% of the imports in 2014, followed by France (9,8%), Germany (5,4%) and Netherlands (4,9%). In the exportations, Spain remains as an important client for national products, representing 36,9% in 2014, followed by Angola (11,8%), France (9.1%) and Brazil (6,3%) (INE I.P, 2015).

Considering now the demand and offer in the market, Portugal was only able to produce 72,2% of the meat necessary to satisfy the consumer consumption and the average meat consumption by resident was 108,1 kilograms. In the milk and dairy products the level of self-sufficiency was 96,8% in 2014, the milk for human consumption in particular had a degree of self-sufficiency of 110,5%, this value was obtained because of the fall of human consumption of this product in 2,1%, the same situation applies to dairy products (INE I.P, 2015).

The cereal self-sufficiency level in 2013/2014 increased by 17,5% than in 2012/2013, even though this value for cereals is structurally low, it was the best in the last four years, achieving 25,5%. The production of whitened rice in Portugal improved by 3,8% between 2012/2013 and 2013/2014, presenting a level of self-sufficiency of 97,0% in 2013/2014. Portugal is not considered self-sufficient in fruits, with a rate of importation of 26,0% between 2011/2012 and 2013/2014 where it showed a self-sufficiency level of 76,8%. The human consumption of this product increased 13,4% in 2013/2014. The olive oil has a value of 103,7% in self-sufficiency (INE I.P, 2015).

In the trade balance of forestry, all groups showed an excess of merchandise in 2014. The "furniture, wood, constructions and rattan products" had the highest increase with 38,3 million euros because of the growth in exportations. Paper and cardboard registered the highest amount in excesses in the sector with a value of 754,2 million euros, overcoming the cork group with a value of 717,7 million euros. The groups of pulp of wood, wood and resin products showed a decrease in trade balance comparing to the previous year (INE I.P, 2015).

Concerning the fisheries, in 2014 there were 15 producers organization to which belonged 1585 fishing boats in total, slightly larger number than in 2013. It was observed a diminution in the amount of sardines caught, less 42,8%, as well as mackerel, less 22,5%, and horse mackerel with less 3,8% the main reason for this situation was a solid restriction in the catch of sardine in Portugal's' Mainland. There was a considerable rise in the annual price for the fish unloaded from 1,70€/kg in 2013 to 2,02 €/kg in 2014. According with the most recent information the Statistics Portugal gathered, in 2013 industrial production in fisheries, reached 246 thousand tones, more 11,2% then in 2012 and sales increased by 3,7%. From the quantity mentioned before, more than a half of it corresponds to frozen products and the remaining to salted and dry products and in this particular group, the codfish represents 82% of its' total production. Furthermore the structure of canned fish it was registered that the canned tuna overcame the canned sardine production in 2013. International trade balance of fishery activity had a 662,5 million euros, showing an augment of 7.1%. As for the imports, frozen fish was the major part of importation, being the main suppliers Spain with 42,5% and the Netherlands with 21,6%. The dried and salted fish characterized by having the larger deficit in 2014 with 214,2 million euros, it increased 1,2% and the main provider in Sweden (55,5% in 2014) followed by the Netherlands. For the canned fish, the balance was positive to Portugal in 2014, with excess of 50,4 million euros, and lower by 12,9% than in 2013 (INE I.P, 2015).

Industrial/Secondary sector

In the industrial sector, the whole value amount in products and industrial services in 2014 attained 76.1 billion euros, a raise of 0,4%, an increase comparing to the previous year. Nonetheless, this result was affected by the strong decrease of the production value in the refined petroleum products partition, which was less 15,7%, reflecting the prices reduction of these products. Apart from these situations, the nominal variation of the remaining industrial activities was 2.9% in 2014, less 0.7% relating to 2013 (INE I.P, 2015).

Roughly, regarding the industrial production is observed a robust concentration that represents the ten major enterprises in each division, which put together, make more than a half of the total production. Even so there is some diversity in this sector, where fifty of the major food products industries and metallic products make part of less than half of the total produced in global. Five of the main activities out of twenty six are able to produce 44,4% of the global value production, being the food product, coke and refined petroleum manufacturers representors of 24,7% of that percentage, a small decrease to 2013. Gas oils was able to reach the amount of four billion euros in sales, more than twice the value of second placed product with the highest sales (conventional thermal electricity), however these products still show a nominal decrease of 13% and 3,6% in relation to 2013 (INE I.P, 2015).

The areas that more contributed positively for the sector growth were automobile manufacturers with a variation of 7,6%, clothing industry with a growth of 11,3%, and metallic products manufactures except machines and equipment with an increase of 5,3% . The ones that contributed in a negative form for the activity evolution were the refined petroleum products partition already mentioned before and electronical equipment manufactures and food industries that have a decrease of 9,9% (INE I.P, 2015).

This sector needs to be modernized. Industries in this country are mostly small and medium companies but also are the ones that want to reinvent and attempt to transform constantly (PwC Portugal, 2013).

Comparing to the rest of the UE, Portugal remains in a little “on the side” because we still lack some investment in key areas such as technology, operational organization and working methods in order to be more competitive. Since the industry needs large amounts of energy in order to function, the cost of energy is one of the main concerns for most of the Portuguese industrial companies because it has a direct impact in the revenue and weakens the competitive power facing global concurrent industries with more inexpensive energy (PwC Portugal, 2013).

This could mean the unviability of some industries where the energy cost is very relevant. Other measures this sector has to have in consideration are the investments in training and innovation in their companies as the industries require intensive and continuous flow of know-how, need to be updated about technological developments, tendencies and how to potentialize the in house knowledge (PwC Portugal, 2013).

The size also matters, the largest companies have better results, in both production and financial matters as well higher level of exportations and likewise the progress of a company, capacity for innovation and development and entrepreneurship depends on the size of the company. However, a

cluster constituted by small and larger companies with scalability, innovation, agility and entrepreneurship will be key to the relaunch of the industry as a sector of relevance to the country at an international scale, putting the companies at a higher level of competition in the external markets of its activities (PwC Portugal, 2013).

The portuguese industry still has not a good reputation in environmental and working matters, innovation and remuneration making difficult to be attractive and retain talented workers, get financing and participation in political initiatives. The relaunch of the industrial sector in Portugal must realign with the Europe 2020 strategy focusing on international competition by making a transition for a knowledge economy, technological and green (PwC Portugal, 2013).

Nowadays we are facing a strict economic cycle, building the need for more dynamic productive national sectors. With the economic crises was possible to observe in the last decades there is a higher concentration of economic activity in the tertiary sector, reduction of activity in the productive sector and transactional goods, fragilities at competition level and lack of diversification in the industries (BPI Portugal, 2015).

Industrial companies have to invest in products process optimization, innovations, different markets and assertive practices in order to achieve their objectives (BPI Portugal, 2015).

To improve the industry companies also need to identify clusters, access to credits at a reasonable price, raw materials and energy with amounts more similar to the rest of the Europe, less bureaucracy and better judicial system. According with the data obtained and analyzed by the bank obtained by it and Pordata, they concluded that with time, as Portugal became more focus in the tertiary sector, the secondary would lose economic and social prominence. When considering the GVA, of the total amount of 152 billion euros in 2014, about 21,4% belonged to secondary sector (BPI Portugal, 2015).

Commercial/ Tertiary sector

In opposite to the three previous years, the Gross Domestic Product recorded an increase, in real terms, to 0,9% (INE I.P, 2015).

For this growth the main areas that contributed positively for it were the private consume and the formation of gross capital, after three years of reductions. The public consume had a negative impact, although less severe than the last three years as well as the net external demand which was negative in contrary to the previous year, due to an growth in goods and services importation, more 7,2%, than exportations, just 3,9% (INE I.P, 2015).

In 2014 the unemployment rate decreased to 13,9% from the 16,2% registered in 2013. There was also a positive result in the main economic indicators in the non-financial entrepreneurial sector. The number of these types of companies increased more 0,4% and also the number of employees that work in these companies with a raise of 1,7%, there were less 0.8% in 2013 and the same situation was verified in business revenue which also had less 0,8% in 2013 (INE I.P, 2015).

The commercial sector had a similar path to the one mentioned before, it recorded a lessening of 1,3% of companies, the business revenue also increased more 3,2% than 2013 and the amount of

sold merchandises also grew to 2,9%, number of employees rose slightly and the remuneration augmented 2% (INE I.P, 2015).

The automobile commerce, reparation and maintenance subsector showed a considerable increase of 17,2% in business revenue after the increase of 4,1% in 2013, the commercial margin also increased in a global manner and individually in each company of this subsector to 11,1% and 11,3% respectively. For the growth of the business revenue in this subsector, the main contributor was the commerce of automobile vehicles, which represents 72,7% of the business revenue (about 10 thousand million euros), showing a growth of 22%, in 2013 it was 4,7% (INE I.P, 2015).

The wholesale commerce was the subsector with fewer results in the entire commerce sector with decreases in the number of companies (from -1,6% in 2013 to -2,1% in 2014). The employees number stabilized at -3,8%, this subsector also had slight growths in the business revenue to 1% (-1,2% in the previous year) and the commercial margin also increased to 2,3% (-2,7% the year before) and 4,5% per company, the previous year was -1,2%. In this situation, the factor that contributed more for the growth of business revenue was the wholesale of food products, drinks and tobacco and the wholesale of goods for domestic consume, making 76,9% of the total business revenue in the wholesale commerce subsector and the wholesale of fuels and construction material corresponds to 28,2% of the business revenue. Also the wholesale companies are located especially in the north of the countries (37,3%), Lisbon (28,7%) and center (21,6%) (INE I.P, 2015).

In relation to the retail commerce, it was the only one to show augments in the number of employees although the number of companies have decreased to -1,2% in comparison to 2,9% in 2013. The retail commerce likewise presents positive variations in the other parameters comparing to the year before. The non-specialized retail commerce, that takes into account the supermarkets and other generic companies produced 40,3% of the business revenue of the total subsector, while the specialized companies made the majority of the business revenue in 2014 (INE I.P, 2015).

Ninety eight of the large enterprises with more than 250 employees corresponded to 18,8% of the business revenue from all the commercial sector. Individual companies make 57,6% of the sector and societies although fewer in number generate 95% in business revenue of the sectorial activity and guaranteed 78% of the employment in the sector (INE I.P, 2015).

The retailed commerce presents 61,2% of the exiting companies in the commercial sector while the wholesome commerce is a quarter of it, but it produced 51,5% of the global business revenue and the automobile subsector is about 12,5% of the total number of companies (INE I.P, 2015).

The electronical commerce delivered 14,8% of the global business revenue in total commercial companies with ten or more employees which is a raise comparing with the preceding year. The proportion of companies that made orders through electronic networks were 35,1% while the percentage of companies that received orders through the same means was 26,7%. The equipment for technology and information systems is a significant part among the retail companies that was sold in specialized companies and others that are not (INE I.P, 2015).

In the non-financial companies, the commercial sector showed to have interesting results, it represented 20,3% of total of the companies, 21,2% of employees at service and 37,3% of the business revenue of the entire non-financial business sector (INE I.P, 2015).

2.6. INTERNET OF THINGS IN PORTUGAL

2.6.1. Overview

There are four main factors which can affect the IoT market. These four factors are; the economy, because it determines the ICT investment available for new technologies such as IoT, so whether the economy is healthy or not, it will have an impact in the IoT market. The embedded computing, which allows the connectivity between objects and networks. The internet usage, wherein people use the internet for browsing, communicating, social networking and commerce, however, when the internet connects to everything, the usage will increase immensely. The last factor is the regional growth and government support as there are significant differences among the several regions in the world in terms of ICT insertion, government support in that area, particularly in IoT, and economic development. With the support from governments and action within European Union to achieve standardization will be possible to have a clear impact in the IoT development for the region (Aguzzi et al., 2014).

The four factors mentioned previously in addition to the dynamics of member states and economic situation, divide the countries in the EU28 in four clusters. Divide as fast growth, good growth, low growth and very low growth countries, with Portugal being in the cluster of the very low growth countries in comparison to the rest of Europe in the IoT market (Aguzzi et al., 2014).

Even though all countries will take part in the coming of the IoT, the countries that invested more in ICT are more likely to return the benefits from the Internet of Things than those that did not. Consequently, countries like UK, Germany and France are more likely to be the first ahead in the market, taking more than half of the IoT revenues in combination with Spain, Italy and the Netherlands, making it around 75%. The main initiative for this technology in Portugal appointed by the author is PlanIT Valley. Still taking into account those four factors (capabilities) and the initiative level, in the report the Netherlands, Sweden or UK will be successful in the initiatives and capabilities as leaders in the Internet of Things technology. Portugal for instance is very active in taking initiative projects for IoT, but does not show the required capabilities when it comes to infrastructure, know-how and connectivity (Aguzzi et al., 2014).

The Smart Cities magazine has an article written by the author mentioned about the IoT in Portugal where she interviewed several entities that gave their opinions about its' prospective. One of the opinions is that we are already are using the Internet of Things in our society in a very connected urban environment. At the pace the IoT is emerging and being adopted in Portugal, it cannot show much of a difference from the evolution in other countries since the IoT possesses the capability for intercommunication, creating a reduction of distances and allowing the opportunity of developing both global and local solutions. Allowing the internalization of the projects developed in Portugal (Filipa Cardoso, 2016).

It was also known that Brussels is going to make an investment of 100 million euros for six pilot projects at large scale, beginning in 2017. According to the investigator interviewed in the article analyzed, Pedro Maló, the Internet of Things in Portugal can take three directions (Filipa Cardoso, 2016).

First is the investigation projects led by the European funds with the Horizon 2020, which means pilot projects throughout the country, after which; the second is that here will be development of national technology with great results and an enormous exportation potential and lastly there are the opportunities that come with the large scale European projects (Filipa Cardoso, 2016).

If Portugal creates something that goes along with those types of projects or complements them, then it is possible to increase the effect of innovation and scale, obtaining a decent visibility and at the same time creating something significant, robust and notable (Filipa Cardoso, 2016).

Indra, an information technology enterprise, shares from the same perspective as Pedro Maló, saying that Portugal is well positioned. The director of Soluções Tecnológicas, Vasco Mendes de Almeida adds although it is required to know how to arrange the implementations of the technology in a form that it has applicability, makes sense and added value in the citizens and organizations life (Filipa Cardoso,2016).

It was stated that the sectors like health, transport, utilities and safety and security could adopt different patterns due to the integration of information more easily, as for instance smart cities that already shows that kind of integration and is taken into account by decision makers. For Indra there are two main components, sensors and data analytics. It is stated that the IoT may work as an infrastructure for the smart cities having as a foundation of interoperability of real world objects with the virtual world and at the same time process that information through big data. Esri Business Director in Portugal, Nuno Pereira Leite indicated the exponential increasing of the utilization and combination between GIS and IoT sensors is a case of success, and it already exists nowadays. For example, this arrangement was applied in the water sector and it is helping to reduce losses, maintenance and planning costs. In addition, the technology can assist in detecting, alerting and showing to the employees at service the damaged water network section through a digital map, which saves large amounts of time and money for technicians to find the source of the problem. Furthermore it will also help to avoid future damages and problems (Filipa Cardoso,2016).

In a different interview conducted by Célia Marques for the newspaper “Económico”, Pedro Maló said the main forms where Portugal can have a significant impact in the handling of large amounts of data gathered by the IoT technologies is by mining useful information from all that data for posterior exploration by diverse entities. One different approach in which Portugal can be successful while leading with IoT is in the development of hardware technology for devices that collect information and data for specific applications (Célia Marques, 2016).

Agenda Portugal Digital applies the ambition from Europe Digital Agenda into national perspective and summarizes the main challenges for the future in I&D and innovation for ICT in Portugal, also mentioning specific measures for development. In the case of IoT it will focus in I&D of the technology, national industry of “things connected to the internet”, public infrastructures for things connected to the internet in different domains (smart cities), smart transportation, smart grids and smart healthcare, connectivity with enterprises private infrastructures and Internet of Things service market interoperable at European level. (FCT)

Through a study elaborated by Accenture Strategy (2015) in conjunction with The Economist Intelligence Unit, a purpose to understand is that of the strategies in the digital investment scenario and the prospects of IoT for the Portuguese companies. Most of the portuguese companies who

participated in the study identify a positive impact the IoT can bring both to the economy and to their businesses. About 54% say the central impact is in the increase of operational efficiency while others said it was the direct augment of business revenue. Besides the impact in an operational view, the executives believe the IoT will bring also better working conditions through the increase of job positions (around 96% agreed) and employee salary (about 86%). Furthermore, 66% stated they understand the concept of the Internet of Things and 92% believe this technology will bring new sources of income, although only 14% said they already have a strategy defined for the IoT. However, around 82% are in the initial stage of the strategy and 2% not yet reached that point. Portuguese managers appointed the key barriers for the IoT growth the lack of access to funding and to the technology. The main benefits identified in the study include, better internal control and a supervision level in the enterprise, operational security, optimization of the assets and productivity. Generally, the executives are of the opinion that the IoT will bring them benefits and most of companies refer to follow the belief that this technology will make a difference. The principal question is which companies are going to exploit this opportunity and be successful and which ones are going to be left behind this digital transformation (Accenture Strategy, 2015).

The overall problems mentioned in the analyzed articles were the security and privacy due to the number of devices always connected to someone or something and the increasing number of hacker attacks. Other concerning issue is the digital illiteracy caused by demographic changes and population aging, leading to decision based only on technology from people that are more comfortable with it which may not be the best decision for the rest of the individuals affected by it. Besides the advantages mentioned throughout the articles, it is highlighted how to take advantage of the Internet of Things, treating the data and information in the most beneficial and profitable manner to improve the possibilities for enterprises strategy and citizens' lives.

2.6.2. Internet of Things Projects in Portugal

In an article from Económico newspaper, where the author Célia Marques (2015) interviews Pedro Maló, is mentioned that one of the main projects in Portugal is conducted by TICE.pt. It is a pilot project at large scale with the support of the Portugal 2020 field to launch enterprises, institutions of the national scientific system and the public sector in the IoT sector (Célia Marques, 2015).

The project PROTEUS consists of using an intelligent sensor system which measures in real time the physical and chemical factors for consumable, residual and pluvial waters. This project started in February 2015 and had an investment of 4 million euros (Célia Marques, 2015).

One very successful portuguese startup in the Internet of Things area is Sensefinity. This startup focuses on the Internet of Things for the masses. The main projects they worked on are the Smart Farm, where a customer wanted to compare the quality of the milk with the feeding ground of the sheep and at the same time monitor them. Therefore, the startup through the technology enabled the customer to study historical data and compare the best batches of milk with the feeding ground used. This will help farmers, with basis on data, to take the best decisions for a better product quality. Other projects from this startup include the Sensorice Cold Chain Monitoring, which helps in the monitoring and control of vaccines, food or sensitive chemicals storage and handling conditions by automatically sending alarms and onset crossing notifications. It also analyzes the performance of

fridges in the supermarkets and can help hotels to save energy and even elaborates HACCP reports. This project was applied to Delta Cafés, Yonest and Fragoleto. Furthermore, the Sensorice Cold Chain Monitoring won the first prize in the EIT Digital Idea Challenge (Sensifinity, 2016).

The company NEC announced it is developing a solution to apply to the agricultural sector in order to collect and analyze large sets of data. This idea was implemented in January 2015 into a tomato plantation in Castanheira do Ribatejo. The purpose of the solution was to generate a virtual agricultural field with every morsel of information about the weather, soil and vegetation conditions assembled using drones, sensors and satellites. All of this combined allowed for the possibility of creating simulations or forecasts for those virtual fields, which later were used to make customized recommendations about cultivation and productivity estimations. This technology was developed having considered the optimization of agricultural resources and enables us to make scientific modulations in accordance with crop growth levels and environmental conditions (NEC, 2016).

Besides these examples there are innumerous projects and small to larger enterprises and universities focused in developing and implementing Internet of Things all across the country by creating new and innovative solutions with the objective of improving the functioning of other enterprises and society. In Chapter 4 are going to be approached a few more case studies in more detail.

3. RESEARCH METHODOLOGY

3.1. RESEARCH STRATEGY

In this chapter, the purpose is to explore a research methodology effective enough to gather the most viable results so that we can extract clear and concise conclusions to use as support the subjects approached in the literature review.

For the topic in the study in the present dissertation, the research strategy considered involves choosing enterprises known for being leaders in the adoption of emerging technologies in their business as well as being leader in the market analyzed. Furthermore, the idea is also doing the interview for enterprises that provide or implement the services and compare visions about this technology, what impacts the enterprises have in mind and what the IoT will bring to their business and even society. Startup enterprises will be analyzed as the main mission and growth will be based on the use of IoT technologies to help the improvement of other enterprises in the market. Some public entities are also going to be studied in order to understand the implications and what the IoT is going to bring from their perspective.

Therefore, the research methodology that seems more appropriate in order to study this subject is a case study, since an analysis will be illustrative of situations of the large and small companies, which will be applied to entities with direct contact with IoT in Portugal.

In the following subchapter, the “case study” research methodology is explained.

In Chapter 4 it is possible to observe the draft of the approach used for each case study, with the details of the interview script as well as the analysis of the interviews conducted as per the type of entities previously mentioned.

3.2. CASE STUDY

Case studies are used as research methodology to investigate a occurrence in its neutral environment, by using various means of gathering data and information from one or more entities and then proceeding to the analysis of that information. This type of methodology is more appropriate for investigation, classification and hypothesis development. The investigator must be accessible towards the investigation without altering the results obtained in any form. One of the characteristics for this research methodology is that it may not be possible to identify sets of dependent and independent variables beforehand. This type of methodology can use quantitative, qualitative methods or a combination of both. The case study represents a research strategy connected to a history, hypothesis, experiment or simulation that can also lead to a different research strategy. The main problem with this methodology is that, it is quite complicated to apply the conclusions gathered from its applicability into a general setting. However, the authors also mention that generality may not be problematic from another point of view. In that perspective, this type of methodology can be considered usable because it is seen as a method for organizing data rather than a technique for obtaining data. The focus in this case is to present a logical reasoning

used to describe the results obtained and reach a conclusion through them (Kanellis & Papadopoulos, 2009).

In software engineering research, as well as in most situations related to technology depending on the population analyzed the trend has been quantitative methodologies, although for some years the qualitative methodologies for research in this area have been implemented mostly in situations that can be studied in isolation. This method can provide an insightful understanding of the results obtained and most academics disregard the case study as a viable methodology because it is less valuable and difficult to apply to a general population. The authors, with ground in other articles, defend that in information systems research, the case studies' methodology is more developed than in software engineering (Runeson & Höst, 2009).

Considering this, it may be possible to say that a case study is a reasonable methodology to apply to this research.

Case studies to explain a situation or problem but also can be used for descriptive purposes if the generality is just used in order to understand the context. There are three types of case studies: the positivist, critical and interpretative. The positivist consists of searching for evidence of formal propositions, measure variables and testing hypothesis. The critical is based on making social critiques and interpretative tries to understand the occurrences from the participants point view of the context having a tendency for a descriptive and explanatory perspective (Runeson & Höst, 2009).

In the Internet of Things business models research seemingly the most suitable type of case study is the interpretative since it is going to study the "as-is" and "to-be" situation of business models and IoT market in Portugal in the different sectors.

The existing types of data, are the quantitative and qualitative data. For case studies, the more common is qualitative data, although to achieve better results, the most appropriate would be a combination of quantitative and qualitative data making it a more flexible type of data gathering tool. This combination is called triangulation. Being divided in four types of triangulation, the data source triangulation uses more than one data source or assembles the same data in different periods, observer triangulation uses more than one observer in the study, methodological triangulation combines both qualitative and quantitative methods and the theory triangulation, uses alternative theories or points of view (Runeson & Höst, 2009).

In this dissertation the data source triangulation theory will be adopted since the method used are going to be interviews applied to different companies from different perspectives and backgrounds.

The case study processes into five points to be elaborated: the case study design where the objectives and structure are defined analyzes the manners through which data can be collected, proceed to the data collection, analyze the results obtained through the data gathered and finally includes reporting. These procedures are applied to some extent for empirical studies. But since case studies can be versatile there can be alterations to these techniques and nevertheless strong preparation is required. The plan for a case study has into account: the objective of what is expected from this method. The case, which is the topic that is going to be analyzed, the theory to establish the case study. The research question, what to know about the subject. The methods on how to

gather the data and the selection strategy, which are the sources providing viable information (Runeson & Höst, 2009).

Following these guidelines to design a plan for case studies, the objective for the case in this document is to understand how the situation for the Internet of Things in Portugal is, how companies view it and what expectations they have about it for the their enterprise, society and for the diverse sectors. The case is the Internet of Things in Portugal from the market and economic perspective. The research question is which the Internet of Things business models in Portugal are. As for the data collection method, interviews will be made use of along with the selection strategy for the purpose and objective of this dissertation. The interviews will be applied to some large enterprises that develop and/or provide IoT services and startups with the same objectives, as well as to some public institutions with the objective of gathering different opinions and visions for the Internet of Things in order to understand the perspective and point of view from different sides of market in Portugal.

The types of methods to gather data are the direct method, such as interviews. The indirect method can be conducted through surveys, for instance. The independent method can be conducted through documentation analysis, for instance. In case studies, most of the times it is necessary to collect sensitive information, which has to be handled within certain rules. It is required to have a high level of research ethic such as request for informed consent, review board approval, confidentiality, treatment of sensitive information and feedback (Runeson & Höst, 2009).

In this dissertation, as mentioned previously, the only method used will be the face-to-face interview, as it will be easier to interact with the person interviewed and give margin to make additional questions, if necessary.

In order to conduct an interview and gather data, it is required to prepare a set of questions to be applied to a set of specific targets for the study about the topic being analyzed for the research. Usually interviews are made individually with each source, but group interviews are also possible (Runeson & Höst, 2009).

For this document, the interviews will be individual with each defined subject using a guided set of interview questions that will be presented in Chapter 4.

The questions for the interviews can be open ended leaving scope for a wide range of answers and points of view or close ended giving only a few options for different answers. The interviews can be divided into three types of structures. The unstructured is constructed as general interests for both parties in the interview where they can exchange ideas and opinions. The structured interview is solely based on planned questions and the interview is conducted in the same order the questions are presented and the semi structured has planned questions, but the order and if they are used or not depends on the flow of the conversation which, allows improvisations and explorations of the studied topics. The interview session has specific structures as well as, the funnel model, where the interview starts with open questions and along the interview the questions become more specific. The pyramid model, starts with specific questions and then begins to open to more general questions. The time-glass model, starts with open questions, and starts focusing more on specific questions in the middle and at the end of the interview uses open ended questions again(Runeson & Höst, 2009)..

For this research, the structure of the interview is going to be structured and for the type of session the pyramid model will be taken into account. As a method to facilitate data collection and further analysis, the interviews will be recorded and posteriorly transcribed.

In the data analysis, the main objective is to extract conclusions from the data obtained and keep them coherent and true to the data. In this process we also investigate if there are patterns between results or data gathered for the collecting method. Finally, in order to do the report we should have enough data and clear results for the reader to understand the chain of evidence and thought (Runeson & Höst, 2009).

