



INTERNATIONAL
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The Role of Internet of Things

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SID: 3304160002

SCHOOL OF SCIENCE & TECHNOLOGY

A thesis submitted for the degree of

Master of Science (MSc) in Energy Building Design

DECEMBER 2018

BERLIN – GERMANY



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Abstract

This dissertation was written as a part of the MSc in Energy Building Design at the International Hellenic University. We are presenting a literature review about the Internet of Things in this dissertation. More specifically, we are exploring the role of Internet of Things in transforming conventional buildings to smart buildings and the role of Internet-connected devices when these are applied from small to big scale. First, we are identifying the potential benefits of Internet-connected devices in buildings and in terms of smart houses, and we are closing with the potential benefits of Internet-connected devices in urban scale, in terms of smart cities. This dissertation aims to clarify all aspects of the above-mentioned benefits, focusing in innovation, energy saving and sustainability.

Acknowledgements

Finally, it is with immense gratitude that I acknowledge the support and help of my Professor Dionysia Denia Kolokotsa who supervised this dissertation and provided me with all the necessary assistance.

This thesis is dedicated to my mother! A Master's degree would have remained a dream had it not been for her that stood by me through thick or thin and supported me throughout my life.

Louna Kapeta

06/12/2018

Contents

ABSTRACT & ACKNOWLEDGMENTS	III
CONTENTS	V
1 INTRODUCTION.....	1
2 THEORETICAL BACKGROUND - IOT	3
2.1 WHAT IS THE INTERNET OF THINGS.....	3
2.2 FACTORS FAVOURING THE IOT BLOOM.....	3
2.3 IOT CHARACTERISTICS.....	5
2.4 THE IMPACT OF IOT ON ECONOMY.....	8
2.4.1 <i>Expected profit from IoT.....</i>	<i>11</i>
2.4.2 <i>Size of the IoT market.....</i>	<i>12</i>
3 SMART HOME: ARCHITECTURE, TECHNOLOGIES AND SYSTEMS.....	13
3.1 SMART HOME DEFINITION.....	13
3.2 ARCHITECTURE	16
3.3 TECHNOLOGIES.....	18
3.3.1 <i>Power information service</i>	<i>18</i>
3.3.2 <i>Home appliances interactive control.....</i>	<i>18</i>
3.3.3 <i>Household electricity management.....</i>	<i>18</i>
3.3.4 <i>Self-service payment service.....</i>	<i>19</i>
3.4 SMART HOME POWER SERVICE SYSTEM.....	19
3.5 SMART HOME FUNDAMENTAL EQUIPMENT	21
3.5.1 <i>System master.....</i>	<i>21</i>
3.5.2 <i>Family intelligent interactive terminal.....</i>	<i>21</i>
3.5.3 <i>Smart electrical equipment.....</i>	<i>21</i>
3.5.3.1..... <i>Smart sockets</i>	
22	
3.5.3.2..... <i>Grid-friendly electrical appliances</i>	
24	

3.5.3.3.....	7. Smart Home Communication System	
	25	
3.6	SMART NEIGHBOURHOODS	29
3.6.1	<i>Technologies</i>	29
3.6.2	<i>Residential property security services</i>	29
3.6.3	<i>Utilities Information Services (municipal, medical)</i>	30
3.6.4	<i>Business information services (information customization, information interaction, news subscription services, etc.)</i>	30
3.7	TECHNOLOGIES AND SYSTEMS.....	31
3.8	SUPPORTING END USERS TO CONTROL THEIR SMART HOME	32
3.8.1	<i>Designing tools for smart homes</i>	32
3.8.2	<i>Identification of smart home tools</i>	34
3.8.3	<i>Literature review on tools for smart homes</i>	38
3.9	A FRAMEWORK FOR PERSONALIZED USER INTERFACES.....	39
3.9.1	<i>Requirements for personalized user interfaces</i>	40
4	OTHER INTERNET OF THINGS APPLICATIONS.....	43
4.1.1	<i>Smart clothing</i>	43
4.1.2	<i>Smart energy and smart energy systems</i>	46
4.1.3	<i>Smart metering</i>	47
4.1.4	<i>Smart system for children's chronic illness monitoring</i>	48
4.1.5	<i>Context-aware system to assist wheelchair users</i>	49
4.1.6	<i>Analyzing user location discovery methods in smart homes</i>	53
4.2	EXPANSION TO SMART CITIES	55
5	SMART CITIES	56
5.1	SMART CITY DEFINITION	56
5.2	SMART CITIES TECHNOLOGIES AND SUBSYSTEMS.....	59
6	RESEARCH METHODOLOGY	63
6.1	RESEARCH METHODS.....	65
6.2	LITERATURE REVIEW – WRITTEN SOURCES	65
6.3	DATA COLLECTION	65
6.3.1	<i>Primary data sources</i>	66
6.3.2	<i>Secondary data sources</i>	66

7 CONCLUSIONS	67
8 BIBLIOGRAPHY	69
APPENDIX	77
FIGURES.....	78
TABLES.....	78

1 Introduction

The world is evolving in fast pace thanks to everyday evolutions in the broader sector of technology. Along with the global energy problem, triggered by the forthcoming depletion of fossil fuel reserves and by the climate change, there is a never-ending need for continuous growth because the global population is in blooming exponentially every year. The continuous growth is on one hand a necessity in order for human kind to be able to feed and support the rising population, while on the other hand is in contrast with the above-mentioned energy problem. This stands because growth is, conventionally, linked with energy consumption and environmental damage. The one-way to solve this multi-variable problem is to achieve sustainable growth in order for people to be able to handle all the above-mentioned issues. Energy saving via smart buildings or even via smart neighborhoods and via smart cities is crucial in order to achieve actual sustainable growth.

Speaking of smart buildings and other smart terms, these have appeared in the last few years, or maybe in the last decade in a rather primary form. Transforming a conventional, let's say house, to a smart house is dependent on a specific set of technological advances that have appeared in this decade and which have started getting more mature in the past few years.

The most crucial achievements, which pave the way for smart houses, buildings etc., is the Internet of Things technology, also known as Internet of Everything, which is usually abbreviated as IoT.

The world is facing a rapid growth in the utilization of Internet of Things, which is commonly measured by the number of Internet connected devices globally in order for the people around the globe to be sufficiently fed and thrive.

2 Theoretical Background - IoT

Theoretical background on the internet of Things is examined in brief in this chapter. The quick review we conduct, focus on the possibility to construct smart buildings via IoT methods. According to what, already existing conventional buildings alter, IoT system usage is being accepted. Then remodeling into smart constructions also applies the usage of IoT systems.

2.1 What is the Internet of Things

The solution to manage devices automatically was given by IoT technology and the fundamental issue was exceeded ever after. Physical world via digital signals was easy to control and monitor. This facility leads to digitalize parameters as temperature, humidity, energy demand into the physical world. The interaction of people according to their environment could be transformed by IoT.

2.2 Factors favouring the IoT bloom

Since 2012 IoT becomes more and more popular as shown in figure 1 according to the trends that google notice.

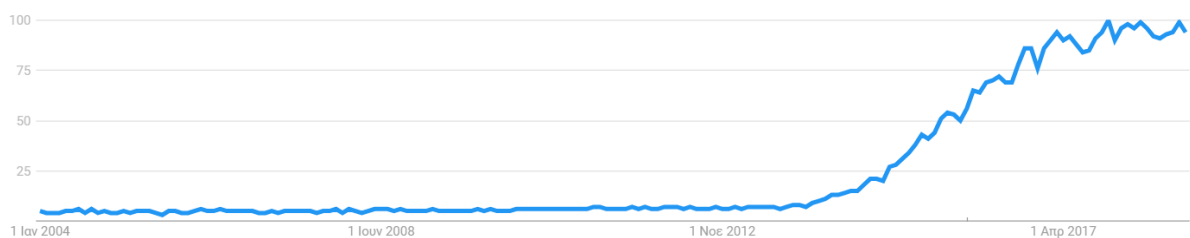


Figure 1: Google trends – searches for IoT term globally (2004-present)

Reduce of technologies cost and new technological achievements are the main factors that favored the IoT expansion.

