Smart Home

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Abstract

This research explores different applications to Smart Houses, the difficulties to make them viable and their role in the bigger picture. Current strategies and approaches directed to integrate and innovate the Smart technologies to improve the everyday life. Helping people physically and also mentally but also to improve the power consumption in the house. Either by turning off some devices or lights when not used or even with the help of the smart grid, this grid does not need to reduce electricity consumption to help the user save, it instead tries to use it or store it (if the user has the right equipment) when it is the cheapest, because has we know depending on the usage and the contract, the price can fluctuate. Also, the user can sell if he have for example solar panels and the smart grid detects a high demand for electricity. Both types of smart-home raise some questions about the extend and type to which the control can take place as well as the ecological impact. The Internet of Things (IoT) has been receiving additional attention . It has now an important role in society and technology. It can support various applications and services in various domains, such as smart cities and smart homes. IOT connects devices to allow people's interaction to one another and simplify sharing information. In this article IOT is considered the foundation of smart home's.

1 Introduction

The concept of smart Home has been widespread all over the world and have become a huge importance in recent technology and policy discussions about energy management, climate change, innovation, among others. Regarding policy discussions, one of the 10 priority's of EU are the development of smart homes, in the Strategic Energy Technology Plan, in particular "Create technologies and services for smart homes that provide smart solutions to energy consumers" [18];[10].

The market of smart home has been increasing in the past years, Market analysts Berg Insight evaluate that in the end of 2017 there were 22.5 million smart homes in Europe and estimated that the market will grown around 30% a year, or 84 million smart homes by 2022. The countries that are leading the market of smart home in Europe are France, Germany and United Kingdom[18].

The concept of smart home are changing the way we talk about homes and are considerate core elements to promote smart grids and smart cities [12]. New technology has been affecting the way energy is generated, distributed and consumed, the smart home technology offers a lot of benefits to households, in terms of energy management, comfort, security, convenience, among others[14].

The rest of this article is structured as follows. In Sect. 2, we specify the concept, objectives and specificities of smart home. In Sect. 3, we develop the concept of smart grid. In Sect. 4, we present the concept of Internet of things (IOT) and how they can communicate and gather data with their sensors, not only that, but easing the everyday life of the user. In Sect. 5, we show how consumers perceived the benefits and risks of smart home technologies.

2 Smart Home

There are several possible definitions for smart home, according to Hayes (2022)[20], "A smart home refers to a convenient home setup where appliances and devices can be automatically controlled remotely from anywhere with an internet connection using a mobile or other networked

device. Devices in a smart home are interconnected through the internet, allowing the user to control functions such as security access to the home, temperature, lighting, and a home theater remotely". A smart home can communicate between each smart equipment through wireless or hardwire systems. There are several possible ways for the communication of each smart equipment, such as, powerline, busline and radio frequency. There are several methods of communication between each equipment that could not be compatible between them, therefore the equipment's could not understand each other, it will be necessary to have a mediator, a HUB, that receive all the information of all equipment's and processes it [1]. The main objectives of a smart home are increase home automation, facilitate energy management and reduce environmental emissions [2]. Smart homes can be used to improve comfort, convenience, security and safe, especially in elder people and those with disabilities [3].

There are three elements for a home do be considered smart, such as internal network (i.e the communication between the equipment of the house), intelligent control (the gateways to manage the systems, both with access, from the user, outside the house or by an application of the smart grid) and home automation (connection between equipment's of the house and the services and systems outside the house) [1].