4. STUDY ANALYSIS

4.1. ORGANIZATION STUDY

In order to conduct the case study, several companies were selected to do the interviews. The ones chosen were mainly companies that operate in the area of the Internet of Things, have experience and relevance in the market, and are more familiar with the obstacles and opportunities in it. The objective is to better understand their perspective. In order to have a wider range and focus specifically on one region I selected four entities from Lisbon and three from Porto. There are two interview guides, one that was used for most of the interviews and another one that was conducted to OASC with the objective of having a more strategic point of view about the Internet of Things in the society, presented in subchapter 4.3.

Microsoft Portugal

For the Microsoft Portugal interview, the person contacted was Engr. João Almeida who is Technical Evangelist in the company and works for a department called Developer Experience. He said this department is in some way different from the rest of the other departments, in a sense that they have channels, segments and areas focused on working with some clients in particular, providing them with technical component up to the business advisory. In addition, this department is mostly oriented to the new technologies and they deal with all kinds of clients, from startups to larger dimension companies in Portugal. Within this sphere of clients, one of the departments' aim is to introduce and to explain and inform them about the new technologies and trends, independently of the type of industry the client belongs to. Moreover, they also give a perspective of the Microsoft technology available and how it is developing by making demonstrations, making many events and working very much directly with the communities in Portugal. One of the main objectives of the work of this department is getting to know and supporting partners in events held by the technical communities, not only communities that work with Microsoft technology but also other communities that work with open source technology.

Engr. João Almeida and most of his team have a development background and have more experience in enterprise development area. With the rise of the Internet of Things, they started to work on IoT approximately for one year and a half.

Sensifinity

The interviewee in this case was Engr. Orlando Remédios, CEO of the startup Sensifinity. "The startup was created in 2013 by a team of Nokia employees with experience in machine-to-machine communications, previous version of the Internet of Things and it was perceived there was some difficulty for small and medium companies in adopting the Internet of Things methodology. The company observed several drawbacks mainly in the time and cost of implementation and the difficulty of the IoT components. Our idea for Sensifinity was to create a solution completely integrated which contains the hardware, software and the communications in a manner to facilitate companies to adopt the Internet of Things."

Mainhub

Pedro Rosa, CEO of Mainhub, was the person interviewed, “I frequented the degree in Industrial Engineering and Management but it did not make sense at the time so I started working in Informatics, then went to Poland to work after that went to Microsoft and after Microsoft I created this space. It is a company for incubation, we also have a company of software development and we incubate startups that work in the Internet of Things area, overall Mainhub is an incubation company.”

Cisco Portugal

The interview was conducted with Engr. António Feijão who is responsible for IoT business development in Cisco Portugal. He has considerable experience in information technologies area, particularly in Cisco where he worked more in the sales and pre sales in the technical area.

FEUP

In FEUP the interview was conducted with Professor Luis Almeida, who is an associate professor in the Electrical and Computer Engineering Department of the University of Porto, and a member of the Institute of Telecommunications where he coordinates the Networked Systems group and within it, the Distributed and Real-Time Embedded Systems laboratory. He currently works with real-time communication protocols for embedded systems and wireless communication and middleware for teams of cooperative autonomous agent.

OASC

OASC tries to promote the connection among several cities in using the logic of open platforms it is related to Internet of Things because of the association with smart cities.

Margarida Campolargo, OASC Task Force representative in Portugal, was the person interviewed from Open and Agile Smart Cities (OASC). She is an architect, who started working in the area and then changed mainly to social innovation. Her contact with technology was through the social part and started working in European and international projects for five years. “It began with a project related to technology and social innovation where I was responsible for the pilot project and its practical implementation in an enterprise in Lisbon.” In Lisbon also started a program with Professor Álvaro Oliveira related to human smart cities which is a more evolved concept from smart cities and focuses more in the human part, the technology at the service of human beings and of the citizens. Then she went to Porto and started a collaboration with smart cities associations. She currently works with Porto city hall and Porto Digital (in this interview she is not represented as speaker of either institutions) in the innovation area as responsible for international projects in that department. She is in OASC as well and has her own company, which is focused in the tourism sector and smart cities: it elaborates some projects and strategies and supports networks in its functioning.

Porto City Hall

The person interviewed for this institution is Alderman of Innovation and Environment Engr. Filipe Araújo in an elected position for three years. Originally from Porto, he graduated with a degree in Electrical and Computers Engineering in the University of Porto, did the master degree in

Manchester, through Erasmus and after returning worked for many years in a telecommunication company, after that started getting involved in different processes and projects and is now occupying his current position.

4.2. INTERVIEW GUIDE

I - Present Situation concerning Internet of Things

1. What is your opinion on the Internet of Things?

2. What is the best architecture in your opinion for this technology?

3. What applications do you develop/apply for your customers? What kind of technologies do you use to build them and how long does it usually take?

4. What kind of businesses require your services? Which are the main sectors?

5. What are the main objectives from your clients when implementing an IoT solution?

6. What improvements has the client shown after the implementation? Did it change their type of business model? If so, in your opinion, did it change drastically?

7. What is your type of business model? Do you consider your business model to be much different from that of other technological companies? If so, in what way?

8. Do you think, currently, companies are well prepared to implement and adapt to the changes the Internet of Things solutions can bring? What suggestions do you have for current and potential customers in order for them to implement IoT and stand out from the competition?

9. What do you think about the current national and international IoT market and their economic impact?

10. Have you implemented or are considering to implement an IoT technology? If so, what type of solution do you anticipate? What are your expectations? So far, based on your results, what is your opinion?

11. What do clients demand from IoT suppliers?

12. In what departments will IoT technology be most useful?

13. Do you think IoT can help your business stand out or get ahead from your competitors ?

14. What do you think are the advantages and/or disadvantages of IoT/IoT Portuguese and the international market?

15. Do you think there is enough investment, motivation, partnerships and support from the government or other companies to promote IoT solutions ?

II – Future Situation for the Internet of Things

1. What are your perspectives about the Internet of Things in your business?

2. How do you see your position in the IoT market in 5 to 10 years?

3. Do you expect any differences from the original solution you have developed or do you think your business model will remain the same?

4. Which sectors do you think it will require more IoT solutions in the future?

5. Do you think companies will show more maturity when planning and considering implementing IoT technologies (or any other emergent technology)?

6. How do you idealize the IoT market nationally and internationally in the future, from a supplier perspective? What types of IoT services/products do you think there will be in the future?

7. How do you view the market with the settling of IoT technologies in companies (if does settle)?

8. How much do you think companies will change in order to adapt and work with IoT technologies ?

III – What is your opinion about the utilization of Internet of Things in Portugal?

1. What impact will it have on the society and the economy?

2. How do you think Portugal will position itself in comparison to other countries in Europe? And in the world?

3. Do you think Portuguese citizens will accept and adapt easily to the technology?

4. What other opportunities can IoT bring, for companies, civilians and the government?

4.3. IoT Strategy Interview Guide

1. What is your opinion about the Internet of Things?

2. What kind of projects have you been developing?

3. In what way is the Internet of Things going to help create or improve business models?

4. In strategic terms, which are the cities that stand out more in the utilization of the IoT?

5. Is there support from the government?

6. What is the position of Portugal in relation to the other countries in the IoT and smart cities area?

7. How does IoT play its part when it comes to politics?

8. How do you think citizens will adapt to IoT?

9. What is your vision of the IoT in 5 or 10 years?

4.4. EXECUTION AND RESULT ANALYSIS

The interviews were conducted with each responsible for the Internet of Things in their enterprises and institutions. The interview were recorded in Portuguese and posteriorly transcribed and translated, as presented in this chapter. The objective was to better understand each company's perspective in regards experience with the Internet of Things technology, their markets and their clients.

In this chapter the interview was separated in six key topics: technology, business, strategy, economy, vision and positioning and impact. Each topic begun with a question followed by its respective answer and an analysis about the overall responses received for the particular question. Furthermore, there is a global analysis presented in subchapter 4.5. Some interviews may vary from others as a few questions were made differently in order to provide a more strategic perspective from the interview. The entirety of the interviews can be found in the annex.

I – Technology

1. What is your opinion on the Internet of Things?

Microsoft: *"The Internet of Things is a way through which we can connect to practically any device to the internet in such a way that it is possible to gather telemetric, information that is bidirectional. That is to say we can have any device connected to the internet, connected to many services, and that can provide us with a wide variety of opportunities because we can use services like machine learning with some level of intelligence that can support devices considered to be disconnected. Reality is going to change significantly. As mentioned before, this technology is going to be applied to the vertical market such as the agricultural sector, telecommunications, media, and marketing will be also a great area where IoT can be applied since it will provide more room for creativity and different ideas. Furthermore, this technology will permit all the companies from every sector to create new business models. They can then analyze how the current situation of their business models is, and with the IoT they can explore and expand into new areas they may have not considered before. It can be either a drastic change or a complement to their current business model".*

Sensifinity: *"Many companies have problems connecting the physical world with the digital world. Many of the devices and areas are completely detached from the digital setting of businesses, and the reason for this was that previous technology did not allow for such a connection and the few types of technology used were very expensive. Nowadays, there are new low cost technologies that permit the combination of these two worlds, which is the digitalization revolution we are facing. From this point of view, as long as it is inexpensive, faster and simpler connections from the physical to the digital world, will allow for businesses to evolve. Moreover, it was considering that factor we started to work, reducing the adaption cost for this type of solution, presenting demonstrations to easily implement and control which helps any business to go into the Internet of Things. In the 80's we were in the same situation we are in now with the IoT. Back then only the large companies had financial*

power to purchase computers and manage computation but since the first personal computer from IBM appeared, every company's started to have computers and I think the same is going to happen with this technology. From now on it is going to be this technological revolution that is going to make possible for everyone to have all physical objects interrelated with digital processes."

Mainhub: "*The definition of Internet of Things is something connected to the internet that allows environment monitoring, and for the exchange of information with everything else. Everything that can transmit and receive information is a part of the Internet of Things."*

Cisco: "*The IoT is not a new concept. In a manner, IoT is a market transition that is happening in a massive dimension caused by the technological developments and by the constant intensification of technology prominence, present in our professional or personal lives as members of a society. This is associated with what we call at Cisco the digital transformation, which is the capability of disrupting or changing not only the business model but also the processes, the information, the data transitions in larger amounts and from where we have more capacities to extract knowledge and intelligence. The people are also a part of this set of dynamics of the Internet of Things area, which is not only about the connectivity among more and more things but also allows us to obtain information and influence the way we work and live."*

FEUP: *"In my understanding, IoT is a concept created 15 or even 20 years ago, it is a very similar concept to ubiquitous computing, which is a concept created maybe even before the IoT but more related to an artificial intelligence perspective. With it, the environment becomes more intelligent because they had intelligent components embedded within them, with functions that were reactive to what was happening in a specific situation. This allowed the development of smart houses and from there it escalated to other levels, smart factories, smart industry, and smart cities. Meanwhile the IoT concept was created more recently and in a sturdier manner. It was in a latent stage for a period of time because there were some limitations in the technology to develop communications at a larger scale and it was expensive to implement them to everyday objects. That situation changed very much in the last 5 years and still is changing. Nowadays it is easier to implement microprocessors, components with the capacity to execute small programs and able to communicate with extremely diversified objects, making them to connect among themselves in order to reach a common goal and also be part of distributed programs. For the Internet of Things concept, the word "Internet" stands for the network we adopted as the data communication network interconnecting everyone through our computers. The term "Internet of Things" means that the network that was used among people is now also used for things and allows objects to communicate not only with us but also among themselves to develop new functionalities and other types of activities that were not possible before."*

OASC: *"My vision of the IoT is not very technical. My opinion about these subjects whether it is IoT or platforms/infrastructures that are more complex are essential for the functioning of the city, meaning, we should give priority to citizens and their necessities and in fact the technology is a large support when we want to implement solutions . With the amount of information we gather from every sensor in the things present in the cities, we can make a much more informed decision and act in a more specialized manner. For us, IoT works in this perspective, it is seen as an unlimited source of information, with the capacity for people to act on it in a creative way. Based on the information gathered it is possible to create new solutions, products, concepts and applications. The IoT is*

essential in this era in order to be able to upgrade the services available to the citizens. The IoT allows to give a better and more efficient services and with different scalability than before."

Porto City Hall: "*The Internet of Things is something that has made a name for itself nowadays but for a long time we've been working with devices that communicate among themselves and using the Internet these devices can collaborate and communicate among each other. The name gives the system more potential through the creation of different things of value. We have some projects of Internet of Things, for example, a startup with a project related to autobuses calls the Internet of Moving Things, which is also an interesting concept as we have more contact with the circulation of information and we can collect it. We are in a world in which information is absolutely essential but there is still much more we need to gather. Having the possibility given nowadays the technology for a city that is extremely fascinating and at the same time a great motivation for transformation. Here in Porto we are following this very closely and have some projects related to the technology.*

Two main factors to have in consideration include the Internet of Things is a concept that has existed for a long time and consists of having technology that connects any device, thing or person to the internet and allows the bi directional communication among these elements by exchanging and creating large amounts of information. Moreover the Internet of Things can provide opportunities for the creation of new and innovative ideas, while increasing the potential for the creation of more value, new opportunities and new business models. The Internet of Things has also come to revolutionize the process of decision-making.

2. What is the best architecture, in your opinion, for this technology?

Microsoft: "*With the IoT being a new technology, one of the main considerations is in being able to define some standards which every IoT project will use as foundation. For example, Microsoft already has a certain architecture to apply to Internet of Things projects. The concept of this architecture is having a set of devices that can be connected between them but not connected to the internet. There is the field gateway architecture as well, which is a device connected to the internet and all the other devices, and it is responsible for sending all the gathered information by the devices to a cloud-based backend service because we need the scalability. For example, a project can have a million devices connected that usually are not connected to a field gateway but to an Enfield gateway, and it was necessary to do a dimensioning intervention. The architecture was like this until six months ago; now we have evolved. Nowadays with the offer of our cloud services for these IoT projects makes it possible to have everything automatized .For example, the registration of devices, send commands for the devices as well as reading information."*

Sensifinity: *"We still see many computers, but computation is becoming more mobile due to tablets and smartphones. So we think for any kind of architecture to be adopted, simplicity demands that the architecture should be integrated with the mobility. As such, as we wanted to present solutions "already completed" out of the box. We adopted an architecture based on a communication protocol which is retro compatible with smartphones and Bluetooth low energy. We create our own the protocols that permit this retro compatibility with smartphones and tablets in terms of communication and connection. The information gathered goes to the cloud, which we use because in the future small and medium companies are going to stop having their own data centers even the larger companies may have everything in the cloud. From the perspective of the data acquisition*

nodes we are using our own equipment which is what allows the easy communication between smartphones and the cloud. By using pre-existing equipment, we would have the same problem seen in many projects nowadays, which is the high cost of the project in the implementation. Such as when looking for the right equipment for each specific project and developing specific software which we do not want. Instead we want to deliver a type of situation the works with minimal complexity and maximum utility."

Mainhub*: "There are two important features regarding architectures. First, for now there is no standard defined; but there is a set of concerns. I think what is happening is that people are more concerned in developing solutions and not so preoccupied with communicating among themselves. There is a set of initiatives, because one of the main issues is how to connect two objects from different brands and most of the IoT manufacturers try to solve that matter, so they are all working to a common standard. In my opinion the best architecture would be one where single devices should not be connected to the internet alone. But with some kind of middleware component called broker which would gather the data of several sensors and then would send it into the internet, For example, imagine there are a set of sensors inside a house that communicate with the "brain" of the system that could decide when to send information to the internet. The data can then be analyzed in the cloud and in conjunction with machine learning giving great results."*

Cisco*: "The IoT is a very broad concept, because from the beginning we have many factors to take into account. From how they connect among themselves to the infrastructure required to guarantee that connection, areas like security, how to connect things in a secure manner since we are dealing with information which can be sensible, there has to be concern about the access to information and what does with the data. A set of communication infrastructures but also the advent of the cloud and the potential the cloud brought in this explosion of IoT applications. And a conjunct of new paradigms and new necessities of giving response to what we call use cases that might be associated with IoT. In my opinion it still is an area in which the innovation and dynamics of creative destruction is very strong, there is not a standard model and exist many emergent technologies are being tested. The impact is in beginning to notice that some sectors show some of the potential behind the IoT and mainly the digital transformation."*

FEUP: *"It depends. There is not just one architecture, there are many, because the adequate architectures to certain objectives are sometimes are compatible with other architectures with other objectives. For example, if I wanted to do the monitorization of a large agricultural field, I could use a wireless sensor network, where various small sensors with the capacity of communicating among them, are placed throughout the field and periodically gather information about the defined parameters and send that information. In this case, a method of distributed data catchment is used with the particularity in which the communication flows in one direction to a central point, usually the main node, that is gathering all the data and sends it to the internet, main computer, database or other main application. This architecture is acceptable for this example but it may not be for other situations. In the case of smart cities since it is required to make monitorization at a larger scale, there are not just these individual and wireless sensors but also sensors that are connected to a cabled network or to certain spots or inside building where wireless communication is more difficult. As such, we have different architectures for these types of situations. Sometimes, there can be a sensor concentration in a certain area within a defined distance, depending on the solution, that then are sent to a superior level, this way we have multiple island composed by sensors which are later*

aggregated and sent to a computer of the enterprise managing this service or sent to the cloud. There are centralized architectures which is a computer executing certain application that gets the information in the sensors around it (star architecture). There are architectures more focused in the sensors, where the sensors have more intelligence where it decides when they share the information, whether it is relevant or not and send it when necessary This type of architecture is more distributed. Even so there are other types of architectures when regarding larger scales in which are used to completely distributed architectures although rarely, or architectures in several layers. There is a lower layer that is closer to the environments, the architectures in these layers are typically start type, the top layer the architecture is usually distributed, and there is another upper layer that we do not know where it might be, but it makes the distribution of all the activities. It is also possible to have several reaction layers; in the lower level, it may be possible to make an immediate reaction, the upper level is we can understand with a better perspective because it has information from various places and do a slower feedback, but more complete and then there is the top layer which is the big data. In this situation, the applications in a superior level go get the information from vast ambits, so it has access to much information. With it, it is possible to make optimizations in order to see which method is the best to maximize the efficiency of a process and then transmit to the lower levels the information in order to influence the actuations and become more efficient."

Porto City Hall: *"There is not one closed architecture or standards for the architecture of the Internet of Things. We are still working in that issue. Porto has an association called Porto Digital, in which the city hall, the university and Metro participate. It is an association that developed in the last years the largest optical fiber network in the country. It is around one hundred kilometers spread across the city and we've been working together to potentialize the Internet of Things. We have worked in terms of infrastructure. We have Wi-Fi, environmental, noise and movement sensors among others in the city. We created an integrated management center in order to collect real time information from sensors. So, we have in the same room relevant information for the municipal services, such as police, mobility, civil protection, fire department and environment.. We also have traffic cameras, traffic lights and sensors interconnected. Therefore, the Internet of Things already exists and we manage it. We have been working in urban platforms and we are integrated in a small European group in the European Innovation Partnership called "Urban Platform". We are trying to work on a template about the concept of "what is a urban platform" and what it must deliver. So we are working on those groups that want to create a common ground that also can be understand by the suppliers. For the last three years we have been working in collecting the information and create a layer that will work as an information broker allowing the reception of data from sensors or other "things" and act based on them. This is what urban platforms are trying to achieve and the European Commission as well, for example, the FIWARE. Porto has a node of Future Internet Ware, which is an IoT platform. We manage it and it gathers information. We are working in these areas because there are many things occurring in the world at the same time with the IoT. So we have in the city various concepts concerning this topic. We have to work on this technology, we already tested some situations and are part of these groups because there is much work already done we can apply. -Now we have a model we believe it has to exist to support the structure related to optical fiber, Wi-Fi networks and other mobile networks. We are very focused on the new services in this area which are the sensor network of our several partners and the need of a software layer which is an information broker."*

The most common issue that every interviewee mentioned was the lack of standards in order to define a better architecture. Three factors mentioned by all the entities include that the cloud, machine learning and analytics are undoubtedly part of the components and architectures of the solutions. There are several types of architectures and they are applied and designed according with the type of project and its' objective**.** The architecture must allow the creation of new functionalities and activities and unlock the potential of businesses in order to deliver the maximum efficiency, utility of the processes and minimize complexity. The types of architectures mentioned are a distributed architecture with a central node in which the communication flows in one way and then it sends the data to the internet, database, computer or main application. Another type of architecture consists in connecting sensors to a cabled network if there is difficulty in accessing wireless communications. The star architecture involves having a certain application executing on a computer and it collects the data from the sensors nearby. This is a centralized architecture. There are also architectures based on sensors. In this case the sensors possess a certain intelligence that decides what information to share and which is more relevant, this is another type of architecture more distributed. One architecture that is mentioned more than once is the architecture by layers. It consists of having a lower layers of sensors in the field or other place. The main characteristics for this architecture is being a start type, having a middle layer that could be anywhere and making the distribution of all activity. Instead it is possible to have several reaction layers. In this case there can be a upper layer that is easier to understand and provides a better perspective because it collects information from various sources and gives a more accurate and complete feedback.

II - Business

1. What applications do you develop/apply for your customers? What kind of technologies do you use to build them and how long does it usually take?

Microsoft*: "Nowadays with the cloud services that are much focused in Internet of Things, we have a specific cloud service that is a "pay as you go" service, in which the client pays for the consumption. It is called IoT Suite that makes the periods of development very short, just 10% of the time is spent in the development of backends. The majority of the work is in areas in which the Internet of Things industry still is very immature. The devices components, interoperability, new protocols and all know how present from the hardware development part has shown an acceleration due to the interest from the market. There were already some protocols, it is a component that has been defined recently. The projects take 60% to 90% of the time for the devices. In the area of backend everything is cloud based. One of the advantages of the cloud, besides scability and a defined architecture known in the market, agility is the other advantage. We can create solutions in a matter of minutes, implement the code and run all the required tests, these are some of the characteristics nowadays that matter the most."*

Sensifinity: *"Our clients search for logistic solution in order to monitor stock quality and quantity in real time. Try to understand the machine behavior and preventively access the data and understand if the machine is going to stop functioning or not. The majority of the projects we have are in these areas. It usually takes two weeks to develop a proof of concept and then if the clients are interested or have specific reports depends on the requirements."*

Mainhub: *"As an incubator we are uncertain about the type of problems the startups face or the problem they want to solve. However, what we have seen the most is focused in three different areas: health or aging for monitoring health conditions, industry for automatize processes and domotics to monitor the house. Now and then, some clients bring us some interesting challenges, as for example, someone wanted to monitor the amount of sunlight in the beach in order to inform people and collect the data in relation to skin cancer. As for the time it takes to develop a solution, it is different from developing applications. In the mobile market there are applications developed in a year or even sooner already selling. In the Internet of Things, the cycle is much larger, usually our estimations are that at the end of a year, we have a fully functional prototype and at the end of two years, we have a solution to implement. Giving an example, we had a team here that developed sensors for agriculture and in 6 months they tested innumerous hypothesis and none of them was successful."*

Cisco: *"The Internet of Things is considered one of the most profound transitions in technology today, creating unprecedented opportunities for businesses. Cisco developed an IoT system that helps to enable massive revenue streams, efficiency in automation, and overall business growth with IoT products and solutions.*

The six pillars below include a cohesive and comprehensive set of IoT products and solutions:

• Network connectivity area where Cisco is well recognized and where it is its' main activity,
• IoX and Fog Applications, fog applications have the capacity of distributing processes and running applications in a completely distributed network. The traditional model of having the application based on a datacenter or cloud does not give response to certain use cases in IoT that require the capacity of absolute distribution and closeness to the place where the data are generated and where is necessary to give a response in real time. There are even data with a relatively short life period that are not compatible with the transport to a datacenter to be processed and analyzed. The fog applications allow some analysis of the data in the network but also filter the information more relevant to the datacenter or the cloud because one of the challenges nowadays is how we handle, transport or process the increasing amount of data created by the interconnection of things,
•Data analytics, analytics have to be present from the beginning to the datacenter. Typically the architecture with a data lake, which is a repository of all central information, is applied in some use cases but there are use cases that are not compatible with that model,
• Security – cyber and physical, cyber and physical security, nowadays with the challenges related to threats is our society but also related to certain resources considered more strategic that also have to be protected physically,
• Management and automation, with the necessity of generating high volumes of information it also raises some challenges concerning the existing processes, how the management of the infrastructures is done, high scalability,
• Application platform, most of them are based in the cloud but also application that allow to take advantage from the architectures to stimulate innovation, development and how that the innovation can be created from external factors and not only internal."

FEUP: *"I work in R&D but only in the communications part. What I do is allowing applications to work since they are going to function over a communication layer. Without that layer it is*

impossible for the applications to interact among them and would not have new functionalities, they would be independent objects. Some protocols I have been developing in the course of my investigation are divided in two lines. One of them is related to systems considerably larger. For example, cars or robots that have embedded in them multiple computational units, various microprocessors interconnected. In this case, since they are restricted and in the static to the car or robot, so it is easier to use cabled communications to guarantee that communications are done within certain temporal restrictions. For example, I am capable of guarantying a message sent in a determined instant is received in less than x time. This is very important for some applications to function. Mainly those that are responsible for giving control feedback. In a car if a wheel is spinning faster and I want to break, it has to send information about the speed and other factors, the controller will verify the standard values and send message to rectify the situation if there is something wrong with the components. If the control is not performed in time it is not possible to make an effective control.

The other line is wireless communications for cooperative objects. In a certain manner are developed separately, but when they are near each other can cooperate among themselves. This is more associated with IoT. Our main concern has been with autonomous agents (independent robots or unmanned aerial vehicles (UAV)). What happens is, each of them has certain functionality but when closer to one another they can stablish a connection. From there, create a new functionality that was not possible, was not available before or do it in a different way, more efficiently or effectively. For instance, we have an UAV surveilling a certain area and at some point in time, we want to add another one because of the size of the area. When they detect that there are two of them in the same area, they coordinate the communications among them in order to make a faster coverage of the area. Another example can be a robot that is making the recognition of an unknown area. To maximize the area covered, we start adding more robots that communicate among them to decide where to go. Some similar cases are vehicular networks. For instance, when cars are in a highway and are closer to each other. The cars can come to an agreement and start to communicate about the correct speed they have to adopt and coordinate it to ensure they go together. If they do that, the vehicles behind can save fuel and they can even switch positions, this solution would be a great advantage for trucks."