- Processors cost has decreased by 6000% past decade and the same time their performance has been risen 30%.
- Sensors cost has dropped 50% all that period

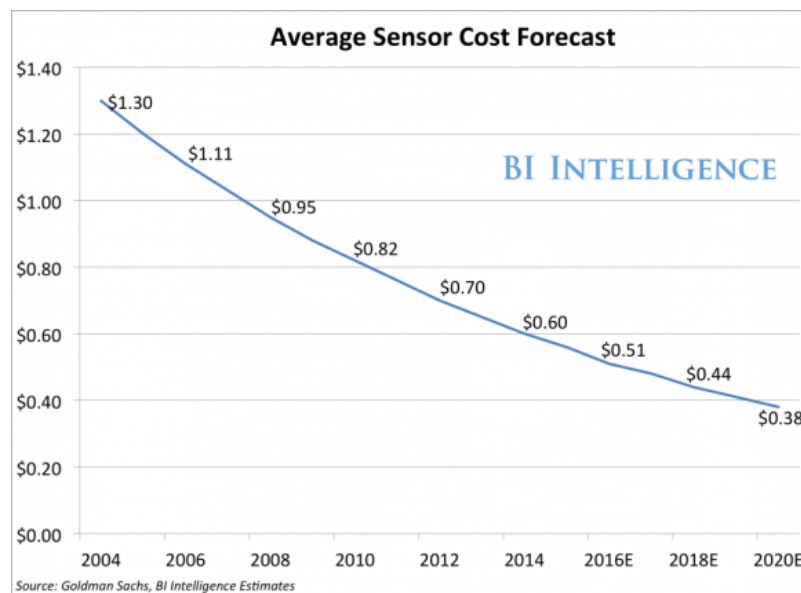


Figure 2: Sensors cost forecast

- Smartphone use is increasing significantly every year. For example, the users in 2014 were around 1,57 billion and during 2018 the number increased to 2,53 billion and by 2020 is expected to be more than 2,87 billion. Additionally, we should consider other devices that carry SIM card and operate connected to Internet as tablets phablets.

- IPv6 communication protocol that deploys makes communication between devices faster. Despite numerous advantages and facilities over IPv4 protocol the transition to IPv6 is difficult and slow with main problem the fact that devices could not operate simultaneously in both protocols.
- MBps cost has dropped from 1245 \$ in 1999 to 23 \$ in 2012. That means that the bandwidth cost has dropped around 5000%.
- Wi-Fi (Internet availability through wireless networks) is rising exponentially. In developed countries, the wireless coverage is omnipresent.
- Data storage revolution was rendered viable as the big amount of data produce annually needed to be kept easier and cheaper. Researchers now have valuable raw data sets to process as the percentage of data has been rising exponentially the past years.

As a result, IoT systems turn out to be cheaper and easier to use and due to these factors started to bloom.

2.3 IoT characteristics

IoT as already mentioned based on preexisting technologies offers interconnection of preexisting technologies offers interconnection of physical devices using holistic infrastructure for electrical appliances, energy meters and all levels of services.

Characteristics of IoT technology are the following:

- **Intelligence**

IoT intelligence allows different devices to communicate with each other as is a mixture of algorithms and computations. Matching hardware with software offering capabilities that are improved day by day thanks to this intelligence. Internet connected devices that follow predefined rules increase. The key element of this technology is its intelligence.

- **Connectivity**

Possibility to communicate IoT devices with broadly used devices such as smartphones and computers sets the path for new market opportunities. The creation of a global network is enhanced. Creation of rust IoT network is improved to use smart devices and services.

- **Dynamic Nature**

IoT devices collect data from their external environment. In order to collect data, they monitor the environment in order to detect potential dynamic changes around them. Once a change is detected, the state of an IoT device will change dynamically, for example it will either switch on or off. Some typical changes are the temperature alteration, speed, geographical location etc. Finally, IoT devices interact with users, so their state change can be triggered by the end user himself.

- **Enormity**

There is a constant growth in the number of Internet connected devices, which characterizes the IoT technology with enormity. The more IoT devices, the more complex the IoT network is going to be, leading to increased complexity in managing the IoT technology collected data.

- **Sensing**

Sensors are a critical element building an IoT technology network. Sensors are responsible for realizing and measuring changes in the environment in order to provide this data to IoT devices. The IoT sensors are used to establish interaction with physical environment to collect data. That data is actually the input to the IoT system.

- **Diversity**

Diversity and heterogeneity are two key IoT technology characteristics. Internet connected devices are based on different hardware platforms and communication networks, but they can still communicate both one to another and with devices in the external, via different networks

All in all, the IoT devices' network is capable to support connectivity amid separate networks. In order to achieve the desirable diversity, the IoT technology network should be featured with scalability, modularity, extensibility and interoperability.

- **Security**

Despite the big number of applications of the IoT technology, there are still information security and privacy issues as far as the IoT network is concerned. Academics and professionals are struggling to resolve such issues. Providing end users with a safe IoT network is crucial because the volume of personal data being transferred from one device to another via the IoT network is enormous, while some of that data consist of sensitive private information.

2.4 The impact of IoT on economy

All kind of consumers understand that the future belongs to IoT: The investments in its solutions will be beneficiary for their financial status. Publishment on Business Insider Report refers to an expected number of devices connected to Internet about 34 billion in 2020 on the other hand Cisco Report predict 50 billion devices. Nevertheless, there is no need of research and calculation to estimate the increase expected I investments (6 \$ trillion according to reports) and the final revenue to multiply. (13 \$ trillion by 2025).

Manufacturing (industry)

Already existing industries used smart sensors in a percentage of 35% by 2016. We expect an additional percent of 8% to install smart sensors and applications according to their announcements of plans till 2020.

(1)

Transportation

It is expected by the 2020 that over 220 million cars will be connected to the internet. As a result, investments to cover this sector are expected to be about 140 \$ billion by the end of 2020. The whole attempt will be made in order to increase car's quality and generally IoT solutions will improve efficiency, reliability and safety to transportation systems. (2)

Defense

Military robots, VAVs and drones is the field that IoT interfere to Defense sector.

We estimate that countries will invest in this technology and more than 120.000 military robots we expect to operate by 2020. (3)

Agriculture

In order to facilitate farmer's production devices that monitor soil for humidity, acidity and weather parameters as temperature and rain are already in use, but it is expected to increase a lot by 2020. The innovation in agriculture sector by using sensors connected with IoT will improve quality and quantity of crops. (3)

Oil, gas and mining

Energy sources exploitation companies already have installed sensors to locate new possible extraction sites, but also to those already existing they want to measure environmental parameters. These devices connected to Internet, decrease their running costs and increase IoT devices annually 70%. Oil wells' and gas rings' orientation to IoT technology indicates the importance of it. (4)

Insurance

Insurance companies use IoT to evaluate better their clients and decide the size of risk they take. The IoT devices they mostly use are drones that detect clients' environment or even their health condition by wearable tracking systems connected to Internet. Investing in IoT devices they expect to improve their efficiency up 50%. (3)

Smart Home

Buildings that incorporate smart systems and specific houses will reach by 2020, 46 million.

Homes' preferable smart systems are those connected with entertainment. Year by year more and more domestic appliance gain part of smart systems market as security devices and temperature regulation devices. Till 2030 most domestic devices will be connected to internet. (3)

Food services

At first IoT via smartphones or other portable devices provided customers with nutrition information. Companies in the food sector afterwards decides to use it aiming in reduction of food waste and improvement of foods quality. At last smart connected kitchens used either of domestic customers either of professionals (restaurants, groceries, etc.) with sensors are able to monitor current food supplies and make orders according to needs, so food waste is reduced.

Business Insider report estimate that more than 300 million devices will be in use for the food sector by 2020.

Infrastructure

When we refer to the infrastructure of the cities we mean, municipal and residential buildings, as well as transportation and commutation networks. With the use of IoT devices buildings become smart they consume less energy and provide better services to citizens. By the end of 2020 is estimated that smart cities that use IoT devices will grow their expenses for them to 147 \$ billion. (4), (3)

Retail

Big supermarkets have already installed smart beacon applications. They offer the possibility to the customers to locate products in store departments, available offers and generally by the use of smartphone or tablet to make easier their shopping. Big retailers apart from facilitate consumers with the support of IoT systems to have an inventory management they analyze habits so as to understand what the public is asking from the market. (3), (5)

Logistics- Supply Chain

Logistics need for better packages tracking and refill in time with products in their warehouses is served better with IoT systems because they successfully forecast and program their operation efficiency. The increasing use of IoT devices as RFID sensors or ibeacon systems that transmit their data to IoT platforms improve the supply chain.(3)

Banks- Finance

In this sector ATMs were the first that installed IoT systems with voice and video assistance to help customers to use them.