There are several smart devices that can be used in a smart home, each device as a application, in particular, security (the device can detect fire, gas and water leeks, property monitoring and protection), energy managements (energy usage and costs), lighting (the lights can be turned on and off automatically based in occupancy sensor), air conditioning (e.g. the house can control to turn off the air conditioning when there is no one in the room) and home appliances (can be used for entertainment or even to improve security, comfort, energy management, among other) [1];[3]. Some examples of smart appliances are the smart bed, which can be programmed to set up your preferred sound, smell, light and temperature settings for when you wake up, smart pillow, that can read a book, play music, check the quality of your sleep and in the case of an emergency or illness it will report, via network, to the emergency system; smart mat that can recognise which user is stepping on the mat, just by sensing the body weight and footprint, and can also be programmed to give voice message to another person; and gate reminder, which reminds what you need, before you leave the house [1]. Later, we will explain in detail how these equipment's communicate with each other.

In Portugal we have some projects already being develop in the smart house area. In 2021 a project made by Bosch and University of Aveiro has started with the objective of innovate smart houses. This project was created to increase more than 20% the energetic efficiency of houses served by the photovoltaic park and reduce the carbon dioxide emissions in each house in more than 20%.[23] Also in 2021 the University of Lisboa started developing a platform named SATO(Self Assessment Towards Optimization of Building Energy) that has the objective to reduce energetic waste, predict equipment failures, create automatic diagnostics of the energetic performance and the correct operation of the building/house. [22]

A smart home can be connected with an external system, known as smart grid, which will help achieve the purposes of the smart home, such as facilitate energy management and reduce environmental emissions.

3 Smart Grid

A building with smart grid is characterized for the flexibly connection and interacting with energy system, which is capable of produce, store and/or consume energy efficiently [7]. Smart grids were generated as a modernized solution to the traditional electricity grid, the objective is to make reduce environmental emissions as well as upgrading the delivery of power, not only that but it will reduce the cost of electricity on smart homes as a consequence. Smart grids can utilize the existing infrastructures so there is not a big problem em the need to build more power plants and

substations, also they are more autonomous and improve the effectiveness and efficiency of power delivery.

Therefore, with this connection between external electricity system, the building and its owners, possible through the smart grid brings several benefits, such as, storing energy from periods of abundant electricity generation in water tanks, storage heaters, freezers or batteries, or even selling energy in periods of low availability. Consumers can control their energy expenditure, by decide to use less electricity in times of high demand, their supply may be cut off if the power demand rises above the level agreed in the customer's supply contract and be restored only after one or more appliances has been switched off [11]. The image 1 shows a working smart grid.