OASC: *"There are several projects OASC is supporting. Currently there is a large project called "Synchronicity" in which Porto city hall is involved. This project consists in implementing concrete objectives with the several cities in the network, since many cities are involved but for the project, just pilot cities participating. With this project, the objective is also expanding the network, for example there are Brazilian cities connected at this network. With China, Japan, Mexico, USA the cities network stops being just European and starts becoming more global. In this context, the cities have been developing several projects. Porto, for instance has very interesting projects in the smart monitorization area done with IoT. One interesting project for example, was created, by Future Cities Project and is called "Urban Sense". It is a platform where we are going to use the sensors to measure environmental and air parameters. Another interesting project is "Hackacity". The objective of this project is not to develop sensors, but a hackaton. Where what matters more is the platform we are developing behind it. The platform has the purpose of gathering the information of every sensor in some Brazilian cities (Olianda and Recife), Dutch cities (Utrecht and Amersfoort) and a Spanish city (Santander) and make it available to every hackers and developers that wish to work with these data. We are working more for this back end. We have partnerships with the universities in the Urban*

Sense project; the universities and companies develop the software. For example, Ubiwhere, a company based in Aveiro is partner in many OASC projects, not only nationally but also at international level. They develop and implement the IoT solutions. There is a vast amount of projects inside the OASC network, from parking sensors to pedestrianized streets and accesses as well as smart lightning. Águeda, a city located in Aveiro is a very interesting situation since it is develops many solutions in the ambit of smart cities, especially pilot projects for the city. This city has a very interesting project concerning smart lightning. It detects if there are people in the street and increase or decrease light intensity. It can shut down certain areas remotely if a construction or repairing is required. There is not the need of sending a technician to the site. If a lightbulb stops working, it is possible to know which one is it. Overall is a very different dynamic from most of other cities. Águeda, Lisbon and Porto are among the most involved cities when it comes to this kind of technology. The projects for smart cities in the OASC framework, are connected to FIWARE which is an open platform supported by the European Commission. The development is mainly made by Telefónica and some other companies that have been investing in this technology. The platform has reached other countries as the ones mentioned before. The main objective of FIWARE is to help cities to get ahead in comparison to others in the rest of the world but also to have access to open data and all the sensor networks in a completely open manner. For that data utilization, standards are created. Any company, as long as it develops applications compatible with those standards may be interoperable with other kinds applications developed by other people. This generates a market where it is possible to stimulate public networks. The services area but at the same time stimulate the market as well because we are helping companies, startups and the entire entrepreneurship sector creating new solutions with an easier approach and more internationalized. If I develop an application that is compatible with other in another country is much more easier to sell and position the company in the market.

Porto City Hall: *"We have several things happening in the city in IoT level. For example in terms of smart metering, we have utilities and companies that use them. In relation to what the city hall has been doing, for instance, the municipal company Águas do Porto has twenty thousand habitations with smart meters. this is something we have been conducting. The water company launched an application in which the clients can consult the data in those smart meters measure and compare the data with another family equal to theirs and see if they are above or below average in water consumption,. Besides this it has other functionalities. Similarly, considering water consumption, in the Porto city park has the irrigation control is done using weather forecast stations, predictive models and act remotely in the system and are expanding this model to other areas of the city. There are gardens that irrigate accordingly with the weather forecast in the city park. We have projects involving public transportation. We are integrated in Future Cities project, which is a European project of competencies center for future cities. We also developed a vehicular network that is the largest in the world, the autobuses communicate among themselves and then with the optical fiber around the city. Usually in the city center, the autobuses do the entire offload in the optical fiber, there is not the necessity of communicating in 3G or 4G. Furthermore, if one of the vehicles is circulating and has another autobus near it, they communicate until they reach an optical fiber point. This allows to manage the city in a completely different manner, obtaining large amounts of data and creating graphics that show how many people connect to Wi-Fi, in which stop they enter and exit, among different types of information. In several parts of the city we also have noise and environmental sensors, measuring the temperature, humidity, wind and other factors, then we also*

have mobility sensors to understand how many people pass by. We have been working with the municipal fleet. It is all geo referenced which allows us to have three hundred vehicles circulating in the city and with the autobuses. The number increases, but it gives us an interesting perspective about the traffic in the city. These are some aspects we have been working on. There are many more we are developing, but the IoT is present in the city. The time developing and implementing depends. There are smaller and simpler projects that do not take very long to implement. There are more complex ones that take more time to implement because of the possible externalities associated with the implementation and it is not an immediate investment.

There is one company interviewed that focus on stock quality and control in real time and predictive machines/machine learning, for controlling stock quality and quantity in logistics. They use their own protocols and equipment. It takes two weeks to develop a proof of concept and depends if the clients are interested according with the requested their specifications. Another company develops solutions for monitoring health conditions, automatize industry processes, agricultural purposes, domotics and other different solutions since it is a startup incubator. As for the time necessary for the development of this applications, in one year it is possible to have a prototype and in two years the solution to implement. Other case the solutions developed are associated with having micro sensors in cars or robots interconnected, the connection of objects with cabled networks in order to have a more efficient control. The solutions working with wireless communications are developed separately but can cooperate with each other. There has been more focus on robot and unmanned aerial vehicles that combine with other elements can create new functionalities of something was not possible before and do it more efficiently or effectively. They are also working on vehicular networks and using UAVs and robots for area surveillance. A different entity is working in the application of smart meters where the clients can consult the data from the various determined parameters, automated and intelligent irrigation systems, predictive models and vehicular network, which will allow for vehicles communicate among each other, namely autobuses, and can give a perspective about traffic control and situation. The time it will take to implement, it depends on the scale of the project, the externalities faced and the obtained return on investment and time achieving it. Another one of the companies interviewed says that composing a solution only takes 10% of the time. The rest of the time is used developing devices. A different entity also says the type of projects or applications being developed are focused on smart monitorization, a project called "Urban Sense" is a platform used to collect and analyze environment and air sensors parameters. Other project is Hackacity, which consists on gathering information collected by every sensor in different cities and make it open for hackers and developers that want to work with this data in order to develop a solution. There are other projects like parking and street sensors as well as smart lightening. The solution in this last project can detect if there are people in the street and increase or decrease light intensity.

Overall there are many different architectures involving different components, depending on the purpose of the solution, but the final objective is to enable processes to be much more efficient and effective facilitating the companies and cities functioning, either in an operational and economic way.

2. What kind of businesses require your services? Which are the main sectors?

Microsoft: *"We are noticing an interest from companies in all the different sectors. For example, in the retail sector in which we have noticed greater interest, the telecommunication sector, energy sector and agricultural sector as well. We can see in the startup ecosystems, there are many startups specialized in IoT and most of the time they are dedicated in a specific sector. For example, in the agricultural sector alone, Microsoft supports two or three startups showing very satisfying results and evolution. Without a doubt that the retail sector is the one in a more advanced stage, besides there are projects being currently implemented. As the market already knows, the IoT will bring much value to the companies and the sectors. The most important factor here is each one of these sectors need to understand which the best business models are and where they can explore the Internet of Things. The retail sector is one of the areas where those types of business models are easier and more logical to identify and adopt. As such they were the first to implement IoT solutions. The other sectors are still studying and analyzing how they can implement and make the most out of the Internet of Things."*

Sensifinity: *"Retail is the main sector demanding these types of solutions. We are specializing in logistics. However, our platform can be used in many other situations. We have several clients that work on the machinery or agriculture area using our equipment to develop their own products because we make available our own IoT stack; the hardware, communication protocols and cloud service. Then they develop their own standards for application, some of the clients are wind and solar power stations and it also can be applied in sports. There are many applications for this stack and we do not have to develop them for that specialized partners in those areas develop the solution even further."*

Mainhub: "*The main sectors and businesses are the health, industry and constructions sector."*

Cisco: "*The IoT can transform nearly every industry - locally and globally. We see a bigger dynamic in areas more challenged by this technology. The business models are disrupting much faster, new innovative ways to interact with the clients and the offer. Sectors like industry, transportation, banking and telecom for example show an increasing interest, concerning and offer no only with the amount of data but also how to monitor and transform it in services of high value to their clients and even using these new areas of development to help positioning themselves in the market. It brings networking technology to places where it was once unavailable or impractical. The challenge is to build the right infrastructure. "*

FEUP: *"I'm only developing enabling technologies for other companies to develop their final product. Since I'm in public investigation area I do not feel the pressure to sell a product but to present interesting results in order to captivate and gather new projects. Because if we do not have new projects, we do not have funding. So we get constricted and cannot develop the investigations. It is not like a traditional business, we do not sell to the masses but we have ideas to sell to investors. That market is much more competitive than the traditional markets. When people are the final clients they are more permissive and diversify more their choices. The main sectors/areas with many final applications are vehicle fleets, coordination among many robots, particularly from search and rescue, transportation and drones coordination. The drones' coordination is often applied for the agricultural*

sector. Other sector is the smart cities, which are related to the ICT communications utilization for city management. This includes transportation fleets, where there exists constant communication between the vehicles and management centers. There is a solution applied to the transports as well where the passengers can have access to the internet in the vehicle. In order to do so there is a network making internet coverage at city level using the traditional public transportation vehicles. With the technology is also possible to make residue management. The type of management is done by detecting where there are more or fewer residues accumulated and how to maximize the routes to go directly to the containers that are fuller. IoT is being used as well for illumination management, detecting people and situations where is needed more or less light, These improves efficiency and reduce unnecessary costs. Smart houses, have similarly functions as the smart cities but at a much smaller scale. The industry with the IoT is also experiencing significant changes, such as Industry 4.0. These changes will take time, perhaps over a decade to show the effective results. The paradigm to IoT is that each object is a thing within a network and from there it can communicate with other objects and allow global control applications to use these objects as individuals."

Porto City Hall: *"In this situation the question would be "what does a city have that can quickly transform and create benefit which can be reinvested in other areas that do not have a very palpable benefit?" There are areas very easy to understand. Mobility is one of them. It is becoming even more necessary to manage mobility in a more intelligent manner and the IoT clearly helps in that. The residues part is extremely important because of the optimization that can be done in residues distribution and collection. Understanding if the containers are full or empty are important areas. The cost reduction part is also significant. For example in the energy sector, the cost reduction will have more impact in public illumination, in the water sector it will have more impact in the irrigation. These are the sector I would enumerate as the sectors more easy to tackle and more important."*

The sectors more commonly mentioned across the several entities are industry, transportation, telecom, energy, agricultural and retail mostly**.** Other sectors also included in this transformation are the water sector, sports, residues, search and rescue, smart cities, health and construction. The Internet of Things is going to bring solutions for every sectors, almost no sector is going to be left outside the disruption this technology is going to bring. The vision the enterprises have for the Internet of Things concerning the sectors is that it will change the approach on how tasks are conducted and it will heavily influence the decision making process leading to an improvement in every players' surroundings.

3. What is your type of business model? Do you consider your business model to be very different from the other technological companies?

Microsoft: *"There are two areas. Azure as a cloud service and platforms such as infrastructure as a service, platform as a service and software as a service. These platforms are developed by a partner that offers the service and we consume it without any kind of concern about the maintenance or provisioning of the platforms.*

The platform as a service in the IoT scenario, since each company and each industry are different, the model that makes more sense in this situation is PaaS. We provide a platform that facilitates the integration between every devices, allows the maintenance, has a very critical point in this technology which is security. The platform provides that out of the box. It gives freedom to implement the most

diverse IoT projects and also because this technology is going to be implemented in every sector and the projects will also be different from each other.

The difference between other technological companies and us is that the other companies have approaches for the Internet of Things technology that have common and different modules because of the diverse background of the companies. We are clearly differentiating into a service company. What would make more sense would be to provide our clients with a platform as a service, I allowing our partners to implement all kind of solutions and resell it to the final customers. For example, Samsung is focused on devices, so it adopts an approach more directed for makers. This type of differentiation is encouraging because of the existence of two areas. One focused on the solution and other more dedicated for makers. This will help the growth at a component level and increase our sector. Furthermore, this type of technology is no longer just related with information technology, it involves electrical systems and every business areas, since the IoT is going to impact every market. Even in the pharmaceutical or agricultural sector, the professionals in these areas have to contribute with their know how in order to complement the Internet of Things projects, as this technology is an area that is bringing everything closer."

Sensifinity: "*Our business model is the subscription model. I think recent companies are adopting this type of model. The larger companies are also adopting that model and I think it is the most common for cloud services."*

Mainhub: *"Our business models is to help startups to develop prototypes because there are many startups and people with ideas but do not have the know how to execute them. With our experience, we help them go from nothing to something testable. We do not know if it is going to work. We try to develop as best as possible a prototype according with the clients' requirements but we cannot control the success of the solution after that. Our business model is very different from other larger companies because it is a very specific model to give this kind of help. It is also different for the startups because we cannot compare them with a larger company. For the startups, the cost structures are nonexistent and save as much as possible in order to implement their solutions, while the larger companies do not have that problem. The startups also have advantages, failing is less costly, faster and easier, having a better margin for improvement. There are two distinct types of business models startups adopt in this incubator. Their client buys the hardware, owns the hardware and from there pays an agreed amount for the service for the time they want to use it. The sensor for the sneakers is like that; a client buys it and then uses the service for the time they want. The other type of business model is renting. The client buys the utilization of a solution for a period. This is noticeable with companies, because buying 1000 sensors or devices would be very expensive. This model decrease the amount expended with the solution, the client can rent the solution for 12 or 24 months or for the period agreed with the supplier. In our company, we help the startups with a project during an amount of time and what we charge is related to the work done in that specific project."*

Cisco: "*We try to be a credible partner for our clients. We offer a wide set of solution and contribute with innovation, services, architectures and offers that gives response in a unique way in the market. This is our purpose to be successful and overcome the challenges associated to this digital transformation.*

Cisco is the proven partner for success in IoT and digitization journeys. Connecting things securely, analyzing data dynamically, and delivering business value demand an intelligent IoT platform. These things also require application execution within a proven IoT network infrastructure and security from fog to cloud. Cisco provides the most comprehensive solution to securely deploy and simply manage your IoT initiatives:

> *• Cisco's IoT portfolio is the most comprehensive suite of products, solutions, and services providing connectivity, security, automation, and insights from the fog to the cloud that organizations can deploy right now,*
>
> *• Cisco's IoT portfolio enables the ecosystem of technology partners to build innovative IoT businesses across all verticals,*
>
> *• Cisco offers a wide range of solutions to automate the service lifecycle of IoT businesses by providing real-time visibility, control, and actionable insights,*
>
> *• Cisco enables customers to automate the process of connecting devices over a global network of the top service providers,*
>
> *• Only Cisco's IoT security delivers scalable, end-to-end threat protection and simplified compliance from fog to cloud,*
>
> *• Cisco IoT offers a simple, secure, and scalable end-to-end IoT solution based on architectures and open standards that integrate with third-party and legacy equipment. "*

FEUP: *"My business model is an investigation model. I have to find areas of innovation, areas where I can contribute and convince investors that certain investigation is useful and relevant in the technological and scientific context, especially in the scientific area. Other technological companies in the end try to do the same thing, the difference is in the market. While the other technological companies have a more defined and open market and have more clients, in our case the market are just a few investors and even more demanding. We have many competitors to access the funding and we have to struggle for it. Generally this is what every company does but in particular there are some differences."*

Porto City Hall: *"The cities business models when talking about IoT are structures that help the projects. When we are investing in optical fiber or a sensor network, we are investing in urban platforms, in something that is an aggregator of these projects. Being able to make even more decision backed by information and data and the business models is based on the fact that the cost saved after implementing those projects is enough to sustain the structure."*

Since were interviewed several types of companies we have many different models. The ones mentioned were infrastructure as a service, platform as a service and software as a service and state that for companies the best one would be platform as a service as it allows the integration among devices and it gives more freedom to develop specific projects. As for the company it is diversifying into a services company and usually there are two types of companies in the IoT area. The ones that develop platforms and solutions and the ones which are more focused in the hardware and IoT physical components. There is also the subscription model, which is normal for cloud services. A similar business model is one where the client buys and owns the hardware and then pays a fee to

use the solution services. Another type of business model consists in renting the clients rents the entire solution hardware and software for a period agreed with the client. In a different perspective about a business model for smart cities is a structure that helps all the other projects from private or public entities to be implemented and aggregate them to make better decisions based on information. There also are business models that focus on delivering scalable end-to-end solutions based on open standards and architectures. The last business model mentioned is in the area of investigation as the name states it focuses on finding and developing innovative solutions to attract investors and show it is relevant for the technological and scientific areas. In this case, the difference is that for companies the market is more open and have more clients whereas in the investigation the market is a small number of investors and this market is very demanding as it also has many competitors. Each company adopts the business model more adequate to achieve their objectives and follow their mission. The focus is also to provide the best possible value for their client, as the Internet of Things has so many diverse applications, the business models adopted also vary according with the purpose. For these reasons, there is not a global or a standard business model, but there are many interesting business models creating value in their own form, for their specific target. Furthermore, the more diverse the business models are, the larger are the chances of differentiating from the competition and the market itself.

III - Strategy

1. What are the main objectives from your clients when implementing an IoT solution?

Microsoft: ***"****Depends. Mainly each sector wants to understand is how to create new business models. For example in the retail sector, we can do several different applications. We have numerous projects in action with the purpose of doing the machine maintenance; allow preventive maintenance using other cloud-based services with machine learning. The smart cities areas a common project being implemented is using IoT to detect empty spaces in parking lots and facilitate the payment method in the parking lot. These are some of the examples to define the business models that have appeared and being worked on. It depends. The way the companies explore the Internet of Things is always different but in one or another everyone benefits from it."*

Sensifinity: *"Our clients search for logistic solution in order to monitor stock quality and quantity in real time. Try to understand the machine behavior and preventively access the data and understand if the machine is going to stop functioning or not."*

Mainhub: *"Improve processes. Most of the situations are related to cycle maturity. We are still focusing in known problems. At some point with the IoT I think we will add more value, at the moment IoT already shows a great importance but for now there is slight value."*

Cisco: ***"****Usually they want to solve a problem. The technology itself is not a solution, but a mean to meet the ends. The first step is to identify the main problem they want to solve and then attack the problem and see how these trends and technologies may help in the solution. This can be a new approach, a new business model for instance, or an internal growth or change as a competitive challenge, market changes. There are several factors, but first and more important is to identify the problem/challenge, what to solve, see the objective and look for the best solution. These*

improvement may be operational, time to market, agile processes, invest in a new area where the approach to the market is completely different, among others, there are many different outcomes we can get from this type of solutions."

FEUP: *"There are two objectives. Generally is to improve efficiency and the other is to have new functionalities that were not possible to perform before. There are functionalities such as, having remote access to certain equipment and be able to control them that way, or program coordination among distributed equipment in space (in different cities or places) which was not possible before because we did not have the technical capability in order to do that. So overall the objectives are innovation, in terms of new functionalities or maintain old ones but with more efficiency*."

Porto City Hall: *"Being our clients the citizens, the big problem of smart cities is something we have to know what the concept is. There are many cities implementing many projects without thinking about the value it can add. We have two important objectives. One is give a service to the client, in this case the municipality and have them to see and get the real value from it. The second is having a benefit it may not be immediately palpable for the municipality. It can benefit anyway because there is a cost saving, since we are talking about public money, in reality is a benefit for everyone. The external factors such as the environmental sensors are used to understand how the city is evolving but are factors more difficult for the citizen to notice."*

The main objectives for implementing the Internet of Things in companies include improving efficiency and helping to create new services or change existing ones. It is also implemented in order to add more value for the clients of the companies and create cost reductions. Furthermore, it also helps to create new business models with problem solving aspects. It also stimulates the market since it helps small to large companies by creating new solutions through an easier approach in a more internationalized manner.

2. Do you think, currently, companies are well prepared to implement and adapt to the changes the Internet of Things solutions can bring? What suggestions do you have for current and potential customers in order for them to implement IoT and stand out from the competition?

Microsoft*: "In Portugal we have verified a very pleasant evolution in the last 6 months to a year. Some Microsoft partners, portuguese small and medium enterprises are providing services and physical devices for Internet of Things implementation. A year ago we were at an embrionary stage. Now there are many partners. The range of options of IoT projects for larger companies is increasing, so they can choose the best projects according with their necessities.*

Suggestions for clients: being from different backgrounds. One of the suggestions is the digital transformation or the Industry 4.0.The arrival of new technologies, especially of the IoT, will let companies to analyze into their businesses, understand how to improve their processes and change drastically the form on how they work. So what we are going to do is to help our clients in this process of digital transformation, understand which areas they can explore technology to reinforce the current business models, create new ones or transform them."

Sensifinity*: "Usually no. Usually they want some consulting in order to understand what is possible to do with the IoT. When they were presented with very expensive projects they would refuse and did not think much about them. In those situations, we have to reach to the clients and show*

them the reality changed. These type of projects are viable but still they do not know that. The suggestion for current or potential clients is to start to adopt and implement now, the implementation costs are minimal now to gain advantage in relation to their competitors, it is very easy to experiment an project and from there to accelerate or choosing another path."

Mainhub: "*No. I think most of the companies do not even think about that. They heard what the Internet of Thing, find it interesting but do not understand how they can benefit from it. The larger Portuguese industry can benefit plenty from this because of the costs optimization, but have not studied very well the possibilities. The companies currently engrossed by the Internet of Things are the startups, incubation and prototyping companies. Others are still trying to understand what to do with this technology. Suggestions for the companies, I think the most relevant for now is try to understand by themselves or with assistance from other companies the improvements they can have if they implement the Internet of Things. As an example, we had a client that worked in the painting market, painting automobile components and it is necessary for them to understand how the manufacturing process can improve, how to have more advantages regarding production to decrease costs or to improve production itself. For that I think they need to understand the concept with someone from outside the company with more knowledge what can be done to achieve those kind of goals, from there they can ask to develop a customized solution or search the startups market and what existing solutions they have and implement the most fitting."*

Cisco*: "Depends on the industry and the enterprises. In certain sectors we see larger investment, dynamic and readiness. In other sectors we see a less forward approach. In Portugal, we have some projects being concretized, namely in the utilities sector, local development, cities, autarchies, etc. However, we would like to see in the Portuguese market enterprises to consider the digital transformation dynamics as an opportunity to reposition themselves at a global level and gain competition power. We would also like to see projects at a larger scale usually we see pilot projects. Nowadays there is certain credibility for this type of solutions, we have some examples in the market scaling that give some confidence concerning the results obtained. The challenge nowadays is to lose the inhibition and to advance in a more decisive manner and consider this an opportunity for the future.*

The suggestions are to understand the problems/challenges they have; their dynamics in the actuation market and business models; the impact the IoT and other technologies may have in that perspective, define a concrete strategy and execute it. Nowadays it is not enough to just define a strategy, it is necessary to implement it as the enterprise may fall behind in the market because the ones that innovate, risk and try to differentiate are the ones that go ahead in the market.

The IoT is a primary enabler of a larger industry transformation under way: digital business transformation. Companies are increasingly looking to digital technologies to create or improve their competitive edge.

The IoT and other technologies are helping companies to transform processes and business models; empower workforce efficiency and innovation; and personalize the citizen, customer, and employee experience. The IoT helps connect physical and digital environments. Data collected from connected devices provides the raw material for businesses to gain insights and respond rapidly to change.

The IoT enables an exchange of data never available before and brings users information securely. Through Cisco® IoT solutions, organizations can create and monetize new business models and services; innovate easily and get more things done, boosting productivity; and deliver insight for better user experiences and engagement."

FEUP: *"I think there are various situations. The companies are composed by people with the will of taking opportunities and transform them into businesses. However, people are very different from each other. There are people with strong scientific knowledge that can integrate or enter in very challenging markets. In the scientific investigation area where we have awareness about the latest innovations developed. These innovations are in small number but they are the best for us because we recognize them as having higher intellectual value as well as higher value in the value chain. We are working in an abstract level much higher and related to higher knowledge. There is a vast level of disparity among companies. There are companies constituted by people with lower level of education but even so try to find a business opportunity. Although they are also the ones with more difficulty in surviving when there is more competition and are more susceptible to the innovation problems because it is easy to fall behind the competitors. We want to change in social terms to change the entrepreneurial profile to approximate as much as possible to the top, the enterprises more related with information. To do that we stablish a partnership between the entrepreneurial tissue and the area of research and development, as for instance, universities. But it is good to have a notion that mutual interest exist and the enterprisers can become investors in scientific investigations when they are interested in the immediate result and when the investigation can have immediate consequences. An effort that has been made to try to have companies working at a higher level of innovation and the IoT is enabling that purpose of innovation. So there are companies that are ready to implement this technology and others that are not."*

Porto City Hall: *"We have a long way to go. Our population is becoming even older. Transforming IoT in a mere digital communication with the citizen is a risk and we do not want that. In the IoT and the way I see the cities, what we want are services for the citizens but also that the citizen sees a benefit in the good management of the city. I do not think we can achieve that just with applications for smartphones. It is interesting but we want to give a clear benefit to the citizen and it has to contribute the improvement of the quality of life. Everybody uses technology if there is a real benefit. Disregarding some population that does not have access to technology, the idea is to use the technology to approximate to the citizen and turn it easy to use. Eventually every citizen will have to interact with technology and that may be a problem but if we take the technology to the citizens, things may be very different."*

There is a small difference of opinions concerning this question. Some interviewees have the opinion that it depends on the company, who is leading it and what kind of opportunities of which they would take advantage. They believe that people with higher a knowledge of the market and technologies will identify that certain innovations will bring greater value in the value chain and that people with less knowledge or education try to find opportunities but still fall behind. It also depends on the sector as some care to invest more in the technology while others do not. One of the interviewees stated that there are already some positive outcomes as small and relatively larger companies are already implementing and offering IoT solutions. However, there is also the belief that the companies are not prepared to implement the technology because they are unaware of what it is and the potential it could not unlock, and consider the projects to be too expensive and unfeasible.

In a different perspective concerning smart cities, the citizens might have a certain resistance to the change, especially the elderly people. But eventually everyone will adapt to it as they will start to understand the benefits and improvement in the quality of life this technology can provide.

In terms of suggestions, some of the recommendations are for companies to analyze the challenges they could face by implementing the IoT technology to the market in which they operate their business model and define a good strategy based on their analysis. Furthermore it is better to start now while that there are fewer competitors and cheaper products.

Overall there are different kinds of companies. The ones with a more open mind take the risk to innovate, and standout from their competition while the smaller businesses are more reserved when it comes to this technology.

IV – Economy

1. What do you think about the current national and international IoT market and their economic impact?

Microsoft: *"It is clear in every country that today there is a necessity for the Internet of Things and is recognized as an area of high investment and research and development. There is a factor that everyone have come to the conclusion, mainly for the consumer perspective which is the standards, between device communication and differences among adopted and protocols. Each company is defending their own position and view of the protocols they adopt because they already have experience using those protocols. Even so there is some confusion in the devices and hardware development about how is the best way of implementing them. There must be a global standard In order to have more agility connecting the devices that are going to be connected to the internet. When we reach the point where everything is connected, the devices to the internet and to the network, showing their functions and services, the possibilities are innumerous. Adding to this point, security is an important subject in the Internet of Things."*

Sensifinity: *"It is going to be an enormous economic impact. There are not going to be processes without IoT components. The impact with the computer and computation introduction started to become ubiquitous, anyone would have three or four computers working every day and the same is going to happen with the IoT at a greater scale. The market will always have some kind of synergy. The larger companies use startups to evolve faster and the startups benefit from the support of larger companies."*

Mainhub: *"The Portuguese market in the IoT is very small. I think any company considering to work in the Internet of Things area focusing only in the Portuguese market may be unsuccessful. To achieve the scaling from costs perspective necessary to compete in the market, we need to produce large quantities. In Portugal we would only sell thousands at best. In the international perspective, what is happening is that they are looking at the market in a serious manner. Meaning, an investor told me a year and half ago: "we do not make investment in startups in the IoT area because in a regular startup (developing mobile applications) the ones more successful in 3 years we can make it be very profitable (or not) for us and we can sell them. In an Internet of Things startup, we only can reach that stage at the end of 5 years, at best." There is a gap of 2 years for the investor- This shows*

investors were less willing to invest in IoT 2 years ago. Nowadays there are many investors to look at the market and understanding that investing IoT is good since it is differentiating in comparison to other technologies. For example due to the period of development of a solution, it is quite difficult for another company to copy a solution. While in the applications development it does not happen. In the international market we are growing considerably, we are talking about billions of devices interconnected. In our market we are still in the beginning but we are also growing at a good pace."