After that bank cashiers are monitoring habits of the public in order to reduce Banks's costs by operating more efficiently. By 2020 half the IoT devices will be installed in Financial Institutions. (4) (6)

Utilities

By Utilities companies we mean distributors of electricity, natural gas and water and already started installation of smart meters for them. The distance measurement, opening and closure eliminate cases of energy stealing and manage to cope the constantly

increasing demand of energy. By 2020 the number of smart energy meters will increase to one billion. (3)

Hospitality

In height-standard hotels, rooms have already installations of smart lock doors, smart air conditioning, lighting and electrical appliance. The improvement of them by using customers mobile phones for application via IoT will eliminate cost by useless operation. Hospitality sector has as vision to provide all available hotel rooms with holistic smart systems based on IoT devices. Besides hotel and marine transporters in order to facilitate their customers movements within their premises aim to install beacon services. (3)

Healthcare

In hospitals and generally to improve healthcare planning we have an invasion of IoT devices. Drugs management, patients' vitals live tracking inside or outside hospital is easier with smart devices. The advantage to install those devices in remote areas helps for first line medical assistance in case of emergency by arranging help from the proper medical staff. (3)

Smart Buildings

Already are in use for Buildings fire detection detection and extreme weather conditions-security and Energy management increase quality of life and decrease running costs. Use of IoT devices lead to better allocation of energy sources. The recourse to create smart buildings is a necessity for future.

2.4.1 Expected profit from IoT

Three sectors of general market are affected profitable from IoT evolution:

- Consumers
- Enterprises
- Governance

The expected profit for all of them is:

- Cost reduction

The contribution in cutting down costs by adopting IoT technology is extended to all the above segments.

- Efficiency improvement

Optimized resources allocation is expected to improve each sector's operations efficiency.

- Creation of innovative products and services

IoT revolution after making possible to monitor consumers' needs and habits can contribute to design innovative products and services. Products should address to modern people's trends and services should be personalized.

- Creation of new revenue streams

Smart parking system based on IoT allows drivers to check in a parking slot and pay via web banking with a smartphone, is an indicative example of innovative services combined with new payment methods.

2.4.2 Size of the IoT market

Globally 70 new devices are connected to internet per second. The number will increase to 20,4 billion by 2020 when they were 8,4 billion in 2017.

The higher percentage (67%) of IoT market is extended in Western Europe, North America and China. (7)

3 Smart Home: Architecture, Technologies and Systems

End-user's reality can be beneficiary after organize home devices to function via Internet and specially with IoT system. By building a house holistically based on IoT technology we convert it to smart home. Examples of smart technology are devices that have the ability to regulate rooms temperature and humidity, to operate lighting automatically and all of them to be operated remotely. Providing residents with innovative solutions not only save money, time, energy but after generalizing this technology to whole buildings and furthermore to whole cities we save our planet.

A number of smart home definitions are presented here and the same time the basic structure of a smart home besides to some systems-technologies that can be installed is the content of this chapter. As a conclusion the attempt to expand smart home philosophy to whole neighborhoods and cities multiply the benefits.

3.1 Smart home definition

Although existing great numbered synonyms for smart home, as smart house, automated house, automated domestique, intelligent house etc the general meaning is the same. Specific technologies have to be applied in the whole house, which by computing and regulations the area the user wish it can be controlled either in place or remotely.

R. Lutolf gave the first definition of smart home "A unique communication system that incorporates different services inside a home create the smart home. It offers the possibility to operate it with comfort, it is secure and economic, and its functionality is flexible and smart." (1)

This definition doesn't refer to intelligence, but mostly to home automation.

A second definition by A. Berlo focuses on automation and intelligence:

“A home or working environment that by proper technology could be controlled automatically via devices and systems may be named smart home”. This definition of smart home implies that automation turns out of residential intelligent systems. Another definition by Winkler aim to elderly people independence: “Smart is a home that is capable to adapt its functions so as to be suitable for elderly people to live on their own”. Of course, a smart house will be capable to change according to the resident’s needs. (2)
(3)

Another definition by Briere and Hurley indicates that smart homes providing capabilities to the users of local networking with the combination of internet connected devices they offer high harmony. (4)

Holistic definition of smart homes points out the use of local communication network via which the most electrical devices and services are connected. In this network not only, local control is possible but also remote control. Additionally, monitoring and access both ways are efficient.

Three necessary points are indicative to characterize a home smart:

- local communication network incorporating electrical devices and services
- monitor and control system for interacting and managing the interconnected devices and services
- automation system to allow the interconnected devices and services to be regulated automatically and remotely

The smart home definition has two aspects:

- either the weight is on in-home smart systems
- or the weight is on the ability to access these systems remotely.

Our last definition but most proper to describe the idea of a smart home is by L. Sathpathy “In a smart home the assistance of technology must help residents to feel comfortable continuously and the same time to be independent. Inside this house all devices, mechanical, electrical, digital, are connected between each other and form a network. Not only the devices are capable to communicate with each other, although the end-user can interfere so as to be able to live in an interactive environment. Sensors for air-conditioning, heating, ventilating, electrical ovens, lightening are interconnected. (5)

Contemporary tendency for smart home’s research is the application of ubiquitous computing. That offers to user’s home automations or remote-control services as far as to assist them with ambient intelligence.

In smart home’s services a crucial part is consumption of smart energy network. It supports the comprehension of the capabilities offered by the power grid. All that happens in real-time and there is an interactive response between the power grid and users.

Intelligent and interactive use of electricity improves the energy efficiency and make us realize how important this may be to the end-user.

In a smart home computer technology, control technology, image display technology and communication technology are connected to the network, use IoT platform, to facilitate resident’s life. It is offered a convenient control and management of the entire system and all the automations required.

We aim here to analyze smart home’s characteristics so as to indicate its compositions and its applications. Also, we clarify the way electricity service systems and communication systems are designed.

3.2 Architecture

After the development of power fiber optic system interconnection through the smart intuitive terminals we accomplish home security data as smoke identification, gas release recognition, robbery threats. All kind of helpful apparatuses are in family's service for vitality control and monetary activity.

Internet connected mobile phones with correspondence to indoor-network accumulate data of water meters, gas meters, etc.

Figure 3 demonstrates the structure of a smart home.

Smart home services and subsystems can be supplied with data from interactive applications or website intuitive site. Collected data can be adopted to others as energy consumption, newspapers or cable TV subscriptions, utilities payments and create a holistic smart home system.