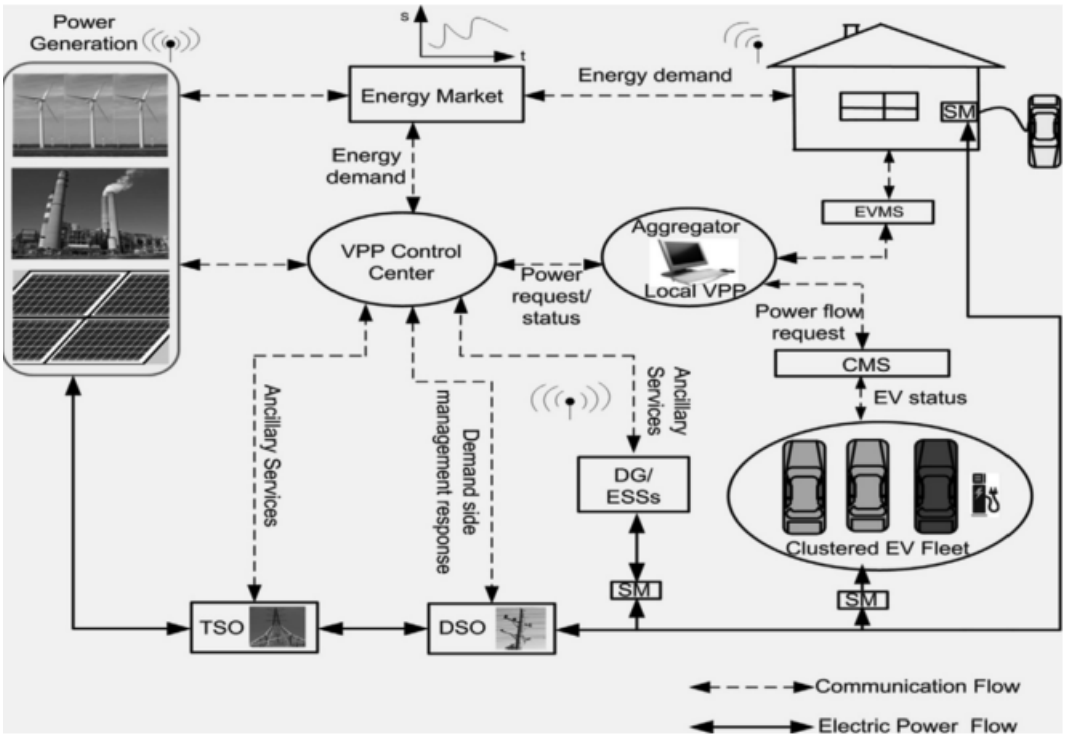

Figure 1: Smart Grid[19]

On table 1, 2 and 3 we have some additional information about Smart grid as a comparison to the traditional grid as well as a description of how each service works and some theoretical possible vulnerabilities

Table 1: Traditional grid and Smart grid characteristics[6]

Traditional Grid	Smart Grid
Mechanization	Digitization
One-way communication	Two-way real-time communication
Centralized power generation	Distributed power generation
Radial Network	Dispersed Network
Less data involved	Large volumes of data involved
Small number of sensors	Many sensors and monitors
Less or no automatic monitoring	Great automatic monitoring
Manual control and recovery	Automatic control and recovery
Less security and privacy concerns	Prone to security and privacy issues
Human attention to system disruptions	Adaptive protection
Simultaneous production and consumption of energy/electricity	Use of storage systems
Limited control	Extensive control system
Slow response to emergencies	Fast response to emergencies
Fewer user choices	Vast user choices

Table 2: How each stakeholder works [19]

Stakeholder	Description
Customer	Electricity is consumed by consumer. It may be domestic, commercial or industrial
Operations	Operations related to power systems are performed. It comprises of regulatory authorities or management responsible for movement of electricity
Markets	Grid assets are used by stakeholders. Both operators and consumers play a role in the market
Generation	Electricity is generated. Generation companies in bulk quantity of electricity are involved as a player
Transmission	Electricity is transmitted. Companies or player responsible for transmission of generated electricity for distribution
Distribution	Electricity is distributed to end consumer and monitored. They include distribution of electricity from and to customers
Service Provider	Provide support services to all the stakeholders involved in generation, transmission and distribution of electric power.

Table 3: Possible Vulnerabilities [5]

Connection based	Device based
RF jamming	physical attacks and natural disasters
Wireless scrambling	Rogue access points
Eavesdropping	Man in the middle attacks
Message modification and injection	Dos attacks
Protocol failures	Replay attacks
Physical attacks and natural disasters	illegitimate use of services
	Masquerading
	Wardriving

4 IOT

IOT, or internet of things, is what we refer as the connection between digital objects with the internet and themselves. IOT is a web of physical objects, like sensors, cars, and connection with the internet, it can send and receive data as well as save and interpret said data in some situations. This provides normal devices used in the everyday the possibility to have computational power and the ability to communicate between them or to the internet. This makes it possible to control said devices throw the internet by a user or even by an application(from internet or from other device on the building)[4].

Because of that, IOT has been receiving various types of attention in the last years led by the building potential to be used in various areas of the human activities. IOT can be interconnected by different ways, WiFi, Bluetooth, power-line, bus-line and radio frequency are only some of the possibilities. This allows the users to build a system in his house enabling the control of many things such as temperature, light and other types of devices like setting a oven to work at a defined time making the food ready at a certain time without the need to even be at home. This is helpful in many ways, gathering information, leading to helping people in their every-day life[4].