Cisco*: "In Portugal we see interest in several areas and the speed of adoption is dependent on a number of factors. For example the ability to invest, competitive environment, innovation dynamic, with sectors like local administration, industry and utilities leading the way. We see pilots, ecosystems, new technologies emerging, like LoRa for LPWAN and we believe that now is the time to start scaling the solutions and prepare for mass adoption.*

We see the market with many dynamics, still a little unorganized, with much experimentation and with "wait and see perspectives" (still trying to decide the path).There are various projects in the market already but not as many and in different areas as we would like to. We think we need more boldness, more courage, more investment and that the moment is now. If we do not take the chance now, even from our country perspective we are going to lose a historical opportunity of going ahead to a new model of economic development in our country.

This new areas may have a relevant economic impact, not only from the employment perspective but also from the point of view of competition, exporting capability, our global positioning as well as in the way we organize internally, how our cities function. In the vision for our country, it is something we have to take the advantage and we have to do it in a decisive manner. We cannot spend too much time with hesitations or short term plans. It is necessary to have a strategic vision for the country and this digital area of IoT and other emergent technologies. These are areas where we can change completely the paradigm of our country."

FEUP: *"I have some contact with more exigent markets such as Germany, Holland and Sweden which are knowledge based societies. When I contact with someone who works directly in the technology business sector it is visible they are much more motivated by the latest technological news. They are always updated and use the latest technology. When something was just launched they are already analyze its' potential and what is the best way of using it. They do not see only that perspective of using it for personal terms but also what they can do with it. In Portugal we are starting to have the same kind of attitude but less than in those societies. We are in the right growth path in relation to the other countries. Concerning the economic impact, it has an enormous potential in two levels. For the larger companies is easier to observe the direct benefits of the technology. One revolutionary factor is to use the IoT and new technologies in small business that are appearing, small niches. In this case, there is an vast potential because if there is a large company with a thousand employees and one hundred companies with ten employees each, in economic and social terms, the second hypothesis is better because is more resistant to changes, modifications, crisis than the larger company. The larger ones have less flexibility than the small companies do and that is what is happening nowadays, these technologies are helping larger and small companies and companies to appear, and that is extraordinary. "*

Porto City Hall: *"I think we in Portugal are making a very interesting path. We do not lead in many of the areas but we lead in some. We have high quality investigation in our country as well as*

universities and polytechnics working in that area. The market nowadays is global so the national companies work at international level and we have to maintain the investment here in Portugal."

In general was stated that as where Portugal is situated in the international market, the country is doing well and is on par with other European countries and may even be ahead of some of those countries in some aspects. The ideal situation would be to retain and maintain the investments in Portugal and avoid taking the startups out of the country as that would decrease the value created in our country while increasing it elsewhere. However, it was recommended that companies must compete in international markets as simply just focusing on the national market is not enough to survive. In addition, the lack of global standards and security can present itself as an obstacle in the adoption and product development in the IoT market. Likewise, there might be some cooperation between startups and larger companies, where both size of companies can grow at a rapid rate and at the same time help startups make a place for themselves in the market. The main countries it is possible to say that stand out in the IoT areas are Germany, Holland and Sweden as they have a different approach to innovation and technology from the rest, but it is safe to say that Portugal will follow.

As for the economic impact generated, an enormous change will be seen and will positively impact financial and strategic business factors and will also be affected by in the size of the companies.

2. What do you think are the advantages and/or disadvantages of IoT/IoT Portuguese and the international market?

Microsoft: *"Right now the advantages are easier to identify. For example, the scalability the cloud provides and possibility of registering devices through the cloud. Disadvantages, because it is a new technology, it presents a certain immaturity-Security is a concerning issue, it still has much to be developed. Standards and communication protocols make most the companies not so eager to implement this kind of technology, at least at a larger scale."*

Sensifinity: *"The advantages in IoT are the access to more data, with more quality and sooner. Everywhere the data quality increases as well as the amount of data, so the basis for decision-making is much better. Disadvantages for this technology now is being very recent and that many companies are not prepared to adopt it."*

Mainhub: *"The advantages I think it is the process improvements. The disadvantage is the low level of maturity. For example in a mobile application we detect a bug, there is no problem. We make a new version and it is available to reinstall it. In the Internet of Things that is not possible. If we find a bug in a device we cannot fix the ones already sold since the clients have them at home. But we can develop a new version. It has costs and then we sell it to other group of clients different from the one that already bought the previous devices and so on. At some point we will have several devices with different versions and problems we have to manage. This type of maturity, of how to develop solutions is a challenge. For the startups there is another challenge which is distribution. For example, it is not easy if a IoT component breaks down. It cannot be sent to some store for repairing and get another one. For startups to do this it is required a very complex process."*

Cisco*: "The advantages is all the potential created by the technology. The disadvantages are the data protection, privacy, security, how to transport, process and transform enormous amounts of*

data into information. From social impact, IoT must have well defined policies about information access and open-minded democratic management of what is the IoT. There is a set of factors that can compromise the benefits or contradict the known benefits in these trends and have to be dealt with by the society and proper entities.

The market is now global with Cloud based solutions, so we are competing globally, have to think at scale and think about the right partnerships.

In Portugal, we should take advantage of the European funds, creating specific programs and prioritizing areas of investment for development, improving our competitive positioning and overall productivity."

FEUP: *"There is some reluctance in some markets. What was been happening is the technological companies have always tried to have access to more data and it implies a decrease in privacy. There has also been a conflict between the growth of innovation in certain services and invasion of privacy. IoT is a emergent market with enormous potential but also with huge threats mainly at social level."*

Porto City Hall: *"It is difficult talking about advantages or disadvantages. When it comes to Internet of Things, the greater problem related to it is essentially data protection and security. It is a fact that cities have and that is why we are working with a city operator to handle this issues. Nowadays when we talk about Internet of Things is not just the public sector. There is information that comes from private companies integrated in the urban platforms. The management of what is communicated, what information is private or sensible and who can have access or not to the information and who can access it through illegal ends are areas that are most concerning. As such they need to be handled carefully. The main issue is how the IoT is used for a clear and proper end."*

The main advantages mentioned for the IoT market and the technology itself include the potential this technology can unlock, the scalability the cloud provides, process improvements and access to more quantities of quality data in a timely manner. However, the disadvantages are a larger concern and the most commonly mentioned ones include data protection, security, data privacy as well as the maturity of the technology and even of the companies.

3. Do you think there is enough investment, motivation, partnerships and support from the government or other companies to promote IoT solutions and adoption?

Microsoft: *"The government has given much support to this type of technology; especially it has supported the startups and the specialized area of IoT. It was this kind of incentive the allowed the startups to appear. We also have been working with the government in the identification of some projects that would make sense in their area, for example applying the IoT to the public administration and patrimony and creating solutions like smart buildings in order to decrease costs the government has, it will make a strong investment in that area. The autarchies are promoting events, creation of network and ecosystems with some companies specialized in the area. I think the government is going to stimulate the economy of small and medium enterprises and startups with projects applied in the cities. They have invested considerably in the promotion, divulgation of the IoT technologies and are present in many events related to that technology."*

Sensifinity: *"The government is very interested in the Internet of Things and understands the importance of the technology. It created a program dedicated for the Industry 4.0 in order to support the digitalization of the industry and support companies that want to innovate in the digitalization area. I think the Portuguese government is participating a great amount in the adoption and implementation of the IoT in companies and society."*

Mainhub: *"There is and there is not. There already a set of spaces in Lisbon. I mention Lisbon in particular because the rest of the country is not as focused in startups as Lisbon, Braga and Porto. These cities have some initiatives but the rest of the country does not have much. In terms of infrastructures and structures we have them. The problem is that the investment made should also be applied to the startups and I think there is not. There are private investors or business angels, but I do not think there is enough investment from Europe in startups."*

Cisco: "*The government has launched some interesting initiatives. We have some programs like Startup Portugal, Industria 4.0 and Simplex. It has a progressive vision about the Internet of Things and the potential it unlocks for the country. But it is necessary to start things, accelerate them and do it at a larger scale with the objective of having larger impact. Otherwise we will not be able to make this necessary transformation.*

The market is still fragmented and the ecosystems are being created, but the opportunities and projects are happening at a growing pace and the perspectives are very positive"

FEUP*: "We have some support programs for entrepreneurial and product innovations and the creation of startups through Framework Programme in a European context and also other programs from the government. It is important for people to understand when these type of investments done are necessary to have self-commitment. Sometimes the dimension of the investment requires support, and if there is not additional support, it is preventing a potential possibility that could work. It may seem that the programs are being terminated or reduced term or not receiving enough support. The reason for that is the increase in competition, making more difficult to have access to those programs."*

OASC: "*The majority of the support for projects Porto has are from public funding. I think the government currently is getting aware to new realities and incentive programs are being launched recently for topics related to mobility, for instance. There are mobilizing projects from national funds allocated for various areas such as smart cities and technologies. In that context, there are some interesting funds the government makes available. The larger investment in this aspect is related mostly with those mobilizing projects and it is not necessarily directed to the cities. That is why I say reality is a little different when talking about city or enterprise. An entity can get much more financing to the government because it is those entities developing the products. I believe there are mobilizing projects that some companies are creating and that they receive support from governmental funds."*

Porto City Hall: "*We are in a process where we know it is necessary to invest. There are solutions that have business models behind them. The cities, public or private partners, the entities exist, we know the business model and just need to know where the investment in the business is, the payback and if there is return on investment. There are several innovations that require investment in order to grow and expand, this is something that has to be addressed. The government has shown*

that is observant about these innovations, but there still is much left to do. If cities want to be more developed, they have to have a perspective where they try to develop the projects at urban scale, not just a small project. To create that impact we need to have investment, we are talking about new opportunities that are going to potentialize new startups and innovation. If they do not have a specific and valid business model, which is rather difficult to define in the beginning, it is necessary to have investment.

Overall the answers showed the fact that the government has invested and supported initiatives for IoT projects, It is aware and observant of what the Internet of Things is and the potential it brings for the economy and society of the country. However, it needs to accelerate in its development and more investment is required to help startups and other companies that are developing IoT projects to grow in order to create value and also invest more in projects being conducted for various cities in Portugal.

V - Vision

1. What are your perspectives about the Internet of Things?

Microsoft: ***"****The pace the technology is evolving is exhilarating. The investment being made and the evolution the IoT is showing is incredibly notable. I think we are going towards Internet of Things standardization, with innumerous solutions and adoptions. The next decade is going to be focused in the adoption of real IoT projects. We are going to watch our cities transform. It will reach a stage of maturity. From the Microsoft perspective, our strategy sets in three factors. We have an area called smart cloud, which is this evolution of registering the devices automatically, before it was not possible, we just could receive information. There is going to be the possibility of using the cloud in a more complex manner, enriching the services and IoT projects. We also have an area called more personal computing that is going to change how we deal with technology. For example, we will not need to use the smartphones and tablets as much. The technology will interact in a more direct way, such as using facial recognition to provide a certain service. The Internet of Things improves productivity both for individuals and for companies."*

Sensifinity: *"In think in the next 5 years there is going to be a "boom" where there are going to be many solutions. Many companies are going to become more aware of the possibilities brought by the IoT. Older companies are going to go into this area, market consolidation can only happen in a further stage. In 5 years, the competition is going to increase and we may be at the highest point of the cycle of the technology where there may also be a start for market consolidation and it is by then that IoT will enter the maturity stage. In the next years there is going to be some confusion because of the lack of standards. When defined there is going to be an orientation by the standards and market is going to be aligned regarding the IoT. "*

Mainhub: *"In our business we are growing in this area. Our idea is to build a larger laboratory with its' own business unit. As for the technology it is going to be inevitable, it is like the internet. It is going to grow to very large proportions. According to a report, there will be 20 billion of devices by 2020, so many that will be massive. It makes sense having a microwave or other appliance saying it is going to stop working tomorrow. Also using machine learning and the communication between*

devices for predictive maintenance, makes sense. We are going to continue to implement the solutions in our building, every time we have an idea we implement it."

Cisco*: "This is a new phase of the Internet that is going to transform, add value and create new use cases that did not exist before. This is a transformation not only of the internet but everything related with it; business models, countries, societies, among others. The future in our understanding involves new areas, enterprises, areas of activity that are going to be the engine of economic development and have the potential of being so for an extended period. With all of these there are going to be many transitions. Some enterprises are going to disappear, other ones are going to appear. This process is going to start accelerate and being more competitive. In this perspective we see the potential is enormous, a leverage for the global economic growth, a leverage for a period of prosperity and new paradigms of social economic organization associated with these trends."*

FEUP: *"The IoT has two levels. The most mentioned level is the communication layer but there is another layer which is the application layer. They are distributed application that are running and use that information gathered in the communication layer. The application layer is going to be connected to intelligent environments. They are environments with sensors and actuators that have the capacity of understanding what is happening around them and adapt to it. For example, in a room detects if there are people in there and adjusts light accordingly with the number of people and their placement and also adjust accordingly with the information parameters and provide the most relevant information for the people. These types of situations, as well temperature adjustments, are related to the concept of intelligent environments that is within the ambit of artificial intelligence. What has been observed is that the application layer is even more related with artificial intelligence that has been developing a lot in the last years and it is going to develop even more since we have more computational power. It is possible to make an search algorithm in order to get more optimizations, solutions, solution renewal and applications management which was not possible to do in the past. So the machine learning Is going to be more efficient, with big data it is possible to have access to a larger amount of data and all of this is going to enable more intelligent systems. For example, there can be systems able to hold conversations with the users, jobs such as call centers are eventually at risk because machines may replace them. The conjunction of communication layer with the artificial intelligence/applications layer are the key to have systems that can interact more naturally with humans and making decisions autonomously in a more efficient manner."*

Porto City Hall: *"The perspective is that this is a good snowball. It is going to grow and it is going to create impact. Nowadays even more the citizens and consumers are going to demand to have a more clear relation with what exists, what it does and question why things are a certain way or not and that can be achieved. We need information even more and use data driven decision making, we are going to making much more decision with enough information to support it."*

Regarding the future of the IoT, it is possible to say that new and different areas of activity, enterprises and improvement in the economic activity will increase even more competition. It is continuously growing at a relatively fast pace and it will create a great impact. The companies and citizens will have a more direct contact with the technology and learn what it is and how it will benefit them. Furthermore, the issue of the lack of standards, security and data protection and privacy can be solved. At a technical level, most of the decisions will be based on the data gathered

by the solutions and IoT will be integrated with artificial intelligence and machine learning systems enabling the existence of more intelligent processes.

2. How do you idealize the IoT market nationally and internationally in the future?

Microsoft: "*Being Portuguese, we are going to follow the trend from the more developed countries because they are in a larger stage of maturity. The startups are going to be differentiators and knowing the Portuguese market, they are going to have plenty of opportunities for their projects. In Portugal, in particular, we are going to have to adapt to the Portuguese reality, meaning, investing in the more profitable areas as tourism, for instance. The first projects will be directed for costs reduction, mainly in the government. All the other sectors are going to accelerate, improving their processes. It is possible that in a few years the products we consume will show a price reduction because the IoT allowed the process improvement of product manufacturing. We also have good companies in this area and in the IoT solutions so I believe we are going to keep up with the rest of the world."*

Sensifinity: *"The suppliers will be global as it happens in the computer market. In the beginning, there may be some local solutions but very rapidly, they are becoming global solutions. American or Chinese companies may dominate the market with the global solutions. There are going to be many services/products since this technology is going to be applied everywhere, agriculture, services and at our homes are some examples."*

Mainhub*: "It also is difficult to say. I hope the Portuguese companies are successful, they will have to sell the products in a different manner. I do not know if through traditional selling models, if Amazon is an adequate place to sell this kind of products, for instance, as the market may become entirely online or if there are going to exist specialized stores. Nevertheless, I hope the companies are successful and remain in Portugal, which is the most important aspect. I hope the startups remain in their country of origin and produce wealth from there instead of going to other country."*

Cisco*: "The national and intern market are gradually grayed. Things are global and the IoT and digital transformation bring that paradigm, which is when we launch an enterprise in Portugal we have to think at a global scale. We cannot think just in the local market. We have to consider that a company in order to survive, grow and be healthy, cannot focus just on one market. It has to be created from the ground and think at a global scale because if not it is only a matter of time until it is completely surpassed by other competitors."*

FEUP: *"The national market in these areas may develop and be at pace with the countries we have as reference and I think we are at a good promptness. I hope there are going to be more entrepreneurs from small companies to larger ones to have vision of being able to use the last innovations."*

Porto City Hall: *"Here we have a huge challenge and only have one way to overcome it which is going in the frontline. If not we are going to have many difficulties and are not going to have as many opportunities as other countries that have positioned themselves*. "

The vision of the market on a national and international scale is very positive as Portugal is at the same pace as every other developed country in levels of development and implementation of the IoT technology. However, since there is no exact distinction between the several countries in this matter,

we have to start thinking on global scale in order for companies to survive and expand. On the whole, it would be best for Portugal to position itself in the frontlines and eventually change their approach and business models as it would be much more difficult to standout and be successful otherwise.

VI – Positioning and impact

1. What impact it will have in the society and economy?

Microsoft: "*The economic impact is going to be enormous because the scale continues to be very wide. That stage of maturity is going to be the stage of implementation. This applies to every large sectors. There is going to be a very appellative business and the need for diversification is immense. It is unlikely the existence of one or two companies being responsible for the majority of the IoT business because that is going to catalyze us. It is going to be quite interesting because we are going to advance in the standards in order to exist a global market completely differentiated with many companies and partners because of the dimension of the market. This technology is going to have an impact seven or eight times stronger than the cellphones."*

Sensifinity: "*As the computer brought some problems for the society such as the privacy or information security, the IoT makes available even more information and channels. These problems in the digital world are going to deteriorate through the Internet of Things. In addition, there are going to be more sources of information and more risk of creating other problems through the extra data, so I think is not so much a problem of the IoT but of the digital revolution*."

Mainhub: *"I hope the impact in the economy is going to be strong also as a way to differentiate because we are not going to do it in another way. At the moment we have tourism and a few other relevant sectors in Portugal. If we can have IoT companies that produce products in large scale and regarding the amount of devices, the Internet of Things would be a relevant sector for the country. The impact in society is going to be interesting to watch. Most of the sensors and IoT exist to help us, but there is always the debate about artificial intelligence. The IoT technologies may tell us to not do something we would like to do. For example, a car can have sensors that measure our emotional state or something and according to parameters set by the car manufacturer, the car may not function if those parameters are not correct. The technology applied to other situations may limit us from doing actions we naturally wanted to do."*

Cisco: *"IoT and Digital transformation have the potential to change dramatically businesses and society with a profound impact in what we do and how we are organized.*

A larger number of persons considers digital service as a commodity and an advantage. The enterprises see themselves with the necessity of delivering services in this area because if they do not, they will fall behind. People choose the enterprises who can give them the best digital service, allowing them to be more autonomous, have available services in any device at any time and give them a higher degree of liberty and access. Even how cities change the form they are managed, how they compete with each other to attract investment, attracting people with higher social and economic status, create better life quality and how they attract business. As such they only can reach those differences if they consider this opportunity of the digital transformation as something to improve their services and have a specific vision of what is the dynamic function of the city, which are

their main challenges, among others.

Any type of sector or enterprise, even cities, how the government relates with the citizens and every public and private sector with the IoT is going to experience an impact that can be bigger or smaller, faster or slower. Nevertheless, the potential the technology nowadays has in changing all these areas is tremendous and nobody is going to be excluded. Portugal is a little behind in the digital inclusion challenge, how we create new generations perfectly adapted to this new reality. There are already some examples but we need to invest more in education for new technological areas, programming, etc. sooner in schools and universities, this is one aspect. Another important factor is how we transform older generations citizens and give them the minimal tools or the support for them to be included in this digital era."

FEUP: *"It has potential for a huge impact. There is a continuous evolution of this technology; it is not just something that started recently. Looking into Portugal situation, we had an incredible transition in terms of technological development. In the telecommunications area for example, from telephonic installation to network virtualization and national coverage, Portugal is a country of reference. We have been always ahead because of circumstantial situations. Portugal had two different telecommunication companies in the beginning where one was more focused in the larger cities and other in the rest of the country. In order to solve that problem and do an entirely national coverage without telecommunications being divided into two companies, Portugal was the first country to have a communication network completely automated without having the manual operators. We were also the first to develop services added to the data communication networks under payment, for example SIBS was always ahead in the world with the services available for ATM cards and network. Brisa is another example of IoT application in a certain mode, it is one of the first examples of IoT where the cars passed under the sensor and the value is automatically deducted from the client. This company was for a long time one of the most innovative companies in the world. Therefore, we have a group tradition in terms of technological development and in taking advantage of communication technologies which is the foundation for IoT. Then when cellphones came, Portugal also had a positive adoption and handling since there are several competitive operators making an almost total coverage of the country and with very interesting services and then came the smartphones and remote internet. Nowadays it is possible to observe that this factors influence the creation of new enterprises. In the society, as the cellphones changed the people drastically, the smartphones are currently having the same impact and the IoT is going to change people even more because it is going to be natural in the future to interact with their surroundings."*

Porto City Hall*: "Public management has direct impacts in what the expenses are to manage the public wellness. We have to take advantage of this opportunity and invest in areas that give us return. In this moment the main focus should be to invest in areas where we can obtain cost savings. If we can do that I think the country has a lot to do in that area. There are many other areas that are not very related to the public ambit and I think the business is going to be the driver of this transformation. We need to have a conjoint perspective and the problem is more based on the business models which are not stabilized enough to know how are we going to launch the technology. There are several parallel processes. The projects that introduce an optimization should be implement and takeoff as soon as possible and have programs in order to do so. We have countries in Europe that apply tens of millions euros in these projects for public services improvement. We still are a little far from it but there also are ways of applying money that translates into a benefit. The impact is*

extreme and we have to take advantage of it and then there are other areas where we have to invest to lead in the front, we need to invest to believe that in the future it is going to translate in an future asset to the economy."

The impact created by IoT in the society and economy is going to be massive and change considerably both factors. It is going to be a stimulation for the economy and as for the society is going to change how we do things and interact with them. It is going to bring a digital change, which is going to provide the creation of new services to which the companies can understand the impact they are going through in this period. It will also increase the digital inclusion since it is a challenge in Portugal. The additional technologies that can interact or belong with the IoT, such as, artificial intelligence are going to have an interesting effect in society as well as the industry. Other factor to have into account is how to avoid problems of information privacy and protection as the IoT is going to intensify that feature. In Portugal we never had many difficulties in adopt and adapt to new technologies so the Internet of Things is not going to be an exception. Overall the IoT is going to cause vast amounts of diversification for the economy and society in different levels and provide new opportunities and ideally also going to increase society life quality.

2. How do you think Portugal will position itself in comparison to the other countries?

Microsoft: *"The most developed countries have an investment capacity much larger than Portugal and it is in those countries where are more early adopters. In Portugal, in the last months to a year there has been an enormous increase of specialized startups. Partners that before were more focused in information technology now have sub companies and groups specialized in the Internet of Things and expanded their network abroad. I think we are evolving at a good pace, but we also have to have in consideration a country like the United States has an investment capacity completely different. Nevertheless, the number of startups we have makes us very proud, this shows that we are more advanced for our country size. Also relatively to the standards, now we see the adoption of those and the entrepreneurial community in Portugal pays great attention to the news about the Internet of Things. We have several protocols and technology that are gaining recognition in the IoT area, leading to the evolution of startups and even larger companies are very interested in working with smaller companies, which is very positive for the economy."*

Sensifinity: *"Excluding Germany that initialized the industrialization in Industry 4.0, Portugal is one of the countries ahead at the moment. If the companies have the capacity and availability of adopting and keep the rhythm in the digitalization, Portugal is one of the main countries in this area. In the world, currently is ahead of the United States or China."*

Mainhub: *"Now there are 3 or 4 countries with companies and startups developing IoT solutions, Portugal, Germany, England and Italy. These are the most interested in this area. Fortunately, we are in this group. If we do the right thing in Portugal having in consideration the support from the government, if universities collaborate and if everything becomes an interesting ecosystem, I think we are well positioned and can have plenty of success. In comparison to the world, I would add two more countries, China for the obvious reasons, because they are very big and have particular interest in the IoT area because of their production capacity and United States because of their capacity for entrepreneurship perspective and financial capacity, and then they take the ideas, produce in China and then sell them. I think we are among the top 10 countries in the Internet of Things area."*

Cisco: "*We have a challenge which us the digital inclusion. There is a statistics by the European community showing Portugal as one of the countries more behind in this aspect. Because there is a high percentage of our society that has not access to the internet and is digitally illiterate. That can be a barrier, so I think it is also important to give support in order to decrease that problem. The other aspect is to prepare the future generations, give them competences and knowledge for this new areas. The third aspect is, as a country we live in a cross path from the economic perspective, our traditional model of economic development expired and we have to look to the digital transformations as an unique opportunity to put our country in the frontline"*

FEUP: *"Portugal has always been very well related and well positioned close to countries with traditions of larger innovation and development, although we have been behind them when it comes about taking advantage in economic terms. At the same time there has been an increase in young entrepreneurs that seize this opportunities in a fantastic fashion. There is a positive evolution, there is a decrease in the entrepreneurial gap comparing with other countries."*

OASC: *"In this situation is more difficult to think at national level and easier to think at city level. Portuguese cities have been leaders in some aspects. For example, Lisbon is involved in a project called "Lighthouse" which is one of the most important projects and it is related with the IoT area and Porto is as first pilot city in a project of urban platforms also related to IoT and is leading the process of pilot and implementation at European level. At this point, the European panorama is very balanced."*

Porto City Hall*: "We are well positioned but with some difficulties in investing in large projects and when the business model is not very perceptible, is more complicated and we should do something in this aspect."*

Considering the larger and more powerful countries in this aspect such as Germany ,Holland, Sweden, Italy and England, Portugal is also in this group when it comes to IoT development. In a more global scale there are more two countries, United States and China with much more economical and production power. Portugal is also very well positioned but there is always the problem of the investment that should be a little higher and we should take better advantages of it, also in the digital inclusion, we are behind in that side.