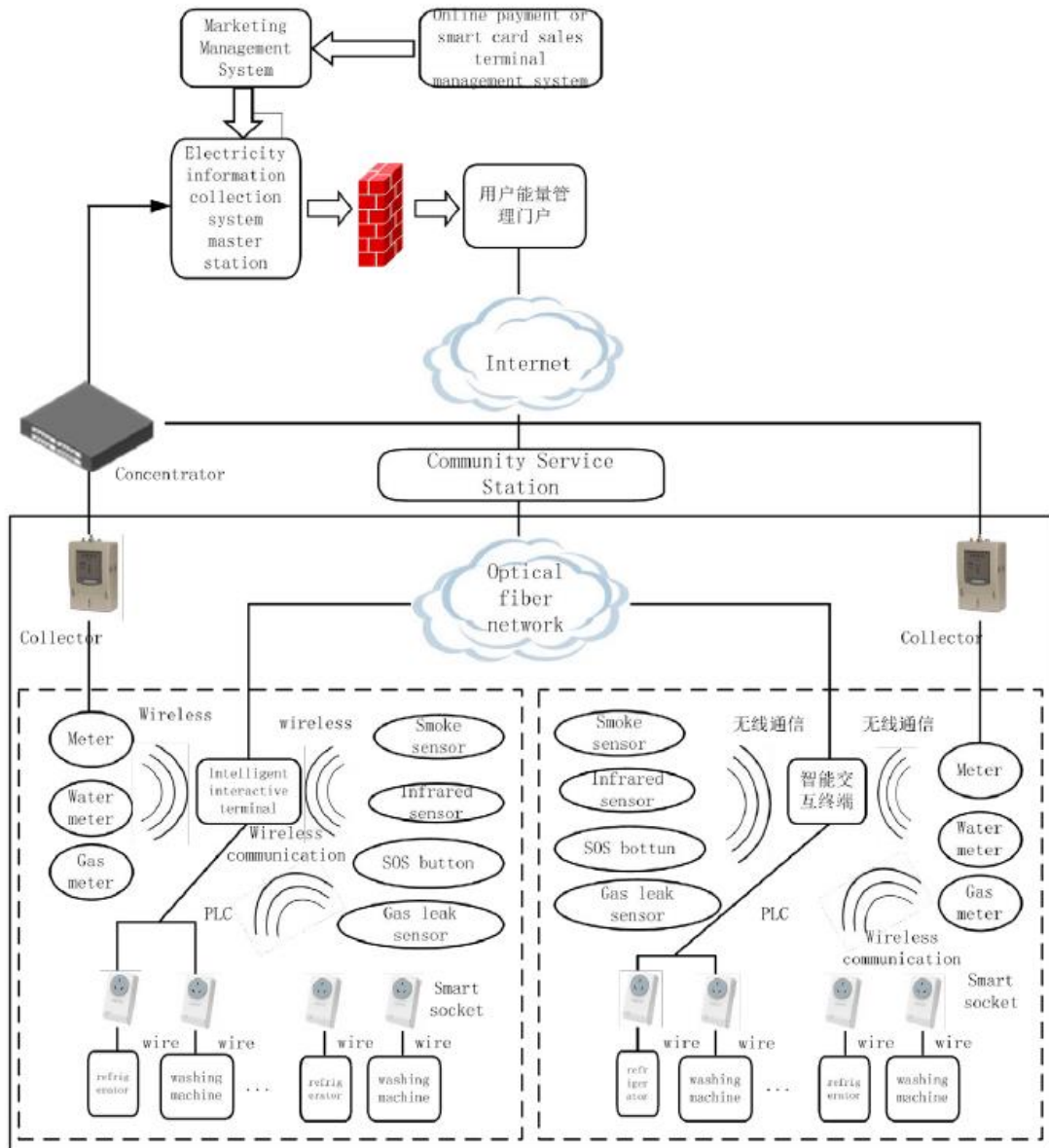


Figure 3: Smart home architecture (1)

Through the service interactive application or website intuitive site to accomplish adaptable data on family energy consumption data, electrical devices remote control, utilities payments, newspapers or cable TV subscriptions, can feed other smart home services and subsystems.

3.3 Technologies

In this paragraph we will be presenting some dominant smart home technologies.

3.3.1 Power information service

The service must operate through the network and keep information. Requests for real-time electricity price, electricity policy, electricity service, user electricity consumption, remaining electricity balance and electricity purchase are information that can be given to relevant questions. (14)

3.3.2 Home appliances interactive control

The analysis of household's electricity loads develops an electricity program that with automatic, intelligent, interactive appliances users are led to rational operation of electricity. (15)

3.3.3 Household electricity management

By having information for a variety of electricity prices (real-time price, time-of-use price) and by examining household's habits as far as it concerns the electrical appliances, we can provide the users with energy-saving proposals. The analysis of voltage, current, load curve, total time of access in electric appliances can create a tailor-made electricity program for each household. (16)

3.3.4 Self-service payment service.

A variety of payments could be chosen. As there is the possibility to pay with telephone, SIMS, website or self-service terminals and other means.

3.4 Smart Home Power Service System

Electricity service system is a platform for monitoring, analyzing and controlling the consumption of electricity in a smart home. Users in a residence like that it is important to know the energy efficiency of electricity management and intelligent service. [9].

Fig 2 shows the structure of the smart home power service system.

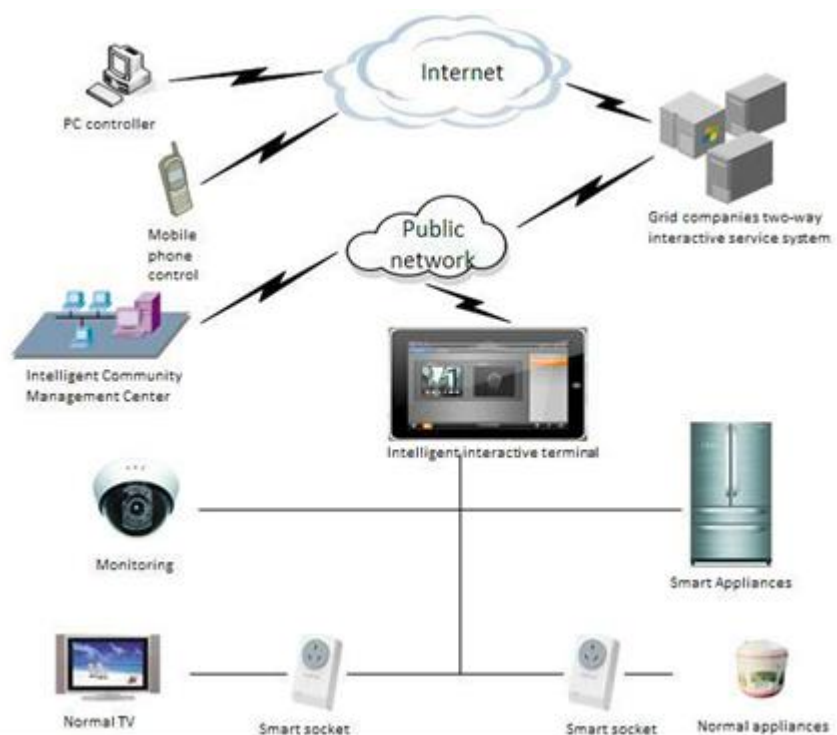


Figure 4: Smart home power service system structure (13)

A smart home electricity service system can mainly consist of main processing unit, a communication network, a user interactive unit and of internet connected electrical appliances. The electrical appliances can communicate with each other as well as with the main processing unit in order to transmit energy consumption data and in order to be able to be switched on or off remotely or locally by the user or automatically upon execution of pre-embedded scenarios by the central processing unit. As far as the communication network is concerned, it can be divided to two levels: a local one in order to establish local communication between a smart home smart device and a global one in order to establish communication with the Internet so that the smart home power service system can interact over the web.

In more detail, we can identify four main system parts:

- The main system consists of database server, application server, front-end machine, router, security equipment and so on.
- The communication channel is separated into long-distance communication network and local communication network. Remote communication using public network communications, local communications network selection of optical fiber composite cable, power line broadband communications, wireless communications.
- Home Intelligent Interactive Terminal is the core part of the smart home system, is the main station and user contact center, is also a smart electrical equipment control center.
- Intelligent electrical equipment includes smart appliances, security equipment and so on. At present, due to the lack of popularization of smart appliances, in order to satisfy the control of non-smart appliances and the collection of electric information, intelligent outlets may be used to control the home appliances or to collect the household appliances.

3.5 Smart home fundamental equipment

In this chapter we are presenting some fundamental smart home equipment. (17)

3.5.1 System master

The main system includes servers, communication networks, workstations and internal interconnection with the marketing system. Marketing applications, service interactive websites and other applications interconnection mainly through the interface server, security equipment and other equipment to complete.

3.5.2 Family intelligent interactive terminal

The home intelligent interactive terminal is installed in a position convenient for users to operate and establish communication and interaction with a smart socket, a smart home appliance and a home security device.

3.5.3 Smart electrical equipment

They are various smart electrical appliances that can be installed in a smart home. The main necessities for such devices are to be able to communicate in order to change their state via a communication channel.

Smart sockets can be used to convert compatible electrical appliances to smart ones. Smart sockets are installed between a power outlet and a conventional electrical appliance in order to feed them with power. Moreover, smart sockets can communicate with a smart home master unit in order to be remotely managed and in order to transmit power consumption data to the master unit.

Smart appliances, such as smart TVs, smart air conditioners, smart washing machines, smart fridges etc, have already been released for commercial purposes. These appliances incorporate a two-way interaction feature in order to both transmit data to a master unit and receive commands from the same unit in order to change their state (on and off).