This devices usually are not made to have direct access to the internet, they are supposed to work without the intervention of anyone, so devices like a computer or a smartphone are not considered IOT by the majority, unlike devices like coffee machine, freezer, fridge or even beds. However this devices can be all controlled by a hub, that works similarly like a router for IOT, this router receives all the information of the various devices and sends back other information, this is the device that allows the connection to the internet by being connected to the home router, also this device is very important because although many IOT can communicate between themselves it is very difficult to do that with every IOT in a house, as the protocols to send information can be very different, and the hub can solve part of that problem by trying to interpret the different protocols and process the information answering back to each [9].

Smart cities are something that will be a reality in a near future, and goes beyond the home or institutional IOT.The internet will then make cities smart, making the life of many people easier and giving more accessibility to them, that is something that is not in place on all cities of the world, especially on developing countries. In developed countries however there are plans to help older people, not only that but, there are already investments in upgrading bridges, highways, smart illumination, mobility based on sensors and equipment's that generate energy when used. Those are plans that are being projected on a near future and will for sure benefit the population[17].

There are different protocols in usage with the IOT. Some data protocols being used are for example MQTT, AMOP, WEBSOCKET and CAOP, they use security like TLS and SSL with the TCP protocol while the last example uses DTLS security with the UDP protocol. Each of them having different advantages and objectives. [16]

5 Perceived benefits and risks of smart home technologies

Several studies (Harms, 2015;[10] have demonstrated that the market of smart home has been increasing, as well as the interest of the consumers, however there are still many consumers that don't understand the concept of smart home and have difficulty trusting these appliances. A study conducted in 2021 by Finbold [21], have demonstrated that the global average of consumers with smart devices at home are 13.5%. More, the countries with the higher levels of consumers with smart devices at home are UK's with 24.9%, Ireland's with 22.2%, Canada's with 21.2% and the US's with 20.2%. On the other hand, Portugal is above the global average, with 6.5%, in 39º position. Several studies [18]; [10];[13] have showed that potential early adopters of smart home technologies are, predominantly, younger, wealthier and have more knowledge about smart home technologies.

Although, there are more people interesting in smart home technologies, as well as its benefits with energy management, there are still some barriers and risks perceived by the consumers. The study of Growth for knowledge (2016)[10] shows that the most significant barrier to adoption of smart home technologies is the cost, lack of awareness and privacy concerns. Market growth of smart home technologies will depend on consumers perception of benefits with acceptable risks. Several studies ([14];[10];[18] have shown that the main benefits identified by consumers are the comfort, reduction of energy use, reduction of environmental impact, improve home value, better management of energy use and the benefits to the health of the household. Other studies have identified additional risks, such as lack of autonomy and dependence of technology.

Despite all the policy that several countries have made, through the years, to promote the market of smart homes, the study conducted by Sovacool Del Rio (2020)[18], shows the polity recommendations given by the consumers, focus essentially on consumer protection, privacy, data security;restrictions or configurations to ensure low-energy or low-carbon;and stronger regulations for energy services or IOT. Therefore, there are still a lot of concerns and reluctance in the acceptance and adoption of smart home technologies.

6 Conclusion

The development of smart home technologies are being updated and getting bigger attention, from both consumers and businesses, as well as the market and interest of the consumers about smart home and their appliances. Despite the increasing interest in smart home, there are still a lot of barriers and concerns. These barriers are mostly, based on security issue, lack of knowledge and the high price. These problems will eventually, be surpassed, through the diffusion of information about smart home and its specificity's, so that people can be more informed about smart technologies and will feel more comfortable and safe about. Regarding the lack of security, it has been addressed by many researches [15],[8] and have been improved over the years and will continue to be.

Even though these barriers exist, smart home technologies are extremely important to energy management and climate change, as well as technology development. The adoption of smart home devices can have several benefits to elder people and those with disabilities, improving their comfort and safety.

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