3. Do you think Portuguese citizens will accept and adapt easily to the technology?

Microsoft: *"We know the demography in Portugal is aging, but now there is a new generation called "millennials" starting to ingress in the employment market and those people are native with internet technologies and this has the tendency to increase. The technologies are going to have a gradual and natural acceptance. Even with the aged population I am looking forward for the work developed with these new technologies. I'm not worried with the adoption of these technologies by the common citizen."*

Sensifinity: *"It is as any other digital system. When it is well constructed and developed, yes citizens can adapt to it easily, when that is not the case, they cannot. The technology is the same but it can be implemented in a more intelligent manner or not. When it is well implemented is very natural to aid the citizen, when it is badly implemented is working against the citizen instead of helping them. It depends of the companies and adopted paradigms when implementing the system."*

Mainhub*: "We will have to adapt to the technology. For example, a startup wanted to monitor the health conditions of the elderly at home but they did not want to use a bracelet to measure that because the elderly would forget to use it. Therefore, the startup would have to implement sensors around the house in which without the direct intervention of the user, it was possible to understand the health situation, for me that's different. When we have to make people to change, as for example, wearing something on them every day and they do not want, we are doing something wrong. In my opinion technology has to be non-intrusive."*

Cisco: *"The new generations are more apt, aware and sensible to the new technologies. However, I think we should strengthen some areas to give higher competences and knowledge. There is the digital inclusion situation in which I think it should be created mechanisms of professional formation for employed people in order to gain more quickly aptitudes in this area. Which is also important from the productivity perspective and we should not leave it just to the enterprises to provide that kind of formation as most of them are small and medium companies with low capacity and resources to give training to their employees."*

FEUP: "*In the past we have examples of great acceptation of new technologies, from ATM cards to cellphones, so I think we are going to adapt rapidly to whatever technologies implemented and our market being small was always receptive to new technologies."*

OASC: *"Everybody has a little resistance to change, but we also have a huge capacity of adaptation. So in one side we are going to resist to this new technology. For instance, there is a society layer (elderly) that is going to have certain difficulty to adapt but also they will not need to because their lifestyle does not imply they have access to this technology. Of course, everyone must be integrated. The younger generations are not going to have many problems in adapt because they may understand more easily the benefits the IoT brings. If I just mention the word "IoT" nobody is going to use it. If I show the people what do they have to gain with what we are proposing, then they will accept it and use it. Most of the people are not going to see the IoT in its entirety, but they will notice there are services that can improve their life. We also have to communicate very well what IoT is."*

Porto City Hall*: "The technology has to be seamless. People more interested in technology can understand that is receiving information from somewhere. Georeferencing is providing a new type of service to understand that the searches made will show them advertising related to it, and there are people that will not realize that. Although I think that is something that must be always perceptible for everyone, but in the cities the technology has to be a little seamless and it already is, in the semaphore management for example. If the technology is non-intrusive in most cases is the best technology we can use, having into account the data anonymization and how do we infer this in our private lives. We are a country of early adopters and I think we should use that condition and try to make it easier of using it."*

The Portuguese citizens will not have many problems in adapting to the technology since we are an ever evolving country. But, in order for us to accept changes, the technology has to be non-intrusive and as normal, it is necessary to take precautions with data protection and privacy issues. As a large part of the population consists of the considered elderly we also need to the technology is easy to

follow and make use of for these users in order to guarantee that with time they also will come to understand how to interact with this technology.

4.5. GLOBAL ANALYSIS

The interviews conducted provided a realistic perspective of the as-is, to-be of the business models and its market and everything it is related to and the massive impact it is going to have.

It was possible to understand the general concept of what is the Internet of Things and the various forms in which can be developed. There are various architectures depending on the type of project and objective the client wants to reach. There still is not one optimal or global architecture that is ideal for every project due to the lack of standards, although work towards that goal is being done. However there are three main components that are almost always part of an architecture, the cloud, machine learning and analytics.

As for the business topic it gave a better perception of the potential and impact the IoT is going to have for the clients and suppliers. There are many different business models. Each company adopts the one that suits best for their objectives, area of actuation and who or what they want to target in order to satisfy the clients' needs, specifications and requirements. The main sectors searching for these type of solutions are industry, transportation, telecom, energy, agricultural and retail mainly**.**

In the topic concerning strategy, what clients pretend to achieve when adopting an IoT solution is to change and innovate in the market in order to get ahead of the competition, provide better and newer services for the clients, improve processes, and reduce cost . In order to do this the companies also need to adapt to technology. These solutions mean there is going to be an inevitable a change in how the companies are going to work internally and externally. Furthermore, before implementing, it is necessary to know exactly what this technology is and what it can unlock, as well as the risks associated with it. There are companies that are better informed but others are not so much. Proper implementation depends on the maturity of each company and the timing to do so, but in part, it also depends on the maturity of the technology. Since we are in an initial stage of the technology, it is comprehensible for the companies to be reluctant. However if they start adopting it in this phase, they will be much more successful in the future because they already are creating value with it, and they are standing out from their competitors. To the contrary if they adopt it much later, it will not have as much impact.

The economic view for the market and the Internet of Things is very positive. The Internet of Things is going to provide many investment opportunities and the return although it is not immediate is expected to be very high. To maximize the economic impact it is suggested for the startups to remain in Portugal to create value for our country instead of moving their business to a more appealing country, although it is also important to expand the solutions and services internationally.. The investments and initiatives made by the government are very interesting because it shows that there is a strong support coming from the government for this technology.

The vision for the future of the Internet of Things is that it is going to grow gradually; it will provide more opportunities and greater potential as it is going to be a more developed and mature technology. The most concerning issues such as data privacy and protection, will be set under

control, as well. The positioning of Portugal in the future is also viewed as very positive, proving to be the most developed countries utilizing this technology.

As for global positioning and impact, it is expected Portugal will have a great impact in the society created by the IoT. It is going to change very much how people will interact with the objects and their surrounding to create new perspectives about these objects. We shall draw attention on fact that people will adapt to the technology, and in Portugal, we can safely assume, there will not be many problems doing so, as we have adapted to most types of technology without major problems. However we have to consider that a layer of society, as in the older generations, may have bigger problems in adapting, but that should not be a predicament since there may be projects initiated in order to integrate them. Currently, Portugal also stands in a good position among the larger countries that are developing IoT solutions and is it expected to remain that way.

5. CONCLUSION

The main objective of this dissertation was to understand is the meaning of the Internet of Things, its' structure, business models and how it is going to create impact and value in the economy and society. This study was elaborated based on seven interviews from different environments and two different regions in Portugal in order to better understand other perspectives, as it is going to be a technology that is going to change the backbone of society and technology in consequence with many other emergent technologies. For that, we tried to understand and analyze the potential of the Internet of Things and what it will bring for the economy and society.

As a result of the research, the main conclusion obtained is that the Internet of Things is an old concept that has gained power in this last few years and that unlocks many things to which we are not very familiar with, although Portugal is almost ready for this digital transformation. There is knowledge about what it is, current limitations and problems, how it can work and about the value generated for the entities, the government and individuals. There are already several solutions and initiatives from young entrepreneurs and larger companies with the objective of developing new and innovative projects to create value and more quality for other companies and citizens. However, these entities have to define a clear path for what they want for themselves and they should not be afraid to risk because in the future the return obtained will be extremely valuable. It may be difficult as the revolution of the Internet of Things is compared to cellphones and computers when were first introduced in the society and economy. But if they define a concrete business model or strategy from the beginning, they will stand out, grow and create impact in the market. If an entity is falling behind the competition, one manner to stand out is by differentiating and the Internet of Things can provide that differentiation, strategically and technologically. If they implement the IoT early on, the probability of surviving and get ahead of the competition is much higher, if they adopt it later when the majority of the entities are already doing the same, the impact will be much smaller. The IoT will help the economy will "boost" and Portugal is very well positioned with the development and implementation of the Internet of Things, having the advantage that the government also supports a great amount the investment and initiatives in the adoption of this technology.

5.1. LIMITATIONS

For this dissertation, the main limitation was that as stated before, the Internet of Things is an extremely vast area, the number of interviews do not show the concrete reality of the business models and the IoT market in Portugal. There still is much more to be investigated concerning this topic.

During the elaboration of the case study there were not major limitations. Every entity approached for the interviews was very receptive and interested in the work being developed. During some interviews, some questions were not answered since they were answered in previous questions, so the transcriptions may differ from the interview guide.

5.2. RECOMMENDATION FOR FUTURE WORK

We need to know more about it and how to use it in a proper manner within certain standards to maximize its adoption and potential, but these are some issues that still have to be worked on. This technology also comes to revolutionize the market and our quotidian lives. There are going to be certain sectors that will see more value in the Internet of Things for now. Some examples are the retail and the industry that have certain maturity to implement it, but in the future, many other different sectors will also adopt the technology to improve their processes and the value they provide. Although several business models already exist in this field, there is a growing possibility that many more will be created or remodeled to adapt to the changing systematic procedures. As for the business models for developers, there are going to be innumerous models because with this technology there are innumerous possibilities to deliver their product to the clients, retain value and obtain a high return. The question that may rise is "how the business models for the Internet of Things are different from any other?". The answer is that most business models most imply change and adaption of the current business models of a company, while others do not.

For now we can only observe what is going to happen moving forward in the market and see how the Internet of Things will grow because of the ongoing opportunities created.

As for future recommendations, it would be interesting to focus on the situation of one sector in particular and observe its evolution and behavior. Particularly, I would like to investigate and study the lack of standards and security issues for the Internet of Things in the future, perhaps through a doctoral degree. These are some of the main reasons because there still is not a higher adoption of the technology and even though we are not too far behind in relation to other countries, we could be at the same level. In order to do so it would be motivating to also study these factors.

One other interesting topic to study would be, in a few years, analyze how the Internet of Things market is in Portugal. See if there are successful and unsuccessful cases of implementation of the Internet of Things, analyze them, and try to understand what went wrong in the unsuccessful case. If possible, propose some measures that could help that entity grow and be more successful with the Internet of Things and make a follow up for a period of time to observe its evolution. It would be also interesting to study, in parallel, the successful case and understand the reason why is it so and analyze possible risk factors concerning the Internet of Things, doing also a follow up of the case progress.

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ANNEX I - INTERVIEWS

Microsoft Portugal

I – Present Situation concerning Internet of Things

1. What is your opinion on the Internet of Things?

"The Internet of Things is a way through which we can connect to practically any device to the internet in such a way that it is possible to gather telemetric, information that is bidirectional. That is to say we can have any device connected to the internet, connected to many services, and that can provide us with a wide variety of opportunities because we can use services like machine learning with some level of intelligence that can support devices considered to be disconnected. Reality is going to change significantly. As mentioned before, this technology is going to be applied to the vertical market such as the agricultural sector, telecommunications, media, and marketing will be also a great area where IoT can be applied since it will provide more room for creativity and different ideas. Furthermore, this technology will permit all the companies from every sector to create new business models. They can then analyze how the current situation of their business models is, and with the IoT they can explore and expand into new areas they may have not considered before. It can be either a drastic change or a complement to their current business model".

2. What is the best architecture for the Internet of Things?

"With the IoT being a new technology, one of the main considerations is in being able to define some standards which every IoT project will use as foundation. For example, Microsoft already has a certain architecture to apply to Internet of Things projects. The concept of this architecture is having a set of devices that can be connected between them, but not connected to the internet. There is the field gateway architecture as well, which is a device connected to the internet and all the other devices, and it is responsible for sending all the gathered information by the devices to a cloud-based backend service because we need the scalability. For example, a project can have a million devices connected that usually are not connected to a field gateway but to an Enfield gateway, and it was necessary to do a dimensioning intervention. The architecture was like this until six months ago; now we have evolved. Nowadays with the offer of our cloud services for these IoT projects makes it possible to have everything automatized .For example, the registration of devices, send commands for the devices as well as reading information."

3. What applications do you develop/apply for your customers? What kind of technologies do you use to build them and how long does it usually take?

"Nowadays with the cloud services that are much focused in Internet of Things, we have a specific cloud service that is a "pay as you go" service, in which the client pays for the consumption. It is called IoT Suite that makes the periods of development very short, just 10% of the time is spent in the development of backend. The majority of the work is in areas in which the Internet of Things industry still is very immature. The devices components, interoperability, new protocols and all the know how present from the hardware development part has shown an acceleration due to the interest from the market. There were already some protocols, it is a component that has been

defined recently. The projects take 60% to 90% of the time for the devices. In the area of backend everything is cloud based. One of the advantages of the cloud, besides scability and a defined architecture known in the market, agility is the other advantage. We can create solutions in a matter of minutes, implement the code and run all the required tests, these are some of the characteristics nowadays that matter the most."

4. What kind of businesses require your services? Which are the main sectors?

"We are noticing an interest from companies in all the different sectors. For example, in the retail sector in which we have noticed greater interest, the telecommunication sector, energy sector and agricultural sector as well. We can see in the startup ecosystems, there are many startups specialized in IoT and most of the time they are dedicated in a specific sector. For example, in the agricultural sector alone, Microsoft supports two or three startups showing very satisfying results and evolution. Without a doubt that the retail sector is the one in a more advanced stage, besides there are projects being currently implemented. As the market already knows, the IoT will bring much value to the companies and the sectors. The most important factor here is each one of these sectors need to understand which the best business models are and where they can explore the Internet of Things. The retail sector is one of the areas where those types of business models are easier and more logical to identify and adopt. As such, they were the first to implement IoT solutions. The other sectors are still studying and analyzing how they can implement and make the most out of the Internet of Things."

5. What are the main objectives from your clients when implementing an IoT solution?

"Depends. Mainly each sector wants to understand is how to create new business models. For example in the retail sector, we can do several different applications. We have numerous projects in action with the purpose of doing the machine maintenance; allow preventive maintenance using other cloud-based services with machine learning. The smart cities areas a common project being implemented is using IoT to detect empty spaces in parking lots and facilitate the payment method in the parking lot. These are some of the examples to define the business models that have appeared and being worked on. It depends. The way the companies explore the Internet of Things is always different but in one or another everyone benefits from it."

6. What improvements has the client shown after the implementation? Did it change their type of business model? If so, in your opinion, did it change drastically?

"In Portugal we have some projects in IoT but are in an exploratory stage. There are a few projects currently running but there is not any that would completely transform certain business area, due to the early stages of the technology. But some projects are showing results beyond the expectations for this kind of stage. I think in the next year, we are going to have more good examples of implementations like these."

7. What is your type of business model? Do you consider your business model to be much different from that other technological companies? If so, in what way?

"There are two areas. Azure as a cloud service and platforms such as infrastructure as a service, platform as a service and also software as a service. These platforms are developed by a partner that

offers the service and we consume it without any kind of concern about the maintenance or provisioning of the platforms.

The platform as a service in the IoT scenario, since each company and each industry are different, the model that makes more sense in this situation is PaaS. We provide a platform that facilitates the integration between every devices, allows the maintenance, has a very critical point in this technology which is security. The platform provides that out of the box. It gives freedom to implement the most diverse IoT projects and also because this technology is going to be implemented in every sector and the projects will also be different from each other.

The difference between other technological companies and us is that the other companies have approaches for the Internet of Things technology that have common and different modules because of the diverse background of the companies. We are clearly differentiating into a service company. What would make more sense would be to provide our clients with a platform as a service, I allowing our partners to implement all kind of solutions and resell it to the final customers. For example, Samsung is focused on the devices, so it adopts an approach more directed for makers. This type of differentiation is encouraging because of the existence of two areas. One focused on the solution and other more dedicated for makers. This will help the growth at a component level and increase our sector. Furthermore, this type of technology is no longer just related with information technology, it involves electrical systems and every business areas, since the IoT is going to impact every market. Even in the pharmaceutical or agricultural sector, the professionals in these areas have to contribute with their know how in order to complement the Internet of Things projects, as this technology is an area that is bringing everything closer."

8. Do you think, currently, companies are well prepared to implement and adapt to the changes the Internet of Things solutions can bring? What suggestion do you have for current and potential customers in order for them to implement IoT and stand out from the competition?

"In Portugal we have verified a very pleasant evolution in the last 6 months to a year. Some Microsoft partners, portuguese small and medium enterprises are providing services and physical devices for Internet of Things implementation. A year ago we were at an embrionary stage. Now there are many partners. The range of options of IoT projects for larger companies is increasing, so they can choose the best projects according with their necessities.

Suggestions for clients: being from different backgrounds. One of the suggestions is the digital transformation or the Industry 4.0.The arrival of new technologies, especially of the IoT, will let companies to analyze into their businesses, understand how to improve their processes and change drastically the form on how they work. So what we are going to do is to help our clients in this process of digital transformation, understand which areas they can explore technology to reinforce the current business models, create new ones or transform them."

9. What do you think about the current national and international IoT market and their economic impact ?

"It is clear in every country that today there is a necessity for the Internet of Things and is recognized as an area of high investment and research and development. There is a factor that everyone have come to the conclusion, mainly for the consumer perspective which is the standards, between device

communication and differences among adopted and protocols. Each company is defending their own position and view of the protocols they adopt because they already have experience using those protocols. Even so there is some confusion in the devices and hardware development about how is the best way of implementing them. There must be a global standard In order to have more agility connecting the devices that are going to be connected to the internet. When we reach the point where everything is connected, the devices to the internet and to the network, showing their functions and services, the possibilities are innumerous. Adding to this point, security is an important subject in the Internet of Things."

10. Have you implemented or are considering to implement an IoT technology? If so, what type of solution do you anticipate? What are your expectations? So far, based on your results, what is your opinion?

"We are now running real projects as proof of concept and currently we are implementing IoT scenarios in our building, with a particularity, we do not want to use just Microsoft technology but also technology from Portuguese partners, the startups ecosystem and older partners, to project the IoT market in the Portuguese companies."

11. What do you demand from your IoT suppliers?

"As this phase still is exploratory, we've been helping the clients to define more customized projects to implement in their industry. Usually they are simpler projects due to the initial stage of the technology but others can be a slightly more complex. It is an initial investment the clients are making and we help them to define and set concrete details about the project. We give them the know-how of the possibilities of the Internet of Things and they have the know-how of their business, creating a cooperation between both parts for the project. What clients demand the most is orientation on how to make the most out of the IoT having into account their sector. In the implementation which are in an initial phase or a more advanced one, we work together with the clients on the architectures, recommend other partners with experience to work in the projects."

12. In what departments will IoT technology be most useful?

"Typically the departments were IoT is being more focused are the departments of the core business. For example, in the agricultural sector IoT is used in the fields, information gathering or give details about the creation process of the crops. In the financial area IoT is used to improve the relationship with banking customers, improve final customer experience. For example to schedule a meeting with the financial advisor via smartphone, facial recognition with high security level, recognize the customers' age and show product information for a specific segment where the chances of a customer acquiring it is higher. "

13. Do you think IoT can help your business stand out or get ahead from your competitors?

"Yes. The banking example mentioned before is a case of differentiation. What every company looks for is differentiation, find new business models related to that differentiation. Considering all the possibilities IoT can offer, the companies that implement the IoT will have a higher probability of surpassing their competitors that is not so technologically advanced. "

14. What is your opinion about the economic impact the Internet of Things is going to bring?

"According with the Forrester and Gartner reports, there are going to be 19 billion of devices connected to the internet. If we consider the number of mobile devices and since the beginning of that type of technology, we can verify an exponential growth. By 2020 and this stage of implementation we are going through until then, this technology is going to make the revenue, business models and financial impact very interesting. There is business revenues for the area of hardware developers, solution developers, consulting and even for all the other sectors, as the IoT can create other possibilities of services for the innumerous businesses that adopted and implemented the technology from which can be another source of revenue. So the economic perspectives and impact is very significant."

15. What do you think are the advantages and/or disadvantages of IoT/IoT Portuguese and the international market?

"Right now the advantages are easier to identify. For example, the scalability the cloud provides and possibility of registering devices through the cloud. Disadvantages, because it is a new technology, it presents a certain immaturity. Security is a concerning issue, it still has much to be developed. Standards and communication protocols make most the companies not so eager to implement this kind of technology, at least at a larger scale."

16. Do you think there is enough investment, motivation, partnerships and support from the government or other companies to promote IoT solutions?

"The government has given much support to this type of technology; especially it has supported the startups and the specialized area of IoT. It was this kind of incentive the allowed the startups to appear. We also have been working with the government in the identification of some projects that would make sense in their area, for example applying the IoT to the public administration and patrimony and creating solutions like smart buildings in order to decrease costs the government has, it will make a strong investment in that area. The autarchies are promoting events, creation of network and ecosystems with some companies specialized in the area. I think the government is going to stimulate the economy of small and medium enterprises and startups with projects applied in the cities. They have invested considerably in the promotion, divulgation of the IoT technologies and are present in many events related to that technology."

II – Future Situation for the Internet of Things

1. What are your perspectives about the Internet of Things in your business?

"The pace the technology is evolving is exhilarating. The investment being made and the evolution the IoT is showing is incredibly notable. I think we are going towards Internet of Things standardization, with innumerous solutions and adoptions. The next decade is going to be focused in the adoption of real IoT projects. We are going to watch our cities transform. It will reach a stage of maturity. From the Microsoft perspective, our strategy sets in three factors. We have an area called smart cloud, which is this evolution of registering the devices automatically, before it was not possible, we just could receive information. There is going to be the possibility of using the cloud in a

more complex manner, enriching the services and IoT projects. We also have an area called more personal computing that is going to change how we deal with technology. For example, we will not need to use the smartphones and tablets as much. The technology will interact in a more direct way, such as using facial recognition to provide a certain service. The Internet of Things improves productivity both for individuals and for companies."

2. How do you see your position in the IoT market in 10 or 20 years?

"It is very difficult to say. It still is a very volatile industry and it will affect every sector. It is unthinkable for someone to predict where we are going to be in 20 years. However, we can say that we are going towards an technological utilization completely different from the final user point of view, we are going to have a scalability and integration never seen before in the cloud and the area more oriented for productivity. Microsoft developed a video showing where we would be in 15 years in every sectors and areas. The video is called Microsoft Envision and was made by R&D specialists with the objective of identifying a possible path defined by experts in order for us to define our tasks. The three main factors mentioned before, smart cloud, productivity and more personal computing are the result of that vision"

3. Do you expect any differences from the original solution you developed or do you think your business model will remain the same?

"Being positioned as service providers, we are trying to create the best platforms, so that, the implementation of any project in any sector is as fast as possible and we have already achieved that. As mentioned before, most of the time is dedicated to the devices. What we are going to keep doing is to invest in the cloud in order to create solutions even faster for particular cases we come across and continuously we are going to reinforce our main IoT service, adding more features to agilize and implement in a specific niche. For instance, for the cloud we can use other type of services as the machine learning in order to have a prediction in preventive maintenance scenarios for example."

4. Which sectors do you think it will require more IoT solutions in the future?

"Retail is one of the most interesting area in this case and the entire industry, as for example Tesla is going to have a fully automatized factory, Foxconn is also investing in a automatization process. Other areas are the smart cities and smart buildings, which are transversal to every sector because every company has headquarters and so it is a very specific scenario. As for smart cities it is also very interesting because the technology will help us as citizens, as tourists and it is going to improve the life quality in the cities."

5. Do you think companies will show more maturity when planning and considering implementing IoT technologies (or any other emergent technology)?

"Yes. We are now ending the hype stage in the Internet of Things, meaning that we are starting to enter the maturity stage, and this cycle happened to every type of technology, it is an observed pattern in the technology life cycle. The Internet of Things area shows us that, the companies are going to have more experience, are able to implement the projects and democratize them because they can implement the technology in a more inexpensive manner since all the investigation is done, the standards are defined and when that happens there is going to be a huge democratization. There are going to be IoT projects everywhere, industries, cities and many others because it is going to be

easier even for small enterprises since the capital for investment is going to be less and are going to be capable of starting implementing these kind of projects. During the next decade is going to be notable the maturity process in the Internet of Things area."

6. How do you idealize the IoT market nationally and internationally in the future, from a supplier perspective? What types of IoT services/products you think there will be in the future?

"Being Portuguese, we are going to follow the trend from the more developed countries because they are in a larger stage of maturity. The startups are going to be differentiators and knowing the Portuguese market, they are going to have plenty of opportunities for their projects. In Portugal, in particular, we are going to have to adapt to the Portuguese reality, meaning, investing in the more profitable areas as tourism, for instance. The first projects will be directed for costs reduction, mainly in the government. All the other sectors are going to accelerate, improving their processes. It is possible that in a few years the products we consume will show a price reduction because the IoT allowed the process improvement of product manufacturing. We also have good companies in this area and in the IoT solutions so I believe we are going to keep up with the rest of the world."

7. How do you view the market with the settling of IoT technologies in companies (if does settle)?

"According with the reports done by Forrester and Gartner we are going through the hype stage of the technology. The maturation stage is going to be at for at least a decade without a doubt, the benefit analyzed in those market analysis is that the Internet of Things is going to be disruptive, transformational in every sector, the IoT is going to exist for many year and it is going to transform itself. Nowadays we are implementing and adopting the IoT for the sectors benefit, after the maturation stage, when the technology is regularized everywhere and because it is an enormous area, it is possible for the maturity stage duration to be over a decade. We also may interact with the IoT in conjunction of other peripheral technology, such as holograms."

9. How much do you think companies will change in order to adapt and work with IoT technologies in their companies?

"It is going to be very transformational. In the last 15 years, 60% of the companies in the Fortune 500 list changed the top of the list change drastically during this period. Many companies that were in this list nowadays do not exist anymore and I think that tendency is going to continue. The companies that do not differentiate, the ones that do not invest in technology as much or do not differentiate according with their final consumer in order to give a better value proposal to them will end up disappearing, meaning, the impact is going to be significant. The companies need to find manners of differentiation with the utilization of the Internet of Things"

III – What is your opinion about the utilization of Internet of Things in Portugal?

1. What impact it will have in the society and economy?

"The economic impact is going to be enormous because the scale continues to be very wide. That stage of maturity is going to be the stage of implementation. This applies to every large sectors. There is going to be a very appellative business and the need for diversification is immense. It is

unlikely the existence of one or two companies being responsible for the majority of the IoT business because that is going to catalyze us. It is going to be quite interesting because we are going to advance in the standards in order to exist a global market completely differentiated with many companies and partners because of the dimension of the market. This technology is going to have an impact seven or eight times stronger than the cellphones."

2. How do you think Portugal will position itself in comparison to the other countries in Europe? And in the world?

"The most developed countries have an investment capacity much larger than Portugal and it is in those countries where are more early adopters. In Portugal, in the last months to a year there has been an enormous increase of specialized startups. Partners that before were more focused in information technology now have sub companies and groups specialized in the Internet of Things and expanded their network abroad. I think we are evolving at a good pace, but we also have to have in consideration a country like the United States has an investment capacity completely different. Nevertheless the number of startups we have makes us very proud, this shows that we are more advanced for our country size. Also relatively to the standards, now we see the adoption of those and the entrepreneurial community in Portugal pays great attention to the news about the Internet of Things. We have several protocols and technology that are gaining recognition in the IoT area, leading to the evolution of startups and even larger companies are very interested in working with smaller companies, which is very positive for the economy."

3. How do you think the government will use, incentive and support this technology?

"The government has a pronounced interest in using the Internet of Things for cost reduction and process improvement in the Citizen Store (Loja do Cidadão), the government is very focused in renovate and large part of that renovation are linked to IoT areas and the autarchies are more focused in applying the IoT the smart cities."

4. Do you think Portuguese citizens will accept and adapt easily to the technology?

"We know the demography in Portugal is aging, but now there is a new generation called "millennials" starting to ingress in the employment market and those people are native with internet technologies and this has the tendency to increase. The technologies are going to have a gradual and natural acceptance. Even with the aged population I am looking forward for the work developed with these new technologies. I'm not worried with the adoption of these technologies by the common citizen."

5. What other opportunities can IoT bring, for companies, civilians and government?

"The exploratory stage is ending and we are entering in the maturity stage, where we can see projects running that correspond to the predictions made for the IoT are, where they are going to have an impact over the citizens, cities, industries, agriculture, pharmaceuticals, banking… In the next few years we are going to observe new proposals and that will make the highest impact. As the IoT involves the digital transformation from most sectors, we as citizens and consumers will see the services and products to transform considerably into becoming easier to obtain and purchase as well as the improvement of agility than we currently have. All of this is going to create new areas that

today we still do not have. If we look back in 10 or 15 years from now, this stage is going to be considered very rudimental."