Smart home security systems can be installed for a home's habitants to be able to monitor their home remotely. Some characteristic smart home security equipment consists of smart motion sensors, smoke sensors, gas leak sensors, surveillance cameras etc. The smart home security system is totally interactive with users since it feeds users with data regarding a home's safety parameters and it can be fed with data from users, for example to turn the lights on in case of a security breach. Furthermore, such systems can be programmed in order to execute automatic scenarios, for example they can notify the user about a gas leak alarm, switch the central gas supply off and notify the fire brigade automatically.

3.5.3.1 Smart sockets

The majority of smart homes are going to result from existing homes. Moreover, investing in a total replacement of conventional electrical appliances with new smart ones may be inexpedient, since users can enjoy the same advantages by turning older appliances to smart ones via smart sockets.

A smart socket can collect real-time data with high accuracy, such as electrical consumption, and it can also receive data via a local communication network. Moreover, a smart socket can interrupt the power to a conventional device, turning it off, or the opposite.

The main smart socket functions include the following:

- power consumption measurement display
- on-off control
- transmitting control commands to old electrical appliances

Users can establish a smart energy management system at low cost, since they can be able to manage energy consumed and execute predefined scenarios via smart sockets and a central processing unit:

Collect the real-time value of voltage, current, power and power factor of home appliance and save it and upload the required data; intelligent socket on the appliance through the power control, to achieve the purpose of energy saving.

The smart socket can be controlled by the intelligent interactive terminal, collection host, network client, mobile phone and other media, and then the switch of the household appliance can be controlled by the smart socket.

In case smart sockets are used complementarily in a smart home incorporating smart devices, they can operate in the following way:

Comes with short-range wireless communication module and smart socket (using the matching wireless communication module) used in conjunction with the realization of the following functions:

Collect the real-time value of voltage, current, power and power factor of home appliance and save it, and upload the required data;

Intelligent socket on the appliance through the power control, to achieve the purpose of energy saving;

Control commands initiated by the intelligent interactive terminal are transparently transmitted to the home appliance through the wireless module of the smart socket, and are used for starting, adjusting and controlling home appliances.

The smart socket can be controlled by the intelligent interactive terminal, collection host, network client, mobile phone and other media, and then the switch of the household appliance can be controlled by the smart socket.

Integrated network appliance mode

All functions of the smart socket fully integrated into smart appliances, to achieve direct control of the terminal smart appliances. The specific functions are as follows:

It can not only collect the real-time value such as voltage, current and power of home appliances, but also switch on and off the home appliances, and can start, adjust and control home appliances to complete all the functions of non-smart appliances and network appliances and achieve the maximum Intelligence. In order to increase adoption, priority should be given to PLC communication, cost savings, and stable and reliable in the home.

3.5.3.2 Grid-friendly electrical appliances

Grid-Friendly Appliances (GFAs) mainly use embedded technology to automatically disconnect the electrical network from the power grid when the frequency signal of the power grid is detected below a pre-set threshold by tracking the AC voltage or frequency signal of the grid in real time. When many GFAs perform this function, it helps to protect the grid and prevent grid oscillations.

It is foreseeable that GFAs will respond to voltage or frequency signals as well as price signals and demand-side management signals.

Grid-friendly electrical appliances functions

The GFAs corresponding to a small electronic control platform, which calculates the AC fundamental frequency of the grid voltage signal, to prevent distortion of the output signal and grid frequency oscillation.

Grid-friendly electrical appliances Response time

The response time of GFAs needs to consider the frequency measurement mode and should consider the influence of the low-pass digital filter.

Grid-friendly electrical appliances signal output

The output of GFAs is a binary signal used to control the delay switch.

Grid-friendly electrical appliances main components

Load Control Module - Monitor GFAs.

- Home gateway - wirelessly communicates with the load control module and forwards the signal to the backend server over a broadband cable modem or ADSL connection.
- Background Server - receives data periodically from each home gateway.

3.5.3.3 7. Smart Home Communication System

In this paragraph we are analyzing the architecture of a smart home communication system.

A smart home communication system can be divided into external network, gateway and internal network 3 parts.

External network can be a cell LAN, cable television networks, telephone networks and the Internet, mostly using more mature technology. Intranet is used to interconnect the various household appliances within the family, equipment, LAN, due to the vast diversity of connected devices, the network also showed a great diversity of forms.

Home networks are largely divided into three categories according to their functions: a control network for controlling functions, a data network for exchanging data messages, and a multimedia network for transmitting audio and video.

The home gateway is a network connecting device that connects the home intranet and the extranet and accesses the intranet to the extranet to provide the extranet with the control function of interconnecting devices in the home.

At the same time, the home gateway allows the home to adopt different networking technologies and utilize Gateways provide bridging capabilities for different communication subnets so that networked devices within each subnet can communicate with each other.

- Home Appliances Network: Home appliances (refrigerators, air conditioners, TVs, microwave ovens, washing machines, lighting, etc.) make up networks through wired or wireless connections to exchange information.
- Security: Including the surrounding area protection, home video intercom, access control, burglar alarm, fire, gas leaks, water spills, etc.).
- High-speed access to information: Internet, video phones, cell LAN access to the home through the gateway.
- Residential Services: Community Management Center can monitor and manage equipment and environment in its jurisdiction.

The main consideration of smart home system is the home internal communication network, which mainly includes two parts: smart home gateway and home smart sensor node. Smart Home Gateway is a family resource management and configuration center to complete the home networking and node control and other functions.

The gateway of the smart home connects each sensor switch node in the home network through the networking technology, realizes the management and control of the internal network of the smart home through the standard communication protocol, and serves as the interactive interface of the information of the home network and the external network.

Intelligent home can achieve a variety of functions, such as: home monitoring, internal and external information exchange, energy management, home security, scene settings are inseparable from the smart home gateway support, many of the features are based on smart home gateway and achieved.

The IoT Network model should be compatible with the smart home system, which is a kind of a central control system based on a central processing unit which has access and control over all electrical appliances and services, such as security, and communicates with the web.

A smart home communication network will be utilized to control the smart home system via data acquisition, using a command control module and TCP/IP protocol module to connect the smart home system to the Internet. Such a network can be separated in three types:

- telephone remote control
- network remote control
- on-site operation

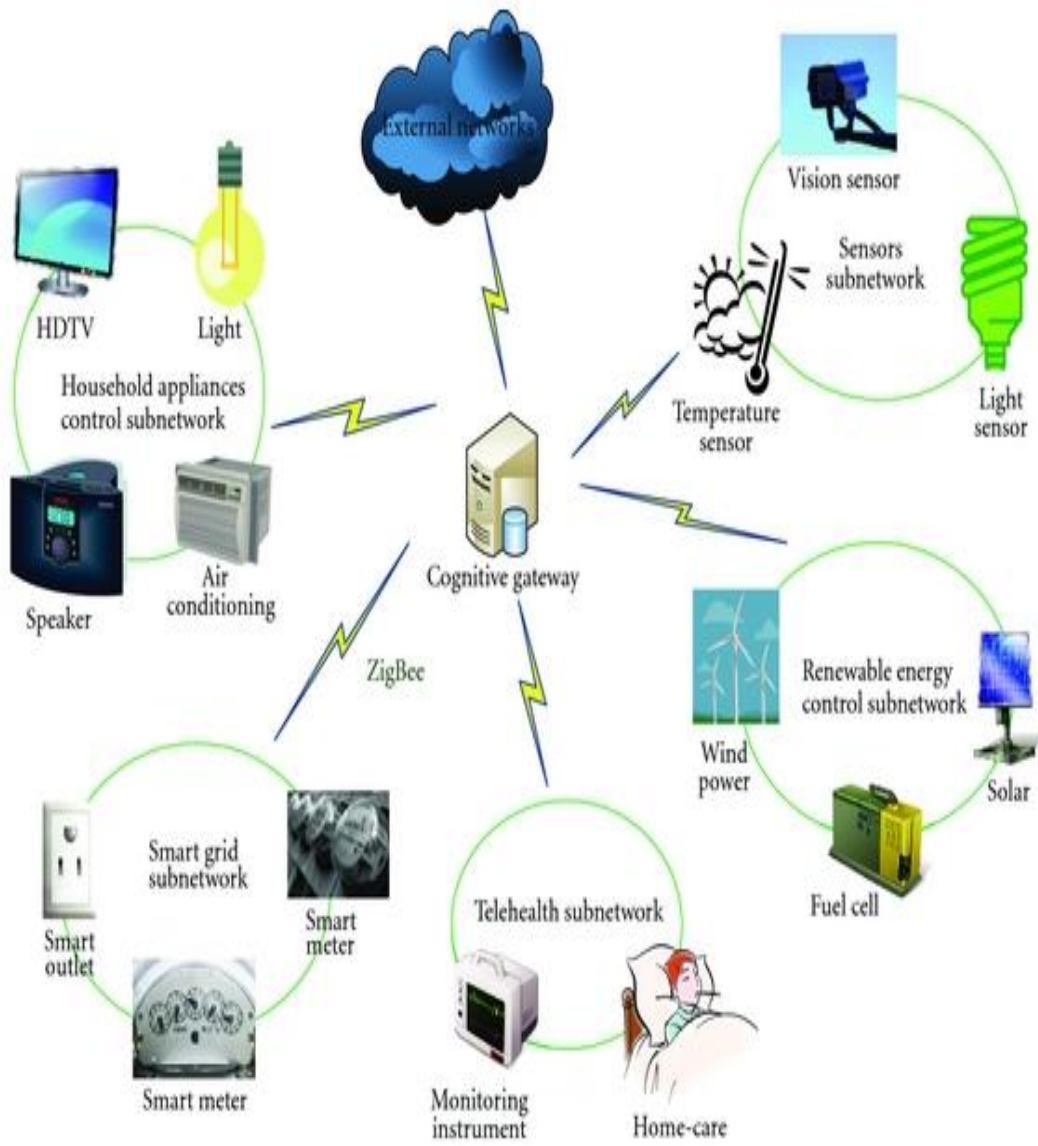


Figure 5: Smart home devices network (15)

3.6 Smart neighbourhoods

When IoT applications are incorporated to a neighborhood's structure and the houses that consist this neighborhood are smart then the neighborhood is considered smart. A typical framework for a smart and green neighborhood is presented in figure 6.



Figure 6: A typical smart neighbourhood framework (16)

3.6.1 Technologies

By increasing the knowledge of IoT technology to the general population and be awarded people of its use. Applications of smart neighborhoods are similar to smart homes only in higher scale.

Next paragraph includes some informatics according to smart services we can apply so as to create smart neighborhoods.

3.6.2 Residential property security services.

With remote monitoring and sensors for smoke or gas, or other alarm signals we can achieve a total management of security services. When an unexpected situation take place through smart systems an emergency call can done. The relevant emergency department will be notified for help.

3.6.3 Utilities Information Services (municipal, medical)

Utilities information Services (municipal, medical) With smart applications citizens is possible to have access to municipal information, construction information, traffic information, health information. Smart systems according to users' needs could provide medical services, online consulting and appointments with for distance medical staff. The establishment of smart systems is crucial special for residents of remoted regions. (16)

3.6.4 Business information services (information customization, information interaction, news subscription services, etc.)

Smart systems can identify users' needs and provide with specific real-time information, as weather, stock, foreign exchange, product can session or booking products. Besides interactive distribution of supermarkets is offered.

3.7 Technologies and Systems

A typical smart-home electricity service system topology is depicted in Figure 7.

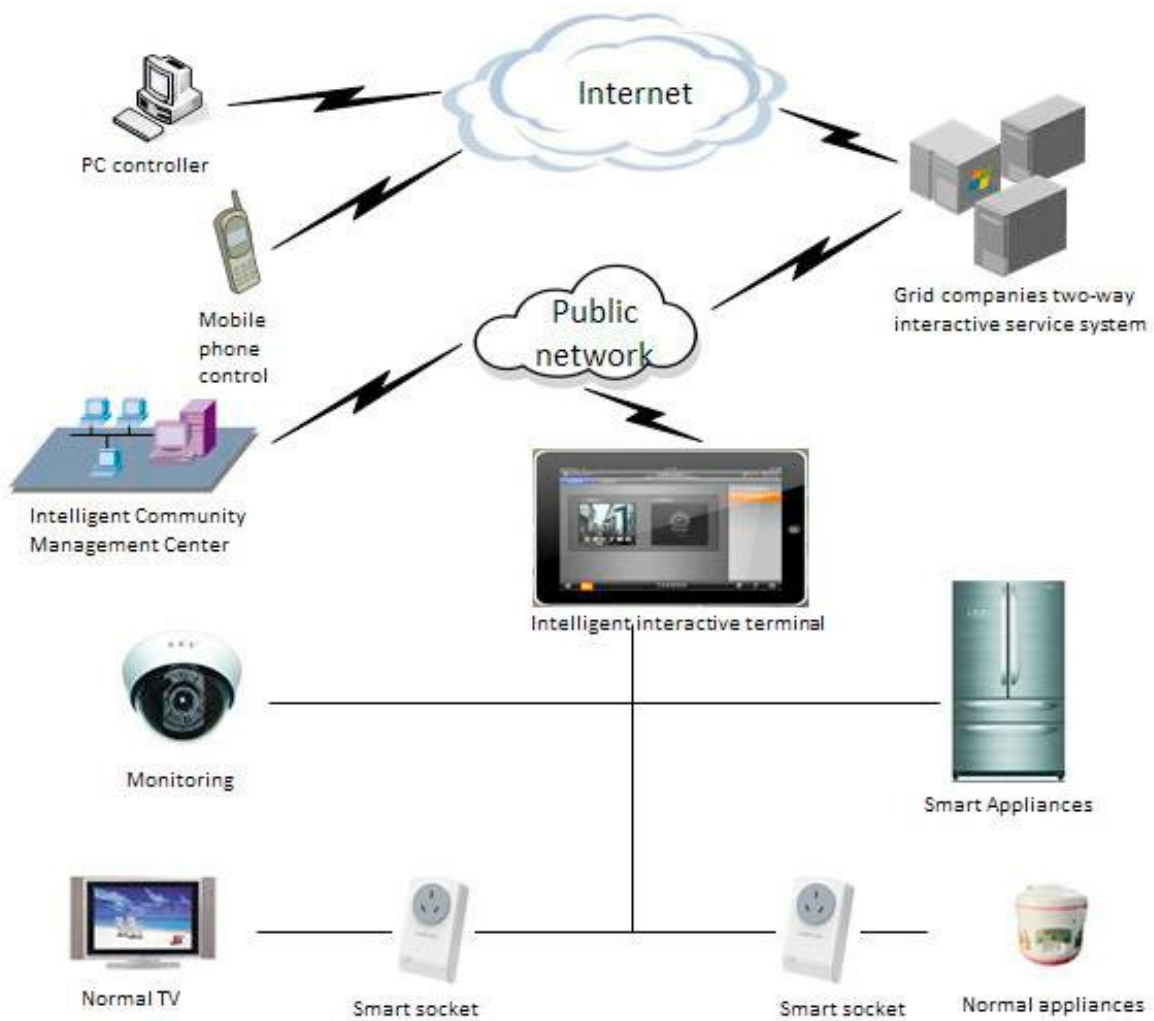


Figure 7: A typical smart-home electricity service system topology (13)

3.8 Supporting end-users to control their smart house

Convenience and effective management of users is an aspect that researchers in the field of Artificial Intelligence must take into consideration. The careful design of applications and tools in a smart home have to offer to smart home users' advantages of them and not create additional problems.

Smart home solutions may have major or minor advantages and disadvantages and the variety of them render the decision of choosing the most suitable for each home difficult. The evaluation of tools most beneficiary, appropriate and easier to be used from each family would be desired by an interactive mechanism that its assessments after taking care to gather all parameters should be a mixture of devices to create a customized program different needs vary according to environment they live as well as their personal characteristics.

In the following, paragraphs are examined the most suitable tools that with a mixture of them we could have an optimized smart home. Designers after evaluating the findings could proceed to further improvement of smart homes management.