Sensifinity

I – Present Situation concerning Internet of Things

1. What is your opinion on the Internet of Things?

"Many companies have problems connecting the physical world with the digital world. Many of the devices and areas are completely detached from the digital setting of businesses, and the reason for this was that previous technology did not allow for such a connection and the few types of technology used were very expensive. Nowadays, there are new low cost technologies that permit the combination of these two worlds, which is the digitalization revolution we are facing. From this point of view, as long as it is inexpensive, faster and simpler connections from the physical to the digital world, will allow for businesses to evolve. Moreover, it was considering that factor we started to work, reducing the adaption cost for this type of solution, presenting demonstrations to easily implement and control which helps any business to go into the Internet of Things. In the 80's we were in the same situation we are in now with the IoT. Back then only the large companies had financial power to purchase computers and manage computation but since the first personal computer from IBM appeared, every company's started to have computers and I think the same is going to happen with this technology. From now on it is going to be this technological revolution that is going to make possible for everyone to have all physical objects interrelated with digital processes."

2. What is the best architecture for the Internet of Things?

"We still see many computers, but computation is becoming more mobile due to tablets and smartphones. So we think for any kind of architecture to be adopted, simplicity demands that the architecture should be integrated with the mobility. As such, as we wanted to present solutions "already completed" out of the box. We adopted an architecture based on a communication protocol which is retro compatible with smartphones and Bluetooth low energy. We create our own the protocols that permit this retro compatibility with smartphones and tablets in terms of communication and connection. The information gathered goes to the cloud, which we use because in the future small and medium companies are going to stop having their own data centers even the larger companies may have everything in the cloud. From the perspective of the data acquisition nodes we are using our own equipment which is what allows the easy communication between smartphones and the cloud. By using pre-existing equipment, we would have the same problem seen in many projects nowadays, which is the high cost of the project in the implementation. Such as when looking for the right equipment for each specific project and developing specific software which we do not want. Instead we want to deliver a type of situation the works with minimal complexity and maximum utility."

3. What applications do you develop/apply for your customers? What kind of technologies do you use to build them and how long does it usually take?

"Our clients search for logistic solution in order to monitor stock quality and quantity in real time. Try to understand the machine behavior and preventively access the data and understand if the machine

is going to stop functioning or not. The majority of the projects we have are in these areas. It usually takes two weeks to develop a proof of concept and then if the clients are interested or have specific reports depends on the requirements."

4. What kind of businesses require your services? Which are the main sectors? What are the main objectives from your clients when implementing an IoT solution?

"Retail is the main sector demanding these types of solutions. We are specializing in logistics. However, our platform can be used in many other situations. We have several clients that work on the machinery or agriculture area using our equipment to develop their own products because we make available our own IoT stack; the hardware, communication protocols and cloud service. Then they develop their own standards for application, some of the clients are wind and solar power stations and it also can be applied in sports. There are many applications for this stack and we do not have to develop them for that specialized partners in those areas develop the solution even further."

5. What improvements has the client shown after the implementation? Did it change their type of business model? If so, in your opinion, did it change drastically?

"Yes. For example, in the logistics area we can predict deficiency in the refrigeration chain and prevent food, chemicals or vaccines expire and that is very important. In a situation of product loss can be also a day that did not have revenue, making the losses effect greater. By implementing solutions like this, we can prevent a situation such as the one mention before; saving the value for the company. Currently, the clients are still maintaining their business models, but there are cases of larger companies that adopted this technology and started creating new business models, for example renting equipment and services instead of sell and maintenance."

6. What is your type of business model? Do you consider your business model to be much different from that of other technological companies? If so, in what way?

"Our business model is the subscription model. I think recent companies are adopting this type of model. The larger companies are also adopting that model and I think it is the most common for cloud services."

7. Do you think, currently, companies are well prepared to implement and adapt to the changes the Internet of Things solutions can bring? What suggestion do you have for current and potential customers in order for them to implement IoT and stand out from the competition?

"Usually no. Usually they want some consulting in order to understand what is possible to do with the IoT. When they were presented with very expensive projects they would refuse and did not think much about them. In those situations, we have to reach to the clients and show them the reality changed. These type of projects are viable but still they do not know that. The suggestion for current or potential clients is to start to adopt and implement now, the implementation costs are minimal now to gain advantage in relation to their competitors, it is very easy to experiment an project and from there to accelerate or choosing another path."

8. What do you think about the current national and international IoT market and their economic impact ?

“It is going to be an enormous economic impact. There are not going to be processes without IoT components, the impact with the computer and computation introduction started to become ubiquitous, anyone would have three or four computers working every day and the same is going to happen with the IoT at a greater scale. The market will always have some kind of synergy, the larger companies use startups to evolve faster and the startups benefit from the support of larger companies.”

9. Have you implemented or are considering to implement an IoT technology? If so, what type of solution do you anticipate? What are your expectations? So far, based on your results, what is your opinion?

“We are going to implement the IoT technology here in Startup Sintra, implementing sensors in the building.”

10. What do you demand from your IoT suppliers?

“Our suppliers are mostly from Asia, they are technological suppliers. From partners perspective we need them because we are focusing very much in logistics but we know our platform can be used for much more. So the partners have an important function, they can take the work already completed and adapt to their business area and we share the development and maintenance costs of the platform, as startups having larger companies as partners is also the best way of grow and evolve in the outside market.”

11. In what departments will IoT technology be most useful?

“Probably the IoT would be very useful in all of them. For example, in the human resources department it could be used to monitor the environment, the noise, humidity and temperature. Other departments are the logistic, in the IT to regulate the temperatures in the data centers, basically every processes can be improved with IoT.”

12. Do you think IoT can help your business stand out or get ahead from your competitors ?

“Currently, since it is a new technology, yes, it can. But I think in 10 years it will be a base technology as computation is. This moment it will stand out by being thei first ones to adopt it.”

13. What do you think are the advantages and/or disadvantages of IoT/IoT Portuguese and the international market?

“The advantages in IoT are the access to more data, with more quality and sooner. Everywhere the data quality increases as well as the amount of data, so the basis for decision-making is much better. Disadvantages for this technology now is being very recent and that many companies are not prepared to adopt it.”

14. Do you think there is enough investment, motivation, partnerships and support from the government or other companies to promote IoT solutions?

"The government is very interested in the Internet of Things and understands the importance of the technology. It created a program dedicated for the Industry 4.0 in order to support the digitalization of the industry and support companies that want to innovate in the digitalization area. I think the Portuguese government is participating a great amount in the adoption and implementation of the IoT in companies and society."

II – Future Situation for the Internet of Things

1. What are your perspectives about the Internet of Things in your business? How do you see your position in the IoT market in 5 or 10 years?

"In think in the next 5 years there is going to be a "boom" where there are going to be many solutions. Many companies are going to become more aware of the possibilities brought by the IoT. Older companies are going to go into this area, market consolidation can only happen in a further stage. In 5 years, the competition is going to increase and we may be at the highest point of the cycle of the technology where there may also be a start for market consolidation and it is by then that IoT will enter the maturity stage. In the next years there is going to be some confusion because of the lack of standards. When defined there is going to be an orientation by the standards and market is going to be aligned regarding the IoT."

2. Do you expect any differences from the original solution you developed or do you think your business model will remain the same?

"We have the capacity of innovate and change business models if the clients or the market demand it. We do not have any reason for not changing, depends much on what the market gives us."

3. Which sectors do you think it will require more IoT solutions in the future?

"Retail and logistics, seems to be the main sector to require IoT even in the future."

4. Do you think companies will show more maturity when planning and considering implementing IoT technologies (or any other emergent technology)?

"Yes."

5. How do you idealize the IoT market nationally and internationally in the future, from a supplier perspective? What types of IoT services/products you think there will be in the future?

"The suppliers will be global as it happens in the computer market. In the beginning, there may be some local solutions but very rapidly, they are becoming global solutions. American or Chinese companies may dominate the market with the global solutions. There are going to be many services/products since this technology is going to be applied everywhere, agriculture, services and at our homes are some examples."

6. How do you view the market with the settling of IoT technologies in companies (if does settle)?

"It is going to grow for a very long time and in the future, maybe in 30 years; it will be natural for any product to be an IoT or have IoT components in them."

7. How much do you think companies will change in order to adapt and work with IoT technologies in their companies?

"I do not know how much, but they will have to change, if they do not they will disappear."

III – What is your opinion about the utilization of Internet of Things in Portugal?

1. What impact it will have in the society?

"As the computer brought some problems for the society such as the privacy or information security, the IoT makes available even more information and channels. These problems in the digital world are going to deteriorate through the Internet of Things. In addition, there are going to be more sources of information and more risk of creating other problems through the extra data, so I think is not so much a problem of the IoT but of the digital revolution."

2. How do you think Portugal will position itself in comparison to the other countries in Europe? And in the world?

"Excluding Germany that initialized the industrialization in Industry 4.0, Portugal is one of the countries ahead at the moment. If the companies have the capacity and availability of adopting and keep the rhythm in the digitalization, Portugal is one of the main countries in this area. In the world, currently is ahead of the United States or China."

3. Do you think Portuguese citizens will accept and adapt easily to the technology?

"It is as any other digital system. When it is well constructed and developed, yes citizens can adapt to it easily, when that is not the case, they cannot. The technology is the same but it can be implemented in a more intelligent manner or not. When it is well implemented is very natural to aid the citizen, when it is badly implemented is working against the citizen instead of helping them. It depends of the companies and adopted paradigms when implementing the system."

4. What other opportunities can IoT bring, for companies, civilians and government?

"Increase competitiveness, decrease excessive costs, it is possible to spend less money because we know better the processes, raw materials or energy and we are not going to produce something that is not necessary. There are going to be many essential gains with the IoT."

Mainhub

I – Present Situation concerning Internet of Things

1. What is your opinion on the Internet of Things?

"The definition of Internet of Things is something connected to the internet that allows environment monitoring, and for the exchange of information with everything else. Everything that can transmit and receive information is a part of the Internet of Things."

2. What is the best architecture for the Internet of Things?

"There are two important features regarding architectures. First, for now there is no standard defined; but there is a set of concerns. I think what is happening is that people are more concerned in developing solutions and not so preoccupied with communicating among themselves. There is a set of initiatives, because one of the main issues is how to connect two objects from different brands and most of the IoT manufacturers try to solve that matter, so they are all working to a common standard. In my opinion the best architecture would be one where single devices should not be connected to the internet alone. But with some kind of middleware component called broker which would gather the data of several sensors and then would send it into the internet, For example, imagine there are a set of sensors inside a house that communicate with the "brain" of the system that could decide when to send information to the internet. The data can then be analyzed in the cloud and in conjunction with machine learning giving great results."

3. What applications do you develop/apply for your customers? What kind of technologies do you use to build them and how long does it usually take?

"As an incubator we are uncertain about the type of problems the startups face or the problem they want to solve. However, what we have seen the most is focused in three different areas: health or aging for monitoring health conditions, industry for automatize processes and domotics to monitor the house. Now and then, some clients bring us some interesting challenges, as for example, someone wanted to monitor the amount of sunlight in the beach in order to inform people and collect the data in relation to skin cancer. As for the time it takes to develop a solution, it is different from developing applications. In the mobile market there are applications developed in a year or even sooner already selling. In the Internet of Things, the cycle is much larger, usually our estimations are that at the end a year we have a fully functional prototype and at the end of two years, we have a solution to implement. Giving an example, we had a team here that developed sensors for agriculture and in 6 months they tested innumerous hypothesis and none of them was successful."

4. What kind of businesses require your services? Which are the main sectors?

"The main sectors and businesses are the health, industry and constructions sector."

5. What are the main objectives from your clients when implementing an IoT solution?

"Improve processes. Most of the situations are related to cycle maturity. We are still focusing in known problems. At some point with the IoT I think we will add more value, at the moment IoT already shows a great importance but for now there is slight value."

6. What improvements has the client shown after the implementation?

“There are several of our clients and others that developed really interesting solutions. As for example, one of them developed a sensor for sneakers to teach people how to run and increase the performance and it has some success. Another company develops prototypes in IoT for the health area that is having considerable success.”

7. What is your type of business model? Do you consider your business model to be much different from that of other technological companies? If so, in what way?

“Our business model is to help startups to develop prototypes because there are many startups and people with ideas but do not have the know how to execute them. With our experience, we help them go from nothing to something testable. We do not know if it is going to work. We try to develop as best as possible a prototype according with the clients’ requirements but we cannot control the success of the solution after that. Our business model is very different from other larger companies because it is a very specific model to give this kind of help. It is also different for the startups because we cannot compare them with a larger company. For the startups, the cost structures are nonexistent and save as much as possible in order to implement their solutions, while the larger companies do not have that problem. The startups also have advantages, failing is less costly, faster and easier, having a better margin for improvement. There are two distinct types of business models startups adopt in this incubator. Their client buys the hardware, owns the hardware and from there pays an agreed amount for the service for the time they want to use it. The sensor for the sneakers is like that; a client buys it and then uses the service for the time they want. The other type of business model is renting. The client buys the utilization of a solution for a period. This is noticeable with companies, because buying 1000 sensors or devices would be very expensive. This model decrease the amount expended with the solution, the client can rent the solution for 12 or 24 months or for the period agreed with the supplier. In our company, we help the startups with a project during an amount of time and what we charge is related to the work done in that specific project.”

8. Do you think, currently, companies are well prepared to implement and adapt to the changes the Internet of Things solutions can bring? What suggestion do you have for current and potential customers in order for them to implement IoT and stand out from the competition?

“No. I think most of the companies do not even think about that. They heard what the Internet of Thing, find it interesting but do not understand how they can benefit from it. The larger Portuguese industry can benefit plenty from this because of the costs optimization, but have not studied very well the possibilities. The companies currently engrossed by the Internet of Things are the startups, incubation and prototyping companies. Others are still trying to understand what to do with this technology. Suggestions for the companies, I think the most relevant for now is try to understand by themselves or with assistance from other companies the improvements they can have if they implement the Internet of Things. As an example, we had a client that worked in the painting market, painting automobile components and it is necessary for them to understand how the manufacturing process can improve, how to have more advantages regarding production to decrease costs or to improve production itself. For that I think they need to understand the concept with someone from outside the company with more knowledge what can be done to achieve those kind of goals, from

there they can ask to develop a customized solution or search the startups market and what existing solutions they have and implement the most fitting."

9. What do you think about the current national and international IoT market and their economic impact?

"The Portuguese market in the IoT is very small. I think any company considering to work in the Internet of Things area focusing only in the Portuguese market may be unsuccessful. To achieve the scaling from costs perspective necessary to compete in the market, we need to produce large quantities. In Portugal we would only sell thousands at best. In the international perspective, what is happening is that they are looking at the market in a serious manner. Meaning, an investor told me a year and half ago: "we do not make investment in startups in the IoT area because in a regular startup (developing mobile applications) the ones more successful in 3 years we can make it be very profitable (or not) for us and we can sell them. In an Internet of Things startup, we only can reach that stage at the end of 5 years, at best." There is a gap of 2 years for the investor- This shows investors were less willing to invest in IoT 2 years ago. Nowadays there are many investors to look at the market and understanding that investing IoT is good since it is differentiating in comparison to other technologies. For example due to the period of development of a solution, it is quite difficult for another company to copy a solution. While in the applications development it does not happen. In the international market we are growing considerably, we are talking about billions of devices interconnected. In our market we are still in the beginning but we are also growing at a good pace."

10. What is your opinion about the economic impact?

"For the IoT technologies everything is manufactured in China, which is another factor to be resolved, not just in Portugal but other countries as well. Even if the startup is very successful, develops, and sells interesting solutions in the same place, part of the created value goes to China. . Most of the investors are from the United States and what they usually do is buy the company and take it to their country as such we lose another part of the generated value. So a Portuguese startup that is successful in the international market and maintains its' headquarter in national territory and uses as much Portuguese resources as possible, we would have a great economic impact."

11. Have you implemented or are considering to implement an IoT technology? If so, what type of solution do you anticipate? What are your expectations? So far, based on your results, what is your opinion?

"We already have. Our lightning works through remote control, each light has an IP associated in which we can tell them to turn on or off. We also have humidity and temperature sensors. We use our space as a laboratory; every time we have an idea first we implement it here and test it. There always is a problem that comes with the IoT ,which is when we change from a traditional system we know it works to a new one (such as using the switch to turn on the light and then use a remote controlled system, in this case). It is very challenging to maintain the reliability of a device that has been working well using the previous system and now using a more recent and technological system because of the *bugs* and the way it changes things."

12. What do clients demand from IoT suppliers?

”They demand from us to help them develop certain function, they come with the ideas and then ask us to develop a prototype. An example for this was a client who wanted to measure the air pollution in the cities, but after the prototype they need much more, they need to know what to buys, costs associated, quantity manufactured, packaging and other subjects they have more difficult to do.”

13. In what departments will IoT technology be most useful?

“In general I think IoT technology would be more useful in process improvement, although the factories and manufacturing would have more advantage. For example in human resources what could happen would be solutions that allow to understand employee satisfaction, a solution developed here is a sensor to measure the noise in a room that turns red when it is too loud in a room in order for people to notice that and change their behavior.”

14. Do you think IoT can help your business stand out or get ahead from your competitors ?

“Yes, right now, being competitive is very important. The best is to have large level of competition, less costs and to know what the market wants and if the IoT helps us to achieve that, yes.”

15. What do you think are the advantages and/or disadvantages of IoT/IoT Portuguese and the international market?

“The advantages I think it is the process improvements. The disadvantage is the low level of maturity. For example in an mobile application we detect a bug, there is no problem. We make a new version and it is available to reinstall it. In the Internet of Things that is not possible. If we find a bug in a device we cannot fix the ones already sold since the clients have them at home. But we can develop a new version. It has costs and then we sell it to other group of clients different from the one that already bought the previous devices and so on. At some point we will have several devices with different versions and problems we have to manage. This type of maturity, of how to develop solutions is a challenge. For the startups there is another challenge which is distribution. For example it is not easy if a IoT component breaks down. It cannot be sent to some store for repairing and get another one. For startups to do this it is required a very complex process.”

16. Do you think there is enough investment, motivation, partnerships and support from the government or other companies to promote IoT solutions?

“There is and there is not. There already a set of spaces in Lisbon. I mention Lisbon in particular because the rest of the country is not as focused in startups as Lisbon, Braga and Porto. These cities have some initiatives but the rest of the country does not have much. In terms of infrastructures and structures we have them. The problem is that the investment made should also be applied to the startups and I think there is not. There are private investors or business angels, but I do not think there is enough investment from Europe in startups.”

II – Future Situation for the Internet of Things

1. What are your perspectives about the Internet of Things in your business?

"In our business we are growing in this area. Our idea is to build a larger laboratory with its' own business unit. As for the technology, it is going to be inevitable it is like the internet. It is going to grow to very large proportions. According to a report, there will be 20 billion of devices by 2020, so many that will be massive. It makes sense having a microwave or other appliance saying it is going to stop working tomorrow. Also using machine learning and the communication between devices for predictive maintenance, makes sense. We are going to continue to implement the solutions in our building, every time we have an idea we implement it."

2. How do you see your position in the IoT market in 5 or 10 years?

"It is very difficult to answer, because in 5 years we may be doing something completely different. From our point of view, we will continue helping startups to produce prototypes swiftly and testing them. As for the market, it is going to be complicated since it is a global market and are competing with startups all over the world, if the ideas and implementation are good we will have success."

3. **Do you expect any differences from the original solution you developed or do you think your business model will remain the same?**

"Yes, we try to differentiate. The startups depend, sometimes the ideas they have already exist and we try to warn them to that situation."

4. Do you think companies will show more maturity when planning and considering implementing IoT technologies (or any other emergent technology)?

"Yes. I hope so. We are living at the beginning of the cycle, there still is many people learning and experimenting and until the products become real and functional, there are many problems to be solved, security, interoperability, communications, battery are challenges to overcome."

5. How do you idealize the IoT market nationally and internationally in the future, from a supplier perspective? What types of IoT services/products you think there will be in the future?

"It also is difficult to say. I hope the Portuguese companies are successful, they will have to sell the products in a different manner. I do not know if through traditional selling models, if Amazon is an adequate place to sell this kind of products, for instance, as the market may become entirely online or if there are going to exist specialized stores. Nevertheless, I hope the companies are successful and remain in Portugal, which is the most important aspect. I hope the startups remain in their country of origin and produce wealth from there instead of going to other country."

6. How do you view the market with the settling of IoT technologies in companies (if does settle)?

"The Internet of Things is connected to many other technologies. It is connected to machine learning, big data, cloud, everything is part of the IoT. There may be solutions based on the connection of these technologies that can generate much wealth to us as humans, we are going to have behaviors we will not need to have because something is going to tell them "do this like that because it is better". What I hope it happens is that everyone is going to benefit from this and the transition to

the maturity stage maybe around 2020, since the number of devices coming out every year we are in the beginning of that transition."

7. How much do you think companies will change in order to adapt and work with IoT technologies in their companies?

"I think it is better to adapt the technology to the problems the companies are facing. So when a human has a necessity, creating something related to that necessity in order to fulfill it, makes sense, otherwise it is difficult to sell anything. Then the benefits generated from there shows that the company or person has suitability to implement other things with different behaviors, that way we can change some of the previous behaviors. "

III – What is your opinion about the utilization of Internet of Things in Portugal?

1. What impact it will have in the society and economy?

"I hope the impact in the economy is going to be strong also as a way to differentiate because we are not going to do it in another way. At the moment we have tourism and a few other relevant sectors in Portugal. If we can have IoT companies that produce products in large scale and regarding the amount of devices, the Internet of Things would be a relevant sector for the country. The impact in society is going to be interesting to watch. Most of the sensors and IoT exist to help us, but there is always the debate about artificial intelligence. The IoT technologies may tell us to not to do something we would like to do. For example, a car can have sensors that measure our emotional state or something and according to parameters set by the car manufacturer, the car may not function if those parameters are not correct. The technology applied to other situations may limit us from doing actions we naturally wanted to do."

2. How do you think Portugal will position itself in comparison to the other countries in Europe? And in the world?

"Now there are 3 or 4 countries with companies and startups developing IoT solutions, Portugal, Germany, England and Italy. These are the most interested in this area. Fortunately, we are in this group. If we do the right thing in Portugal having in consideration the support from the government, if universities collaborate and if everything becomes an interesting ecosystem, I think we are well positioned and can have plenty of success. In comparison to the world, I would add two more countries, China for the obvious reasons, because they are very big and have particular interest in the IoT area because of their production capacity and United States because of their capacity for entrepreneurship perspective and financial capacity, and then they take the ideas, produce in China and then sell them. I think we are among the top 10 countries in the Internet of Things area."

3. How do you think the government will use, incentive and support this technology?

"There are two persons that have contributed very much in order for this are to have success. One of them was the former state secretary for innovation, Carlos Oliveira currently is responsible for Startup Braga in Braga, he took important measure in order to get things done. The Municipality of

Lisbon and current state secretary for industry, João Vasconcelos did the same. If things remain as they are and proceed to what they plan to do I think we are on the right path."

4. Do you think Portuguese citizens will accept and adapt easily to the technology?

"We will have to adapt to the technology. For example, a startup wanted to monitor the health conditions of the elderly at home but they did not want to use a bracelet to measure that because the elderly would forget to use it. Therefore, the startup would have to implement sensors around the house in which without the direct intervention of the user, it was possible to understand the health situation, for me that's different. When we have to make people to change, as for example, wearing something on them every day and they do not want, we are doing something wrong. In my opinion technology has to be non-intrusive."

5. What other opportunities can IoT bring, for companies, civilians and government?

"For the government their main interest is to increase the wealth for the country. The main advantage is to maintain the companies that implement and improve cost structures and export, also improving life quality for Portuguese citizens. For the organizations from the client perspective I hope they have benefits from the production process in order to guarantee a better competition in the market. From the IoT supplier perspective I hope they export as much as possible, as user I believe that is the easiest challenge because I do not believe a product works well if there is not a necessity for it.

Cisco Portugal

I – Present Situation concerning Internet of Things

1. What is your opinion on the Internet of Things?

"The IoT is not a new concept. In a manner, IoT is a market transition that is happening in a massive dimension caused by the technological developments and by the constant intensification of technology prominence, present in our professional or personal lives as members of a society. This is associated with what we call at Cisco the digital transformation, which is the capability of disrupting or changing not only the business model but also the processes, the information, the data transitions in larger amounts and from where we have more capacities to extract knowledge and intelligence. The people are also a part of this set of dynamics of the Internet of Things area, which is not only about the connectivity among more and more things but also allows us to obtain information and influence the way we work and live."

2. What is the best architecture for the Internet of Things?

"The IoT is a very broad concept, because from the beginning we have many factors to take into account. From how they connect among themselves to the infrastructure required to guarantee that connection, areas like security, how to connect things in a secure manner since we are dealing with information which can be sensible, there has to be concern about the access to information and what does with the data. A set of communication infrastructures but also the advent of the cloud and the potential the cloud brought in this explosion of IoT applications. And a conjunct of new

paradigms and new necessities of giving response to what we call use cases that might be associated with IoT. In my opinion it still is an area in which the innovation and dynamics of creative destruction is very strong, there is not a standard model and exist many emergent technologies are being tested. The impact is in beginning to notice that some sectors show some of the potential behind the IoT and mainly the digital transformation."

3. What applications do you develop/apply for your customers, what kind of technologies do you use to build them and how long does it usually take?

"The Internet of Things (IoT) is considered one of the most profound transitions in technology today, creating unprecedented opportunities for businesses. Cisco developed an IoT system that helps to enable massive revenue streams, efficiency in automation, and overall business growth with IoT products and solutions.

The six pillars below include a cohesive and comprehensive set of IoT products and solutions:

• Network connectivity area where Cisco is well recognized and where it is its' main activity,
• IoX and Fog Applications, fog applications have the capacity of distributing processes and running applications in a completely distributed network. The traditional model of having the application based on a datacenter or cloud does not give response to certain use cases in IoT that require the capacity of absolute distribution and closeness to the place where the data are generated and where is necessary to give a response in real time. There are even data with a relatively short life period that are not compatible with the transport to a datacenter to be processed and analyzed. The fog applications allow some analysis of the data in the network but also filter the information more relevant to the datacenter or the cloud because one of the challenges nowadays is how we handle, transport or process the increasing amount of data created by the interconnection of things
•Data analytics, analytics have to be present from the beginning to the datacenter. Typically the architecture with a data lake, which is a repository of all central information, is applied in some use cases but there are use cases that are not compatible with that model.
• Security – cyber and physical, cyber and physical security, nowadays with the challenges related to threats is our society but also related to certain resources considered more strategic that also have to be protected physically
• Management and automation, with the necessity of generating high volumes of information it also raises some challenges concerning the existing processes, how the management of the infrastructures is done, high scalability and
• Application platform, most of them are based in the cloud but also application that allow to take advantage from the architectures to stimulate innovation, development and how that the innovation can be created from external factors and not only internal."

4. What kind of businesses require your services? Which are the main sectors?

"The IoT can transform nearly every industry - locally and globally. We see a bigger dynamic in areas more challenged by this technology. The business models are disrupting much faster, new innovative ways to interact with the clients and the offer. Sectors like industry, transportation, banking and telecom for example show an increasing interest, concerning and offer no only with the amount of data but also how to monitor and transform it in services of high value to their clients and even using

these new areas of development to help positioning themselves in the market. It brings networking technology to places where it was once unavailable or impractical. The challenge is to build the right infrastructure."

5. What are the main objectives from your clients when implementing an IoT solution?

"Usually they want to solve a problem. The technology itself is not a solution, but a mean to meet the ends. The first step is to identify the main problem they want to solve and then attack the problem and see how these trends and technologies may help in the solution. This can be a new approach, a new business model for instance, or an internal growth or change as a competitive challenge, market changes. There are several factors, but first and more important is to identify the problem/challenge, what to solve, see the objective and look for the best solution. These improvement may be operational, time to market, agile processes, invest in a new area where the approach to the market is completely different, among others, there are many different outcomes we can get from this type of solutions."

6. What improvements has the client shown after the implementation? Did it change their type of business model?

The IoT is a primary enabler of a larger industry transformation under way: digital business transformation. Companies are increasingly looking to digital technologies to create or improve their competitive edge. The IoT and other technologies are helping companies to transform processes and business models; empower workforce efficiency and innovation; and personalize the citizen, customer, and employee experience. The IoT helps connect physical and digital environments. Data collected from connected devices provides the raw material for businesses to gain insights and respond rapidly to change.

The IoT enables an exchange of data never available before and brings users information securely. Through Cisco® IoT solutions, organizations can create and monetize new business models and services; innovate easily and get more things done, boosting productivity; and deliver insight for better user experiences and engagement.

7. What is your type of business model? Do you consider your business model to be much different from that of other technological companies? If so, in what way?

"We try to be a credible partner for our clients. We offer a wide set of solution and contribute with innovation, services, architectures and offers that gives response in a unique way in the market. This is our purpose to be successful and overcome the challenges associated to this digital transformation.

Cisco is the proven partner for success in IoT and digitization journeys. Connecting things securely, analyzing data dynamically, and delivering business value demand an intelligent IoT platform. These things also require application execution within a proven IoT network infrastructure and security from fog to cloud. Cisco provides the most comprehensive solution to securely deploy and simply manage your IoT initiatives:

• Cisco's IoT portfolio is the most comprehensive suite of products, solutions, and services providing connectivity, security, automation, and insights from the fog to the cloud that organizations can deploy right now,

• Cisco's IoT portfolio enables the ecosystem of technology partners to build innovative IoT businesses across all verticals,

• Cisco offers a wide range of solutions to automate the service lifecycle of IoT businesses by providing real-time visibility, control, and actionable insights,

• Cisco enables customers to automate the process of connecting devices over a global network of the top service providers,

• Only Cisco's IoT security delivers scalable, end-to-end threat protection and simplified compliance from fog to cloud,

• Cisco IoT offers a simple, secure, and scalable end-to-end IoT solution based on architectures and open standards that integrate with third-party and legacy equipment."

8. Do you think, currently, companies are well prepared to implement and adapt to the changes the Internet of Things solutions can bring? What suggestion do you have for current and potential customers in order for them to implement IoT and stand out from the competition?

"Depends on the industry and the enterprises. In certain sectors we see larger investment, dynamic and readiness. In other sectors we see a less forward approach. In Portugal, we have some projects being concretized, namely in the utilities sector, local development, cities, autarchies, etc. However, we would like to see in the Portuguese market enterprises to consider the digital transformation dynamics as an opportunity to reposition themselves at a global level and gain competition power. We would also like to see projects at a larger scale usually we see pilot projects. Nowadays there is certain credibility for this type of solutions, we have some examples in the market scaling that give some confidence concerning the results obtained. The challenge nowadays is to lose the inhibition and to advance in a more decisive manner and consider this an opportunity for the future.

The suggestions are to understand the problems/challenges they have; their dynamics in the actuation market and business models; the impact the IoT and other technologies may have in that perspective, define a concrete strategy and execute it. Nowadays it is not enough to just define a strategy, it is necessary to implement it as the enterprise may fall behind in the market because the ones that innovate, risk and try to differentiate are the ones that go ahead in the market.

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The IoT and other technologies are helping companies to transform processes and business models; empower workforce efficiency and innovation; and personalize the citizen, customer, and employee experience. The IoT helps connect physical and digital environments. Data collected from connected devices provides the raw material for businesses to gain insights and respond rapidly to change.

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9. What do you think about the current national and international IoT market and their economic impact?

"In Portugal we see interest in several areas and the speed of adoption is dependent on a number of factors. For example the ability to invest, competitive environment, innovation dynamic, with sectors like local administration, industry and utilities leading the way. We see pilots, ecosystems, new technologies emerging, like LoRa for LPWAN and we believe that now is the time to start scaling the solutions and prepare for mass adoption.

We see the market with many dynamics, still a little unorganized, with much experimentation and with "wait and see perspectives" (still trying to decide the path).There are various projects in the market already but not as many and in different areas as we would like to. We think we need more boldness, more courage, more investment and that the moment is now. If we do not take the chance now, even from our country perspective we are going to lose a historical opportunity of going ahead to a new model of economic development in our country.

This new areas may have a relevant economic impact, not only from the employment perspective but also from the point of view of competition, exporting capability, our global positioning as well as in the way we organize internally, how our cities function. In the vision for our country, it is something we have to take the advantage and we have to do it in a decisive manner. We cannot spend too much time with hesitations or short term plans. It is necessary to have a strategic vision for the country and this digital area of IoT and other emergent technologies. These are areas where we can change completely the paradigm of our country."

10. Have you implemented or are considering to implement an IoT technology? If so, what type of solution do you anticipate? What are your expectations? So far, based on your results, what is your opinion?

"We have some solutions implemented. Even before selling the IoT products to our clients, first we implement them in our facilities in order to deliver the clients more knowledge and more mature solutions based in our experience. In our building we have a solution of energy management that is aligned with the routines and consumptions. We also have a set of solutions that is related to the way we collaborate, our mobility taking advantage of the data gathered which later is made available internally in order to be more productive and work better."

11. What do clients demand from IoT suppliers?

"The clients want a partner that helps them in these transitions and challenges as well as to help them solve problems they are facing."

12. In what departments will IoT technology be most useful?

"Productivity is one of the most important areas, as well as the manufacturing of our equipment,

technical assistance, the manner of using IoT to obtain data that are more tangible, how can we a give a better level of support, provide a better service… There are several areas where IoT can be used to provide us with more knowledge on how to improve them."

13. Do you think IoT can help your business stand out or get ahead from your competitors ?

Absolutely, because data become intelligence. Enterprises that know how to use that data, are the ones that gain a better competitive advantage difficult to match

14. What do you think are the advantages and/or disadvantages of IoT/IoT Portuguese and the international market?

"The advantages is all the potential created by the technology. The disadvantages are the data protection, privacy, security, how to transport, process and transform enormous amounts of data into information. From social impact, IoT must have well defined policies about information access and open-minded democratic management of what is the IoT. There is a set of factors that can compromise the benefits or contradict the known benefits in these trends and have to be dealt with by the society and proper entities.

The market is now global with Cloud based solutions, so we are competing globally, have to think at scale and think about the right partnerships.

In Portugal, we should take advantage of the European funds, creating specific programs and prioritizing areas of investment for development, improving our competitive positioning and overall productivity."

15. Do you think there is enough investment, motivation, partnerships and support from the government or other companies to promote IoT solutions?

"The government has launched some interesting initiatives. We have some programs like Startup Portugal, Industria 4.0 and Simplex. It has a progressive vision about the Internet of Things and the potential it unlocks for the country. But it is necessary to start things, accelerate them and do it at a larger scale with the objective of having larger impact. Otherwise we will not be able to make this necessary transformation.

The market is still fragmented and the ecosystems are being created, but the opportunities and projects are happening at a growing pace and the perspectives are very positive."

II – Future Situation for the Internet of Things

1. What are your perspectives about the Internet of Things in your business?

"This is a new phase of the Internet that is going to transform, add value and create new use cases that did not exist before. This is a transformation not only of the internet but everything related with it; business models, countries, societies, among others. The future in our understanding involves new areas, enterprises, areas of activity that are going to be the engine of economic development and have the potential of being so for an extended period. With all of these there are going to be many transitions. Some enterprises are going to disappear, another ones are going to appear. This process

is going to start accelerate and being more competitive. In this perspective we see the potential is enormous, a leverage for the global economic growth, a leverage for a period of prosperity and new paradigms of social economic organization associated with these trends."

2. How do you see your position in the IoT market in 5 or 10 years?

"There are going to be new technologies, architecture, cloud models, paradigms about how information systems are organized and in the end the data and information are going to be in the core of everything. The enterprises able to process and manage the data in order to build information and competitive value will be the most apt to be very successful in the future. Everything will focus around on how to access the information. How to monitor the connection of everything. How to transform it in business models, social organization or competitive differentiation in terms of what is going to be the basis of future economy which will be a digital economy, with new fundamentals and new basis with much more potential and with larger power of generating wealth."

3. Do you expect any differences from the original solution you developed or do you think your business model will remain the same?

"Cisco is approaching three types of development models for its activity, internal innovation and development through our R&D department, partnerships with other enterprises that have complementary activities and with this type partnership we can co-develop in solutions that add value. The third model is the area of acquisitions where we monitor the market and may acquire startups, or small and medium enterprises we consider they bring innovation and is align with our vision. Considering these three factors we try to anticipate where the market is going, what the clients want and where the societies are going. By making, that anticipation we can evolve our proposition and our business model in a sense of searching for those answers.

Cisco continues to follow closely this market and the opportunities, using internal developments, partnerships and acquisitions as a way to enrich the offers, increase our value proposition and better serve our customers."

4. Which sectors do you think it will require more IoT solutions in the future?

"All sectors where the digitalization transformation will take place. IoT will allow the capacity for creating business models very quickly and technology nowadays, cloud and the mass of the capacity of connecting things, will reduce costs in entering the market. It is relatively easy to create an enterprise and in a short period start having results in a certain area of activity. The barriers are going to decrease and then there are business models that are going to simply disappear at the same time new ones are created. In the other hand I think the service sector is going to expand a lot and we are going to start having services oriented to application element, intelligence management and information sensibilization, there is going to be a sturdy growth in this sense. Concerning the industrial sector, we can observe the creation of new business models associated with transforming everything in services."

5. Do you think companies will show more maturity when planning and considering implementing IoT technologies (or any other emergent technology)?

"It depends on the application and desired outcome. We see a convergence of traditional

information technologies and operational technologies and as such this solutions gain more importance and critically in terms of business relevance with all implications as a result. With this convergence, the maturity is going to be accelerated since it is so important and relevant for the functioning of enterprises that the precautions, the investment to guarantee the solutions work and are tested and proved to work are growing concerns. As the technology and digital start to have a bigger role in the core enterprises and societies there is an increasing concern on guaranteeing the solutions work and are going to be robust and resilient in order to keep organizations functioning."

6. How do you idealize the IoT market nationally and internationally in the future, from a supplier perspective?

"The national and intern market are gradually grayed. Things are global and the IoT and digital transformation bring that paradigm, which is when we launch an enterprise in Portugal we have to think at a global scale. We cannot think just in the local market. We have to consider that a company in order to survive, grow and be healthy, cannot focus just on one market. It has to be created from the ground and think at a global scale because if not it is only a matter of time until it is completely surpassed by other competitors."

7. How do you view the market with the settling of IoT technologies in companies (if it does settle)?

"In the future the digital and IoT are going to be considered something natural since they will be part of the core of organizational activities and are going to be incorporated in the normal processes inside the enterprises. Even nowadays there are some solutions implemented in said processes, where technology is absolutely incorporated in the enterprise. Besides IoT is not a new concept there are many things connected among themselves for a long time, the difference nowadays is the mass and technological evolution so that there are viable solutions and with a level of impact in which in the past we could not have."

8. How much do you think companies will change in order to adapt and work with IoT technologies in their companies?

"The enterprises have to change at several levels, in internal processes, organization because IoT and the digital will have strong impacts on how enterprises organize themselves, change in the employee profiles and aptitudes and it will have also a great impact in what and how we do things. There are researches saying that a significant part of enterprises existing nowadays are going to disappear in the next decade because of several factors. There may appear a new enterprise with an entirely disruptive business model or because they do not embrace the digital transformation with the boldness ,urgency and investment necessary. Because they cannot take advantage of the data or the information accessed and turn it in revenue sources or new models and from the country perspectives. The ones that fall behind will have more difficulty in creating employment, wealth, attracting investment are going to be society less democratic and transparent and as such this will be a factor of differentiation among countries, cities, societies."

III – What is your opinion about the utilization of Internet of Things in Portugal?

1. What impact it will have in the society and economy?

"IoT and Digital transformation has the potential to change dramatically businesses and society with a profound impact in what we do and how we are organized.
A larger number of persons considers digital service as a commodity and an advantage. The enterprises see themselves with the necessity of delivering services in this area because if they do not they will fall behind. People choose the enterprises who can give them the best digital service, allowing them to be more autonomous, have available services in any device at any time and give them a higher degree of liberty and access. Even how cities change the form they are managed, how they compete with each other to attract investment, attracting people with higher social and economic status, create better life quality and how they attract business. As such they only can reach those differences if they consider this opportunity of the digital transformation as something to improve their services and have a specific vision of what is the dynamic function of the city, which are their main challenges, among others.
Any type of sector or enterprise, even cities, how the government relates with the citizens and every public and private sector with the IoT is going to experience an impact that can be bigger or smaller, faster or slower. Nevertheless, the potential the technology nowadays has in changing all these areas is tremendous and nobody is going to be excluded. Portugal is a little behind in the digital inclusion challenge, how we create new generations perfectly adapted to this new reality. There are already some examples but we need to invest more in education for new technological areas, programming, etc. sooner in schools and universities, this is one aspect. Another important factor is how we transform older generations citizens and give them the minimal tools or the support for them to be included in this digital era."

2. How do you think Portugal will position itself in comparison to the other countries in Europe? And in the world?

"We have a challenge which us the digital inclusion. There is a statistics by the European community showing Portugal as one of the countries more behind in this aspect. Because there is a high percentage of our society that has not access to the internet and is digitally illiterate. That can be a barrier, so I think it is also important to give support in order to decrease that problem. The other aspect is to prepare the future generations, give them competences and knowledge for this new areas. The third aspect is, as a country we live in a cross path from the economic perspective, our traditional model of economic development expired and we have to look to the digital transformations as an unique opportunity to put our country in the frontline"

3. Do you think Portuguese citizens will accept and adapt easily to the technology?

"The new generations are more apt, aware and sensible to the new technologies. However, I think we should strengthen some areas to give higher competences and knowledge. There is the digital inclusion situation in which I think it should be created mechanisms of professional formation for employed people in order to gain more quickly aptitudes in this area. Which is also important from the productivity perspective and we should not leave it just to the enterprises to provide that kind of formation as most of them are small and medium companies with low capacity and resources to give training to their employees."

4. What other opportunities can IoT bring, for companies, civilians and government?

“The potential for every country, enterprise or person is to change its cover, the paradigm, give a qualitative and quantitative jump is a relatively fast manner if things are done with the right gamble, decisive, strong and with the sense of urgency required nowadays. If we have the vision that this is the model and the path it has a great potential to position ourselves at a completely different level. “

FEUP

I – Present Situation concerning Internet of Things

1. What is your opinion on the Internet of Things?

“In my understanding, IoT is a concept created 15 or even 20 years ago, it is a very similar concept to ubiquitous computing, which is a concept created maybe even before the IoT but more related to an artificial intelligence perspective. With it, the environment becomes more intelligent because they had intelligent components embedded within them, with functions that were reactive to what was happening in a specific situation. This allowed the development of smart houses and from there it escalated to other levels, smart factories, smart industry, and smart cities. Meanwhile the IoT concept was created more recently and in a sturdier manner. It was in a latent stage for a period of time because there were some limitations in the technology to develop communications at a larger scale and it was expensive to implement them to everyday objects. That situation changed very much in the last 5 years and still is changing. Nowadays it is easier to implement microprocessors, components with the capacity to execute small programs and able to communicate with extremely diversified objects, making them to connect among themselves in order to reach a common goal and also be part of distributed programs. For the Internet of Things concept, the word “Internet” stands for the network we adopted as the data communication network interconnecting everyone through our computers. The term “Internet of Things” means that the network that was used among people is now also used for things and allows objects to communicate not only with us but also among themselves to develop new functionalities and other types of activities that were not possible before.”

2. What is the best architecture in your opinion for this technology?

“It depends. There is not just one architecture, there are many, because the adequate architectures to certain objectives are sometimes are compatible with other architectures with other objectives. For example, if I wanted to do the monitorization of a large agricultural field, I could use a wireless sensor network, where various small sensors with the capacity of communicating among them, are placed throughout the field and periodically gather information about the defined parameters and send that information. In this case, a method of distributed data catchment is used with the particularity in which the communication flows in one direction to a central point, usually the main node, that is gathering all the data and sends it to the internet, main computer, database or other main application. This architecture is acceptable for this example but it may not be for other situations. In the case of smart cities since it is required to make monitorization at a larger scale, there are not just these individual and wireless sensors but also sensors that are connected to a cabled network or to certain spots or inside building where wireless communication is more difficult.

As such, we have different architectures for these types of situations. Sometimes, there can be a sensor concentration in a certain area within a defined distance, depending on the solution, that then are sent to a superior level, this way we have multiple island composed by sensors which are later aggregated and sent to a computer of the enterprise managing this service or sent to the cloud. There are centralized architectures which is a computer executing certain application that gets the information in the sensors around it (star architecture). There are architectures more focused in the sensors, where the sensors have more intelligence where it decides when they share the information, whether it is relevant or not and send it when necessary This type of architecture is more distributed. Even so there are other types of architectures when regarding larger scales in which are used to completely distributed architectures although rarely, or architectures in several layers. There is a lower layer that is closer to the environments, the architectures in these layers are typically start type, the top layer the architecture is usually distributed, and there is another upper layer that we do not know where it might be, but it makes the distribution of all the activities. It is also possible to have several reaction layers; in the lower level, it may be possible to make an immediate reaction, the upper level is we can understand with a better perspective because it has information from various places and do a slower feedback, but more complete and then there is the top layer which is the big data. In this situation, the applications in a superior level go get the information from vast ambits, so it has access to much information. With it, it is possible to make optimizations in order to see which method is the best to maximize the efficiency of a process and then transmit to the lower levels the information in order to influence the actuations and become more efficient."

3. What applications do you develop/apply for your customers? What kind of technologies do you use to build them and how long does it usually take?

"I work in R&D but only in the communications part. What I do is allowing applications to work since they are going to function over a communication layer. Without that layer it is impossible for the applications to interact among them and would not have new functionalities, they would be independent objects. Some protocols I've been developing in the course of my investigation are divided in two lines. One of them is related to systems considerably larger. For example, cars or robots that have embedded in them multiple computational units, various microprocessors interconnected. In this case, since they are restricted and in the static to the car or robot, so it is easier to use cabled communications to guarantee that communications are done within certain temporal restrictions. For example, t I'm capable of guarantying a message sent in a determined instant is received in less than x time. This is very important for some applications to function. Mainly those that are responsible for giving control feedback. In a car if a wheel is spinning faster and I want to break, it has to send information about the speed and other factors, the controller will verify the standard values and send message to rectify the situation if there is something wrong with the components. If the control is not performed at time it is not possible to make an effective control.

The other line is wireless communications for cooperative objects. In a certain manner are developed separately, but when they are near each other can cooperate among themselves. This is more associated with IoT. Our main concern has been with autonomous agents (independent robots or unmanned aerial vehicles (UAV)). What happens is, each of them has certain functionality but when closer to one another they can stablish a connection. From there, create a new functionality that was not possible, was not available before or do it in a different way, more efficiently or effectively. For

instance, we have an UAV surveilling a certain area and at some point in time, we want to add another one because of the size of the area. When they detect that there are two of them in the same area, they coordinate the communications among them in order to make a faster coverage of the area. Another example can be a robot that is making the recognition of an unknown area. To maximize the area covered, we start adding more robots that communicate among them to decide where to go. Some similar cases are vehicular networks. For instance when cars are in a highway and are closer to each other. The cars can come to an agreement and start to communicate about the correct speed they have to adopt and coordinate it to ensure they go together. If they do that, the vehicles behind can save fuel and they can even switch positions, this solution would be a great advantage for trucks."

4. What kind of businesses require your services? Which are the main sectors?

"I'm only developing enabling technologies for other companies to develop their final product. Since I'm in public investigation area I do not feel the pressure to sell a product but to present interesting results in order to captivate and gather new projects. Because if we do not have new projects, we do not have funding. So we get constricted and cannot develop the investigations. It is not like a traditional business, we do not sell to the masses but we have ideas to sell to investors. That market is much more competitive than the traditional markets. When people are the final clients they are more permissive and diversify more their choices. The main sectors/areas with many final applications are vehicle fleets, coordination among many robots, particularly from search and rescue, transportation and drones coordination. The drones' coordination is often applied for the agricultural sector. Other sector is the smart cities, which are related to the ICT communications utilization for city management. This includes transportation fleets, where there exists constant communication between the vehicles and management centers. There is a solution applied to the transports as well where the passengers can have access to the internet in the vehicle. In order to so there is a network making internet coverage at city level using the traditional public transportation vehicles. With the technology is also possible to make residue management. Thi type of management is done by detecting where there are more or fewer residues accumulated and how to maximize the routes to go directly to the containers that are fuller. IoT is being used as well for illumination management, detecting people and situations where is needed more or less light, These improves efficiency and reduce unnecessary costs. Smart houses, have similarly functions as the smart cities but at a much smaller scale. The industry with the IoT is also experiencing significant changes, such as Industry 4.0. These changes will take time, perhaps over a decade to show the effective results. The paradigm to IoT is that each object is a thing within a network and from there it can communicate with other objects and allow global control applications to use these objects as individuals."

5. What are the main objectives from your clients when implementing an IoT solution?

"There are two objectives. Generally is to improve efficiency and the other is to have new functionalities that were not possible to perform before. There are functionalities such as, having remote access to certain equipment and be able to control them that way, or program coordination among distributed equipment in space (in different cities or places) which was not possible before because we did not have the technical capability in order to do that. So overall the objectives are innovation, in terms of new functionalities or maintain old ones but with more efficiency."

6. What improvements has the client shown after the implementation? Did it change their type of business model?

“In the cases I know of, they’ve shown an improvement of efficiency which leads to a cost reduction. The type of business model changed gradually when companies innovate, when there are new products, they need to have adequate business models.”

7. What is your type of business model? Do you consider your business model to be much different from the other technological companies? If so in what way?

“My business model is an investigation model. I have to find areas of innovation, areas where I can contribute and convince investors that certain investigation is useful and relevant in the technological and scientific context, especially in the scientific area. Other technological companies in the end try to do the same thing, the difference is in the market. While the other technological companies have a more defined and open market and have more clients, in our case the market are just a few investors and even more demanding. We have many competitors to access the funding and we have to struggle for it. Generally this is what every company does but in particular there are some differences.”

8. Do you think, currently, companies are well prepared to implement and adapt to the changes the Internet of Things solutions can bring? What suggestion do you have for current and potential customers in order for them to implement IoT and stand out from the competition?

“I think there are various situations. The companies are composed by people with the will of taking opportunities and transform them into businesses. However, people are very different from each other. There are people with strong scientific knowledge that can integrate or enter in very challenging markets. In the scientific investigation area where we have awareness about the latest innovations developed. These innovations are in small number but they are the best for us because we recognize them as having higher intellectual value as well as higher value in the value chain. We are working in an abstract level much higher and related to higher knowledge. There is a vast level of disparity among companies. There are companies constituted by people with lower level of education but even so try to find a business opportunity. Although they are also the ones with more difficulty in surviving when there is more competition and are more susceptible to the innovation problems because it is easy to fall behind the competitors. We want to change in social terms to change the entrepreneurial profile to approximate as much as possible to the top, the enterprises more related with information. To do that we stablish a partnership between the entrepreneurial tissue and the area of research and development, as for instance, universities. But it is good to have a notion that mutual interest exist and the enterprisers can become investors in scientific investigations when they are interested in the immediate result and when the investigation can have immediate consequences. An effort that has been made to try to have companies working at a higher level of innovation and the IoT is enabling that purpose of innovation. So there are companies that are ready to implement this technology and others that are not.”

9. What do you think about the current national and international IoT market and its economic impact?

"I have some contact with more exigent markets such as Germany, Holland and Sweden which are knowledge based societies. When I contact with someone who works directly in the technology business sector it is visible they are much more motivated by the latest technological news. They are always updated and use the latest technology. When something was just launched they are already analyze its' potential and what is the best way of using it. They do not see only that perspective of using it for personal terms but also what they can do with it. In Portugal we are starting to have the same kind of attitude but less than in those societies. We are in the right growth path in relation to the other countries. Concerning the economic impact, it has an enormous potential in two levels. For the larger companies is easier to observe the direct benefits of the technology. One revolutionary factor is to use the IoT and new technologies in small business that are appearing, small niches. In this case, there is an vast potential because if there is a large company with a thousand employees and one hundred companies with ten employees each, in economic and social terms, the second hypothesis is better because is more resistant to changes, modifications, crisis than the larger company. The larger ones have less flexibility than the small companies do and that is what is happening nowadays, these technologies are helping larger and small companies and companies to appear, and that is extraordinary."

10. Have you implemented or are considering to implement an IoT technology? If so, what type of solution do you anticipate? What are your expectations? So far, based on your results, what is your opinion?

"We have a communication infrastructure implanted in all the campus, but that alone is not IoT, it is the communication infrastructure. From there it is possible to develop applications that work above this structure or applications in parallel, but there is not any in concrete developed recently here."

11. What do you demand from IoT suppliers?

"Maintenance and there are several examples. Some companies hire other companies with certain products and services and also hire ICT companies to install the IoT system on which the initial company is going to develop its' main activities. There is a relation between a company requesting for another to install the structure, as such there are maintenance protocols which is common, but sometimes the maintenance are simplified by the nature of IoT. The companies that install these equipment have facilitated access to its' structure because they follow its' condition periodically. A more interesting case is an open IoT services provider, they have a different communication technology but similar to cellphones, they have atennas in the areas they want to cover and then the sensors they provide to the costumers (companies that want IoT services) are included in the exact equipment and communicate directly with the antenna. Who places the sensors is the provider which most of the times sells the components to install the solution. The sensors that gather the information communicate directly with the infrastructure, the communication infrastructure management is outside the company that hired the data gathering services, and so the hired company is responsible for making available the data required by the customer in exchange for a periodic fee."

12. In what departments will IoT technology be most useful?

"It is very important in every department. The logistics part is extremely important, internal management, production, human resources because it allows communication between people in a different manner. In management and planning because it allows the access to information and the part called enterprise resources management (ERP) needs information as actual as possible causing the decisions to be better. We can make good or bad decisions according with the quality of the information and even in the sales department, IoT is useful because it lets the company to know the customer trends and likes and makes decisions accordingly, for example."

13. Do you think IoT can help your business to stand out or get ahead from your competitors ?

"Of course."

14. What do you think are the advantages and/or disadvantages of IoT/IoT Portuguese and the international market?

"There is some reluctance in some markets. What was been happening is the technological companies have always tried to have access to more data and it implies a decrease in privacy. There has also been a conflict between the growth of innovation in certain services and invasion of privacy. IoT is a emergent market with enormous potential but also with huge threats mainly at social level."

15. Do you think there is enough investment, motivation, partnerships and support from the government or other companies to promote IoT solutions?