3.8.1 Designing tools for smart homes

All tools began to be designed to fit a single user in a smart home, but finally they are adopted from whole families. The fact that they ended to cover more people needs is a person living in the same house. (14)

Promotion of designing methods that cover multi-users needs of smart homes it is a way to resolve the above-mentioned issues. Collaborative activities that take place in a house between family members will be served better with multi-users tools. Such an approach will play a critical role to smart technology.

The guidelines that researchers and designers of smart tools may have, lead them to better results. As a conclusion product that follow are improved and more beneficiary. Although, there are also sufficiently generalized in order to be used for management and control of smart houses. (14)

The guidelines that researchers and designers of smart tools may have, lead them to better results. As a conclusion product that follow are improved and more beneficiary. Although, there are also sufficiently generalized in order to be used for management and control of smart houses.

The fundamental principles to control smart home systems easily and efficiently are:

- Adaptation to one's own needs
- Integration with the rest home
- Easy management for seasonal programs
- Periodic change of programs
- Selection of absolute programs
- Availability of multimodal connections and machine learning features
- Possibility to change according to users' roles

Additionally, during designing smart tools must be taken into consideration the need of debugging, privacy and security matters and lack of programming experience for end-users. The same time need of controlling is important for smart home's users. That means that designed tools should be easily understood from users' skills and the access policy.

The restrictions on access to some parts of the technology to children for example must be properly defined. The need of adequate rules but the importance of avoiding too much constraints on the other hand is specification we can't forget. It is useful to exist a mechanism that creates group of rules about usage, the availability of predefined system configurations and context-aware recommendations.

End-users without programming experience with IoT applications have possibility to control their environment and create rules about it. They can decide how complex it may be. After examining customers' demands, designers and researchers can direct their efforts to domains that their importance is crucial for users.

Finally, there is a study of Do-it-Yourself (DIY) practice in smart homes. There are proposed interesting implications which can be tinkered with by inhabitants. (22)

3.8.2 Identification of smart home tools

According to literature review, the following tools are in compliance with the Davidoff research paper proposed guidelines, in terms of supporting end users to manage their smart home.

Table 1: Smart home tools in accordance with the Davidoff design principles (14)

Smart home tool	Corresponding description
Atooma -A Touch Of Magic¹	A free Italian mobile application which allows end users to define new behaviors by creating rules, according to the E.C.A. paradigm, which can incorporate up to five conditions and five actions. It can be combined with other mobile applications, web services and devices. Developers can use the provided Software Developer Kit (SDK) to produce add-ons.

¹ <http://support.atooma.com>

Smart home tool

Corresponding description

Bip.io²

A web-based automation framework that takes advantage of the graph metaphor for wiring web services denoted as nodes. When nodes relate to arrows, supporting processes guide users to describe actions and actions characteristics. This framework is open for software developers to possibly build new extensions.

A mobile application which provides users with the ability to define sensor-based context-aware guidelines according to the E.C.A. paradigm. It is built on the programming by demonstration method, so as to facilitate users' testing their created guidelines, since they develop them on their own.

GALLAG Strip³

(15)

Various GALLAG compatible sensors and other compatible mobile devices can be installed by software developers for them to be utilized by end users to create new guidelines.

A free web and mobile application that allows creating "if-then" rules combining social networks, web services, and smart things. It presents a good integration with any kind of web service. The user can define for each rule only one condition and only one action. Internet connection is needed to define and run rules.

IFTTT – if this then that⁴

² <https://github.com/bipio-server/bipio>

³ <http://gallag.wikispaces.asu.edu/>

⁴ <https://ifttt.com/>

Smart home tool

Corresponding description

itDuzzit⁵

A web cloud platform with a rule composition paradigm very similar to IFTTT that lets users build their own custom integration solutions (called “duzzits”). A duzzit can be deployed as an online form, a job, a web service, an email drop box, or a widget. Pre-built duzzits available in the Duzzit Library can be modified through the Duzzit Editor.

Locale⁶

An Android application for the automated management of a mobile device. The user can define rules according to the ECA paradigm, but they may include conditions and actions only related to mobile features (the position and orientation of the smartphone, the date and time, the remaining battery power, etc.). It can be extended through external plug-ins to permit integration with web services and other devices connected to the Internet.

Ninjablocks⁷

A cloud-based platform consisting of a physical sphere (“Ninja sphere”) able to interact with a variety of sensors and actuators, and compatible with other services, such as SMS, email, and Arduino. It implements the ECA paradigm, and the users can choose triggers and actions among limited sets; but a rule can consist of any combination of any of those triggers and actions. Developers may exploit the SDK to extend system functionalities.

Tasker⁸

An application for Android that supports the creation of rules with multiple conditions and multiple

⁵ <https://developer.intuit.com/itduzzit>

⁶ <http://www.twofortyfouram.com/>

⁷ <https://ninjablocks.com/>

⁸ <http://tasker.dinglich.net/>

Smart home tool

Corresponding description

actions. It allows composing apps and functions available on mobile devices. It makes available more than 200 actions and it is well integrated with many web services and smart devices through specific plug-ins.

Twine⁹

A physical smart object including standard accelerometers, thermometers, and other sensors, which can be programmed to alert the user in case of problems. It is thought to be left anywhere in the house to collect data. Additional sensors detect floods, leaks, opened doors, and signals from other home systems. “If-then” rules, to control and manage the sensors, can be defined or modified through a web application.

WigWag¹⁰

An open source platform, including a mobile application and a web-based interface, that allows users to monitor and configure devices in a smart home. Users can create “if-then” rules that control the connected devices in a home or office, whether they are right there or far from these places.

We Wired Web¹¹

An integration-as-a-service web application that supports rule creation. Users can create rules via a Web page, in which multiple triggers and actions composing an “if-then” rule can be selected. End users can also define simple and automatic execution flows. Software developers may extend the

⁹ <http://supermechanical.com/twine/>

¹⁰ <http://www.wigwag.com/>

¹¹ <http://wewiredweb.com/>

Smart home tool

Corresponding description

application by adding new web services, triggers, and actions via wiring diagrams.

**Zipato Home
Management¹²**

A web-based application for a complete home control and automation. It requires its own gateway, called Zipabox, to which many different sensors and actuators can be connected, but they must be compliant with Zipato communication protocol. Users may create “if-then” rules through Zipazle, a visual environment that provides typical programming language constructs (e.g., if, while, logical operators).

3.8.3 Literature review on tools for smart homes

A typical smart device which is used as a smart home automation hub, which is gaining more enthusiasts is the amazon Alexa personal assistant, which is depicted below in Figure 8. This device facilitates the control and management of other smart devices installed in a smart home as well as it enables end users’ communication with services outside the smart home. For instance, it can be used to switch on and off electrical appliances as well as to place an order for food delivery.

¹² <http://zipato.com/>



Figure 8: The Amazon Alexa smart home personal assistant

3.9 A Framework for Personalized User Interfaces

Despite the enormous expansion of IoT, smart homes and smart buildings, as well as the upcoming tension to build smart cities, the existence of the technological basis for such applications and the increased awareness about the potential benefits, in fact there is substantial lagging between the reached reality and the expectations behind IoT. The main reason is that the adoption of these technologies has not been widely enough adopted.

According to literature review, there are a couple of serious reasons for the semi complete adoption.

Firstly, the focus of the research community has been rather on what is technologically possible than on what the real user needs are. In addition, research has neglected the topic of appropriate user interfaces. Since the user group of future smart homes will reflect the full range of our society, there is a need for personalized user interfaces that take the individual user requirements and preferences into account.

The second problem is the lack of interoperability between unlike smart home systems. The smart home market is now evolving and consequently it is quite difficult for a user to decide which tools and applications to choose.

Additionally, it is likely that a user gains the highest value by integrating different systems. Along with the problem of low compatibility between different systems comes the fact that devices and backend technologies overarching user interaction concepts are missing.

Due to the above-mentioned reasons, a framework is required, in order to address on the one hand the integration of different backend technologies, and on the other hand the provisioning of device overarching and personalized user interfaces. In order to realize such a system, the Eclipse Smart Home project (E.S.H) and the Universal Remote Console (U.R.C) have been picked for further investigation.

The URC framework was chosen because two of the authors are involved in the related development and standardization processes. ESH was selected, because just like the URC runtime implementation it follows the approach of a central gateway instead of relying on a distributed operating system, as some other IOT platforms do.