"We have some support programs for entrepreneurial and product innovations and the creation of startups through Framework Programme in an European context and also other programs from the government. It is important for people to understand when these type of investments done are necessary to have self commitment. Sometimes the dimension of the investment requires support, and if there is not additional support, it is preventing a potential possibility that could work. It may seem that the programs are getting terminated or reduced term or that do not receive enough support. The reason for that is the increase in competition, making more difficult to have access to those programs."

II – Future Situation for the Internet of Things

1. What are your perspectives about the Internet of Things in your business?

"The IoT has two levels. The most mentioned level is the communication layer but there is another layer which is the application layer. They are distributed application that are running and use that information gathered in the communication layer. The application layer is going to be connected to intelligent environments. They are environments with sensors and actuators that have the capacity of understanding what is happening around them and adapt to it. For example, in a room detects if there are people in there and adjusts light accordingly with the number of people and their placement and also adjust accordingly with the information parameters and provide the most relevant information for the people. These types of situations, as well temperature adjustments, are related to the concept of intelligent environments that is within the ambit of artificial intelligence.

What has been observed is that the application layer is even more related with artificial intelligence that has been developing a lot in the last years and it is going to develop even more since we have more computational power. It is possible to make an search algorithm in order to get more optimizations, solutions, solution renewal and applications management which was not possible to do in the past. So the machine learning Is going to be more efficient, with big data it is possible to have access to a larger amount of data and all of this is going to enable more intelligent systems. For example, there can be systems able to hold conversations with the users, jobs such as call centers are eventually at risk because machines may replace them. The conjunction of communication layer with the artificial intelligence/applications layer are the key to have systems that can interact more naturally with humans and making decisions autonomously in a more efficient manner."

2. How do you see your position in the IoT market in 5 or 10 years?

"It is steadily growing. We have communication technologies that are not very far from the physical limits, for example the velocity of information transactions is not very far from the physical limit, in that sense we are saturating. Allowing the communications to be efficient and effective, meaning, sending clear information sets, recover from errors, be able to group different blocks of related information gathered from different places. In the next 5 or 10 there is going to be an small evolution in each communication channel. In the next 5 years we may be even closer to saturation but in the next 10 years the distribution of communication capacity is going to be more vast than already is since there are going to be more devices communicating between each other. The other part that is growing and is far from saturation is artificial intelligence.

3. Do you think companies will show more maturity when planning and considering to implement IoT technologies (or any other emergent technology)?

"Depends on the maturity of the people who are running the company, they are going to have access to better information, so they can potentially make better decisions."

4. How do you idealize the IoT market nationally and internationally in the future, from a supplier perspective? What types of IoT services/products you think there will be in the future?

"The national market in these areas may develop and be at pace with the countries we have as reference and I think we are at a good promptness. I hope there are going to be more entrepreneurs from small companies to larger ones to have vision of being able to use the last innovations."

III – What is your opinion about the utilization of Internet of Things in Portugal?

1. What impact it will have in the society and economy?

"It has potential for a huge impact. There is a continuous evolution of this technology; it is not just something that started recently. Looking into Portugal situation, we had an incredible transition in terms of technological development. In the telecommunications area for example, from telephonic installation to network virtualization and national coverage, Portugal is a country of reference. We have been always ahead because of circumstantial situations. Portugal had two different telecommunication companies in the beginning where one was more focused in the larger cities and

other in the rest of the country. In order to solve that problem and do an entirely national coverage without telecommunications being divided into two companies, Portugal was the first country to have a communication network completely automated without having the manual operators. We were also the first to develop services added to the data communication networks under payment, for example SIBS was always ahead in the world with the services available for ATM cards and network. Brisa is another example of IoT application in a certain mode, it is one of the first examples of IoT where the cars passed under the sensor and the value is automatically deducted from the client. This company was for a long time one of the most innovative companies in the world. Therefore, we have a group tradition in terms of technological development and in taking advantage of communication technologies which is the foundation for IoT. Then when cellphones came, Portugal also had a positive adoption and handling since there are several competitive operators making an almost total coverage of the country and with very interesting services and then came the smartphones and remote internet. Nowadays it is possible to observe that this factors influence the creation of new enterprises. In the society, as the cellphones changed the people drastically, the smartphones are currently having the same impact and the IoT is going to change people even more because it is going to be natural in the future to interact with their surroundings."

2. How do you think Portugal will position itself in comparison to the other countries in Europe?

"Portugal has always been very well related and well positioned close to countries with traditions of larger innovation and development, although we have been behind them when it comes about taking advantage in economic terms. At the same time there has been an increase in young entrepreneurs that seize this opportunities in a fantastic fashion. There is a positive evolution, there is a decrease in the entrepreneurial gap comparing with other countries."

3. Do you think Portuguese citizens will accept and adapt easily to the technology?

"In the past we have examples of great acceptation of new technologies, from ATM cards to cellphones, so I think we are going to adapt rapidly to whatever technologies implemented and our market being small was always receptive to new technologies."

4. What other opportunities can IoT bring, for companies, civilians and government?

"IoT has, without a doubt, the potentiality of increasing very much the processes efficiency and also opening doors for the creation of new services."

OASC

1. What is your opinion on the Internet of Things?

"My vision of the IoT is not very technical. My opinion about these subjects whether it is IoT or platforms/infrastructures that are more complex are essential for the functioning of the city, meaning, we should give priority to citizens and their necessities and in fact the technology is a large support when we want to implement solutions . With the amount of information we gather from every sensor in the things present in the cities, we can make a much more informed decision and act in a more specialized manner. For us, IoT works in this perspective, it is seen as an unlimited source

of information, with the capacity for people to act on it in a creative way. Based on the information gathered it is possible to create new solutions, products, concepts and applications. The IoT is essential in this era in order to be able to upgrade the services available to the citizens. The IoT allows to give a better and more efficient services and with different scalability than before."

2. What kind of projects have been developing?

"There are several projects OASC is supporting. Currently there is a large project called "Synchronicity" in which Porto city hall is involved. This project consists in implementing concrete objectives with the several cities in the network, since many cities are involved but for the project, just pilot cities participating. With this project, the objective is also expanding the network, for example there are Brazilian cities connected at this network. With China, Japan, Mexico, USA the cities network stops being just European and starts becoming more global. In this context, the cities have been developing several projects. Porto, for instance has very interesting projects in the smart monitorization area done with IoT. One interesting project for example, was created, by Future Cities Project and is called "Urban Sense". It is a platform where we are going to use the sensors to measure environmental and air parameters. Another interesting project is "Hackacity". The objective of this project is not to develop sensors, it is a hackaton. Where what matters more is the platform we are developing behind it. The platform has the purpose of gathering the information of every sensor in some Brazilian cities (Olianda and Recife), Dutch cities (Utrecht and Amersfoort) and a Spanish city (Santander) and make it available to every hackers and developers that wish to work with these data. We are working more for this back end. We have partnerships with the universities in the Urban Sense project; s the universities and companies develop the software. For example, Ubiwhere, a company based in Aveiro is partner in many OASC projects, not only nationally but also at international level. They develop and implement the IoT solutions. There is a vast amount of projects inside the OASC network, from parking sensors to pedestrianized streets and accesses as well as smart lightning. Águeda, a city located in Aveiro is a very interesting situation since it is develops many solutions in the ambit of smart cities, especially pilot projects for the city. This city has a very interesting project concerning smart lightning. It detects if there are people in the street and increase or decrease light intensity. It can shut down certain areas remotely if a construction or repairing is required. There is not the need of sending a technician to the site. If a lightbulb stops working, it is possible to know which one is it. Overall is a very different dynamic from most of other cities. Águeda, Lisbon and Porto are among the most involved cities when it comes to this kind of technology. The projects for smart cities in the OASC framework, are connected to FIWARE which is an open platform supported by the European Commission. The development is mainly made by Telefónica and some other companies that have been investing in that technology. The platform has reached other countries as the ones mentioned before. The main objective of FIWARE is to help cities to get ahead in comparison to others in the rest of the world but also to have access to open data and all the sensor networks in a completely open manner. For that data utilization, standards are created. Any company, as long as it develops applications compatible with those standards may be interoperable with other kinds applications developed by other people. This generates a market where it is possible to stimulate public networks. The services area but at the same time stimulate the market as well because we are helping companies, startups and the entire entrepreneurship sector creating new solutions with an easier approach and more internationalized. If I develop an application that is compatible with other in another country is much more easier to sell and position the company in the market."

3. In what way is the Internet of Things going to help create or improve business models?

"For the IoT is required to tackle the standardization factor, because I can implement everything that is sensor and having everything connected, if I do not have everything with the same standard it is irrelevant, I'll be able to access one kind of data but it will not be possible for a different type. The IoT with standardizations allows access to the global market. For companies that develop IoT, this turns the market much more appealing adding to the fact that with the FIWARE platform is possible to have access to data from any city and develop a good product for them. Whereas before it would require to go to the city and analyze it in person in order to understand it and nowadays that is not necessary. We want to have everything with sensors but if we do not have a program on how to use it it becomes irrelevant. It is needed to consider what kind of information I'm going to use, what parameters do I want the sensor to give me, what can I get from the sensor and other information that may not be relevant now but for other application it could be. The IoT is very interesting and it is necessary to follow it in terms of effective methodologies and work programs, in that sense, it is a huge asset to the market and have to be careful about the programs, methodologies and the information applied to the IoT."

4. In strategic terms, which are the cities that stand out more in the utilization of IoT?

"There are many cities with different types of applications. Nowadays it does not make sense thinking about cities, it does when it comes to city management and each city publicize themselves and work on its image as a city. In my opinion nowadays we talk more about networks, at national scale I think it makes sense to talk about Portugal as a network that may be created even though the connection is not very easy. Sometimes is easier to allow the creation of an OASC and connect with other similar cities from other countries than with national cities. It is difficult to say which city is the one more innovative, there are city doing pilot projects that will not have an enormous impact at city level but it could have in another city. Lisbon and Porto are without a doubt some of the indicators in this panorama, are cities that because of the structure and dimension are always a little bit ahead of the others because it has several projects that can be implemented in different manner and as such it can also have a different impact, when talking about Porto we are considering the Great Porto, not only the city but all the other cities composing the district that are also doing a good job. Évora is doing interesting things in the energy sector, generally across the country there is a vast interest in working with this technology, but not all the cities is ready to work with it. Some of the cities that stand out are Lisboa, Porto, Cascais, Évora and Águeda."

5. Is there support from the government?

"The majority of the support for projects Porto has are from public funding. I think the government currently is getting aware to new realities and incentive programs are being launched recently for topics related to mobility, for instance. There are mobilizing projects from national funds allocated for various areas such as smart cities and technologies. In that context, there are some interesting funds the government makes available. The larger investment in this aspect is related mostly with those mobilizing projects and it is not necessarily directed to the cities. That is why I say reality is a little different when talking about city or enterprise. An entity can get much more financing to the government because it is those entities developing the products. I believe there are mobilizing projects that some companies are creating and that they receive support from governmental funds."

6. What is the position Portugal in relation to the other countries in the IoT and smart cities area?

"In this situation is more difficult to think at national level and easier to think at city level. Portuguese cities have been leaders in some aspects. For example, Lisbon is involved in a project called "Lighthouse" which is one of the most important projects and it is related with the IoT area and Porto is as first pilot city in a project of urban platforms also related to IoT and is leading the process of pilot and implementation at European level. At this point, the European panorama is very balanced."

7. How does IoT play its part when it comes to politics?

"It starts with an initial planning and the political will of wanting to implement and improve. Also this will has to be shown in a plan, every municipality have directive and strategic plans which have more traditional urban interventions and the part of innovation and strategic development and all of this is interrelated. Then it goes form this political motivation to a plan of action and after this the IoT allows in return after implemented, not only the development of every local enterprises which also can create greater impact with this technology, but the fact of being able to make decisions based on information. If the city hall or the municipalities have more information it can take action in a better manner because it is possible to know the real situations. It is different having a street inquiry or have data from sensors. For the streets inquiry, the information has a little trend and can be manipulated, from sensors the information is almost statistics and there is not the necessity of questioning or making these inquires, from the start is possible a more correct decision and this is the advantage that interests to the city halls."

8. How do you think citizens will adapt to IoT?

Everybody has a little resistance to change, but we also have a huge capacity of adaptation. So in one side we are going to resist to this new technology. For instance, there is a society layer (elderly) that is going to have certain difficulty to adapt but also they will not need to because their lifestyle does not imply they have access to this technology. Of course, everyone must be integrated. The younger generations are not going to have many problems in adapt because they may understand more easily the benefits the IoT brings. If I just mention the word "IoT" nobody is going to use it. If I show the people what do they have to gain with what we are proposing, then they will accept it and use it. Most of the people are not going to see the IoT in its entirety, but they will notice there are services that can improve their life. We also have to communicate very well what IoT is."

9. What is your vision of the IoT in 5 or 10 years?

"The cities will have the tendency of adopting even more technology and understand that for a smart city is not just technology. That it is a problem. If people do not communicate, there are even restaurants that offer the meal if they never touch the cellphones, that the technology by itself can even be nefarious but I believe the technology came to stay and all these and this context of IoT will be much more familiar to people. Cities now have a much more humane concern and are beginning to use IoT and other technologies to help solve people everyday problems, although the small cities may have more difficulty and are going gradually adopting it and is going to be present in our lives."

Porto City Hall

I – Present Situation concerning Internet of Things

1. What is your opinion on the Internet of Things?

"The Internet of Things is something that has made a name for itself nowadays but for a long time we've been working with devices that communicate among themselves and using the Internet these devices can collaborate and communicate among each other. The name gives the system more potential through the creation of different things of value. We have some projects of Internet of Things, for example, a startup with a project related to autobuses calls the Internet of Moving Things, which is also an interesting concept as we have more contact with the circulation of information and we can collect it. We are in a world in which information is absolutely essential but there is still much more we need to gather. Having the possibility given nowadays the technology for a city that is extremely fascinating and at the same time a great motivation for transformation. Here in Porto we are following this very closely and have some projects related to the technology."

2. What is the best architecture in your opinion for this technology?

"There is not one closed architecture or standards for the architecture of the Internet of Things. We are still working in that issue. Porto has an association called Porto Digital, in which the city hall, the university and Metro participate. It is an association that developed in the last years the largest optical fiber network in the country. It is around one hundred kilometers spread across the city and we've been working together to potentialize the Internet of Things. We have worked in terms of infrastructure. We have Wi-Fi, environmental, noise and movement sensors among others in the city. We created an integrated management center in order to collect real time information from sensors. So, we have in the same room relevant information for the municipal services, such as police, mobility, civil protection, fire department and environment.. We also have traffic cameras, traffic lights and sensors interconnected. Therefore, the Internet of Things already exists and we manage it. We have been working in urban platforms and we are integrated in a small European group in the European Innovation Partnership called "Urban Platform". We are trying to work on a template about the concept of "what is a urban platform" and what it must deliver. So we are working on those groups that want to create a common ground that also can be understand by the suppliers. For the last three years we have been working in collecting the information and create a layer that will work as an information broker allowing the reception of data from sensors or other "things" and act based on them. This is what urban platforms are trying to achieve and the European Commission as well, for example, the FIWARE. Porto has a node of Future Internet Ware, which is an IoT platform. We manage it and it gathers information. We are working in these areas because there are many things occurring in the world at the same time with the IoT. So we have in the city various concepts concerning this topic. We have to work on this technology, we already tested some situations and are part of these groups because there is much work already done we can apply. Now we have a model we believe it has to exist to support the structure related to optical fiber, Wi-Fi networks and other mobile networks. We are very focused on the new services in this area which are the sensor network of our several partners and the need of a software layer which is an information broker."

3. What applications do you develop/apply? What kind of technologies do you use to build them and how long does it usually take?

“We have several things happening in the city in IoT level. For example in terms of smart metering, we have utilities and companies that use them. In relation to what the city hall has been doing, for instance, the municipal company Águas do Porto has twenty thousand habitations with smart meters. this is something we have been conducting. The water company launched an application in which the clients can consult the data in those smart meters measure and compare the data with another family equal to theirs and see if they are above or below average in water consumption,. Besides this it has other functionalities. Similarly, considering water consumption, in the Porto city park has the irrigation control is done using weather forecast stations, predictive models and act remotely in the system and are expanding this model to other areas of the city. There are gardens that irrigate accordingly with the weather forecast in the city park. We have projects involving public transportation. We are integrated in Future Cities project, which is a European project of competencies center for future cities. We also developed a vehicular network that is the largest in the world, the autobuses communicate among themselves and then with the optical fiber around the city. Usually in the city center, the autobuses do the entire offload in the optical fiber, there is not the necessity of communicating in 3G or 4G. Furthermore, if one of the vehicles is circulating and has another autobus near it, they communicate until they reach an optical fiber point. This allows to manage the city in a completely different manner, obtaining large amounts of data and creating graphics that show how many people connect to Wi-Fi, in which stop they enter and exit, among different types of information. In several parts of the city we also have noise and environmental sensors, measuring the temperature, humidity, wind and other factors, then we also have mobility sensors to understand how many people pass by. We have been working with the municipal fleet. It is all geo referenced which allows us to have three hundred vehicles circulating in the city and with the autobuses. The number increases, but it gives us an interesting perspective about the traffic in the city. These are some aspects we have been working on. There are many more we are developing, but the IoT is present in the city. The time developing and implementing depends. There are smaller and simpler projects that do not take very long to implement. There are more complex ones that take more time to implement because of the possible externalities associated with the implementation and it is not an immediate investment.”

4. What kind of businesses requires your services? Which are the main sectors?

“In this situation the question would be “what does a city have that can quickly transform and create benefit which can be reinvested in other areas that do not have a very palpable benefit?” There are areas very easy to understand. Mobility is one of them. It is becoming even more necessary to manage mobility in a more intelligent manner and the IoT clearly helps in that. The residues part is extremely important because of the optimization that can be done in residues distribution and collection. Understanding if the containers are full or empty are important areas. The cost reduction part is also significant. For example in the energy sector, the cost reduction will have more impact in public illumination, in the water sector it will have more impact in the irrigation. These are the sector I would enumerate as the sectors more easy to tackle and more important.”

5. What are the main objectives from your clients when implementing an IoT solution?

"Being our clients the citizens, the big problem of smart cities is something we have to know what the concept is There are many cities implementing many projects without thinking about the value it can add. We have two important objectives. One is give a service to the client, in this case the municipality and have them to see and get the real value from it. The second is having a benefit it may not be immediately palpable for the municipality. It can benefit anyway because there is a cost saving, since we are talking about public money, in reality is a benefit for everyone. The external factors such as the environmental sensors are used to understand how the city is evolving but are factors more difficult for the citizen to notice."

6. What improvements has the client shown after the implementation? Did it change their type of business model? If so, in your opinion, did it change drastically?

"There are implementation that are not viewed in that way. The environmental sensors and that type of city sensors clearly are not going to change much near the citizen. But the smart meters and the internet available in autobuses for instance, is more palpable. Many times these services have business models based on cost reduction or giving new services to the client in order to gather new business opportunities. For the cities is very important and we are discussing it with other cities in the ambit of an European group about how the cities and these smart models transform in a business model."

7. What is your type of business model? Do you consider your business model to be much different from that of other technological companies? If so, in what way?

"The cities business models when talking about IoT are structures that help the projects. When we are investing in optical fiber or a sensor network, we are investing in urban platforms, in something that is an aggregator of these projects. Being able to make even more decision backed by information and data and the business models is based on the fact that the cost saved after implementing those projects is enough to sustain the structure."

8. Do you think, currently, companies or citizens are well prepared to implement and adapt to the changes the Internet of Things solutions can bring? What suggestion do you have for current and potential customers in order for them to implement IoT and stand out from the competition?

"We have a long way to go. Our population is becoming even older. Transforming IoT in a mere digital communication with the citizen is a risk and we do not want that. In the IoT and the way I see the cities, what we want are services for the citizens but also that the citizen sees a benefit in the good management of the city. I do not think we can achieve that just with applications for smartphones. It is interesting but we want to give a clear benefit to the citizen and it has to contribute the improvement of the quality of life. Everybody uses technology if there is a real benefit. Disregarding some population that does not have access to technology, the idea is to use the technology to approximate to the citizen and turn it easy to use. Eventually every citizen will have to interact with technology and that may be a problem but if we take the technology to the citizens, things may be very different."

9. What do you think about the current national and international IoT market and their economic impact?

"I think we in Portugal are making a very interesting path. We do not lead in many of the areas but we lead in some. We have high quality investigation in our country as well as universities and polytechnics working in that area. The market nowadays is global so the national companies work at international level and we have to maintain the investment here in Portugal. "

10. What do you ask for your IoT clients after implementation?

"In terms of city, every system we are developing and systems developed by different companies, it is them who do the maintenance and when they are not the association Porto Digital is responsible for it as it is becoming a city operator and it is responsible for everything that is IoT , platforms, optical fiber, sensors and others"

11. Do you think IoT can help your business to stand out or get ahead from your competitors ?

"Absolutely."

12. What do you think are the advantages and/or disadvantages of IoT/IoT Portuguese and the international market?

"It is difficult talking about advantages or disadvantages. When it comes to Internet of Things, the greater problem related to it is essentially data protection and security. It is a fact that cities have and that is why we are working with a city operator to handle this issues. Nowadays when we talk about Internet of Things is not just the public sector. There is information that comes from private companies integrated in the urban platforms. The management of what is communicated, what information is private or sensible and who can have access or not to the information and who can access it through illegal ends are areas that are most concerning. As such they need to be handled carefully. The main issue is how the IoT is used for a clear and proper end."

13. Do you think there is enough investment, motivation, partnerships and support from the government or other companies to promote IoT solutions?

"We are in a process where we know it is necessary to invest. There are solutions that have business models behind them. The cities, public or private partners, the entities exist, we know the business model and just need to know where the investment in the business is, the payback and if there is return on investment. There are several innovations that require investment in order to grow and expand, this is something that has to be addressed. The government has shown that is observant about these innovations, but there still is much left to do. If cities want to be more developed, they have to have a perspective where they tries to develop the projects at urban scale, not just a small project. To create that impact we need to have investment, we are talking about new opportunities that are going to potentialize new startups and innovation, If they do not have a specific and valid business model, which is rather difficult to define in the beginning, it is necessary to have investment."

II – Future Situation for the Internet of Things

1. What are your perspectives about the Internet of Things in your business?

"The perspective is that this is a good snowball. It is going to grow and it is going to create impact. Nowadays even more the citizens and consumers are going to demand to have a more clear relation with what exists, what it does and question why things are a certain way or not and that can be achieved. We need information even more and use data driven decision making, we are going to making much more decision with enough information to support it."

2. How do you see your position in the IoT market in 5 or 10 years? What significance and impact it will have in Portugal?

"I do not think it is going to stabilize, we're still in the very beginning and as we are in a world of constant transformation, following the exponential growth curve and I think that's going to continue. We have a big opportunity in Portugal which is be a part of that growth and that is absolutely essential for the country and for the cities."

3. Do you expect any differences from the original business model or will remain the same?

"The business models are something we are concerned with and are working with other European cities in a project called "Smart Impact". It is about how are the new business models because we are starting to transfer to the question of shared economy, it introduces new concepts and models we have to understand how cities work, the business models are not stabilized."

4. Which sectors do you think it will require more IoT solutions in the future?

"In the future I think the urban platform we are developing is holding more and more information, so it will hold information from many of our sectors but also from many other private entities will see a benefit in collaborating in something in common."

5. Do you think companies will show more maturity when planning and considering implementing IoT technologies (or any other emergent technology)?

"Yes, they are going to have much more maturity. We are in the first step that even has not reached our houses, is coming just now where we can measure better our energy, consumptions and other parameters. Business is a very strong driver, when the IoT has a fitting in business terms, the boom is immediate. For example when we change a lightbulb we change it to consume half it did before, when considering a city this means a big cost reduction with very short paybacks, so nowadays change or not has a great impact. All of these components associated with IoT even in the own companies as for example the IoT in the industry, it is talked about for many years, nowadays is more gaining attention and there are other opportunities for the industry."

6. How do you idealize the IoT market nationally and internationally in the future, from a supplier perspective? What types of IoT services/products you think there will be in the future?

"Here we have a huge challenge and only have one way to overcome it which is going in the frontline. If not we are going to have many difficulties and are not going to have as many opportunities as other countries that have positioned themselves."

7. How much do you think cities will change in order to adapt and work with IoT technologies in their companies?

"They are going to change drastically. In Porto, 15 years ago we implemented a solution called Andante and it was the first contactless system in the world and the fisrt intermodal, so when we want we lead. The importance of leading in these areas can open doors in the market to be suppliers of the world and that is very indispensable. We have a structural change that nowadays almost nobody pays attention to it. Leading also has an opportunity cost that if well managed can bring more wealth."

III – What is your opinion about the utilization of Internet of Things in Portugal?

1. What impact it will have in the society and economy?

"Public management has direct impacts in what the expenses are to manage the public wellness. We have to take advantage of this opportunity and invest in areas that give us return. In this moment the main focus should be to invest in areas where we can obtain cost savings.. If we can do that I think the country has a lot to do in that area. There are many other areas that are not very related to the public ambit and I think the business is going to be the driver of this transformation. We need to have a conjoint perspective and the problem is more based on the business models which are not stabilized enough to know how are we going to launch the technology. There are several parallel processes. The projects that introduce an optimization should be implement and takeoff as soon as possible and have programs in order to do so. We have countries in Europe that apply tens of millions euros in these projects for public services improvement. We still are a little far from it but there also are ways of applying money that translates into a benefit. The impact is extreme and we have to take advantage of it and then there are other areas where we have to invest to lead in the front, we need to invest to believe that in the future it is going to translate in an future asset to the economy."

2. How do you think Portugal will position itself in comparison to the other countries in Europe?

"We are well positioned but with some difficulties in investing in large projects and when the business model is not very perceptible, is more complicated and we should do something in this aspect."

3. Do you think Portuguese citizens will accept and adapt easily to the technology?

"The technology has to be seamless. People more interested in technology can understand that is receiving information from somewhere. Georeferencing is providing a new type of service to understand that the searches made will show them advertising related to it, and there are people that will not realize that. Although I think that is something that must be always perceptible for everyone, but in the cities the technology has to be a little seamless and it already is, in the semaphore management for example. If the technology is non-intrusive in most cases is the best technology we can use, having into account the data anonymization and how do we infer this in our private lives. We are a country of early adopters and I think we should use that condition and try to make it easier of using it."

4. What other opportunities can IoT bring, for companies, civilians and government?

“The fact of having things communicating need to have a purpose. We need to understand that the information is created, generated with an objective, that is the driver. Then it is obvious that there is much information created to an objective and we know that it is very useful to others. We started to have many more elements communicating and things becoming intelligent are a huge benefit and it has to be turned into a real benefit for the society. Therefore, for the city, the question for the urban platform or city operator is one we are addressing because there has to be an entity responsible for that function. The semaphore or water management is a subject in which the city has to elect an entity that make sense to have a role in the future of the IoT, while in the companies is going to be very important for various areas, for example we have startups in Porto working in vehicular network, maintenance of the equipment to understand who does, what, when, as well as in the irrigation to understand if it worked or not or if there are leaks. So all of these aspects and opportunities are enormous and they are available for companies, municipalities, government, our houses and that has much wealth. Without fears and creating constrictions and controlling the data protection area, we have a big opportunity for the country.”