Other frameworks such as the AllJoyn framework, have their code located directly on the target devices. A similar architecture with a central gateway makes the integration of the two frameworks easier. Another argument for our choice was the open source nature of U.R.C and E.S.H. In addition, both projects are driven by communities instead of industry.

3.9.1 Requirements for personalized user interfaces

The need for abstract representations of physical devices can be illustrated by the following use cases:

- Frequently, elderly people are familiar with a specific device and have problems to adjust to a new one.

Since any device will sooner or later get broken (e.g., washing machine, HVAC system), it is beneficiary for people to keep their familiar user interface. In order to do so, a separation between the physical device and its abstract representation in the smart home system is required.

- Such a separation enables many other use cases, among them supporting users who became paraplegic by an accident. In such a case, the user and their family would want to stay in their familiar home instead of moving into a new home with special equipment. Rather than exchanging a device, just for the sake of an inaccessible user interface, it is more cost-effective and user-friendly to provide an alternative user interface only (e.g. exchange or supplement a touch-screen control panel with one supporting eye tracking).
- Usually, smart homes are inhabited by multiple people with different needs, e.g. people with disabilities or children who should be given limited access to certain functionalities. Having a common abstract layer, it is possible to connect different, personalized user interfaces to it at the same time.

However, sometimes not only exchangeable but also adaptive user interfaces are required. The adaptation of user interfaces can take place on different levels¹⁰. Some of them like adjusting contrast or font size, as well as taking the screen size into account or giving the user interface the look and feel of a native one of the rendering platforms, can easily be done by the controller device at runtime.

Hence this is out of the scope of our considerations. However, when user interfaces should be provided in different languages for people with disabilities or with icons for different cultural areas (U4), it is necessary to exchange some parts of the user interface content. In order to make these supplementary user interface components available to a

large user group and independent of location, a central repository for UI components is required.

Also, it is advantageous to give third parties the chance to provide their own solutions for a narrower user group (U5) (rare language, sign videos for deaf people or other Assistive Technology (AT) solutions). Such a repository should be open and extendable. Furthermore, third parties should be able to contribute on a very modular basis.

Finally, it is considered how the context of use, necessary for any user interface adaptation is handled by the systems.

4 Other Internet of Things applications

In the previous chapter we have analysed the basics about IoT applications to smart homes, with an eye for smart homes and buildings and their potential benefits to users. Moreover, we have presented a framework for users to personalize their smart home in order to augment the end users' experience. In this chapter, we are presenting some broader IoT applications which can be utilized in several fields, such as buildings.

Smart clothing

Chronic disease, such as Alzheimer, is turning to be global health problem. The World Health Organization (W.H.O.) has made significant attempts in the direction of improving chronic disease prevention and medication. The W.H.O. has also played a critical role in creating synergies and networking in its member states, aiming to promote the development of suitable policies, networks and projects regarding the prevention and the optimized management of chronic diseases. (15)

Nevertheless, the above-mentioned actions have not been broadly adopted because of, mainly, cost related issues. Moreover, the need for healthcare is increasing due to the globally aging population, therefore a potential way to manage cost is to provide patients with monitoring at home. Obviously, tackling the challenges in the healthcare sector being expanded to patients' homes is rather complicated. (16)

A few useful functions in the direction of providing healthcare monitoring in home could include the ability to monitor patients' physical indicators in cases of chronic diseases or in rehabilitation periods, for instance after surgery, the ability to manage chronic diseases remotely and the ability to provide first level medical services. (17)

Some major methods that could be followed are the following:

- Medical office-based administrations. Human services frameworks are sent in therapeutic and wellbeing organizations or nursing foundations, where wellbeing pointers for senior individuals are consequently observed. This piece of remaining task at hand on specialists and medical caretakers could ordinarily be overwhelming.
- Personalized wellbeing administrations. It isn't sufficient that a checking framework work just for ailment avoidance and hazard expectation for patients with incessant diseases. Redone social insurance administrations are likewise extremely accommodating, particularly for rehabilitation care and restorative consideration when clients are portable. They will likely give physiological information securing, wellbeing investigation, and ceaseless meeting anytime and anyplace. This social insurance benefit successfully directs sub-solid individuals to change their way of life, control hazard factors, advance physical exercises, and notwithstanding acknowledging self-wellbeing the board these days.
- Rehabilitative restorative helper. Rehabilitative restorative helper can abbreviate the time patients' requirement for recovery and move conventional recovery from healing facilities to house-hold restoration observing. In this manner, the money related weight of patients can be eased, and the turnover rate of sickbeds in clinics can be moved forward. The benefit model of healing facilities can likewise be overhauled. A of services and products have been released in the past few years in order to meet the above-mentioned needs. The common element between such products is that they aim to provide real-time data about a patient's status. (18)

To make the real-time data collection possible, researches are companies are tending to wearable devices, which incorporate a number of sensors. Apart from sensors located on wearables, there has been a new turn to implantable sensors which connect to the internet via a wearable smart device.

These sensors can measure physiological indicators in detail, such as heart rate, oxygen saturation, blood pressure, body temperature etc. Yet, such devices may be expensive or inconvenient for some end users.

A relevant product, under research, is the LiveNet launched by The Media Laboratory of M.I.T. In comparison to more flexible mobile platform, other long-term health nursing applications, incorporating with real-time information processing and streaming with framework classification, have been released. The most well-known include the MagIC and the Life- Guard. (19), (20), (21)

The evolution of Information Technology and Networking allow for better handling any challenge in the designing and utilization of smart clothing devices for medical purposes or even for athletes, where wearables gain a lot of ground lately. (22)

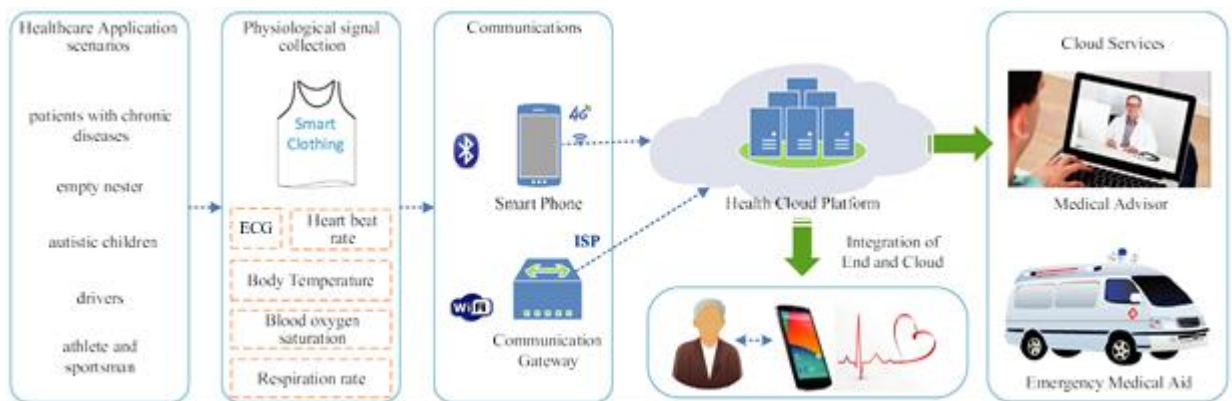


Figure 9: Sustainable physiological indicators data collection system structure (23)

A novel technique for sustainable collection of people’s vital signs, based on smart clothing, is proposed in a L. Hu et al. research paper. According to this paper, the proposed technique, which is abbreviated SVSC, is presented in Figure 9, where the data flow and process points are depicted.

In this proposed technique, users select one healthcare application scenario, for instance autistic children monitoring or patients with chronic diseases, and afterwards the smart clothing is utilized in order to collect their physiological signs. That data is then transmitted to a healthcare cloud storage via the Internet, where processing is taking place. Upon processing, users can receive personalized medical consultation.

This technique can be further evolved if Artificial Intelligence is applied. For instance, in physical rehabilitation training after heart strokes, bone fractures etc., the smart clothing can transmit all the rehabilitation training advice to a wearable Virtual Reality device, such as a pair of VR glasses. The wearable VR device can understand the patient's motions, analyze them and provide the patient with corrective advice.

Finally, VR wearable devices can display a patient's actions and vital signs changes in real-time. In this context, a patient can regulate the rehabilitation exercises to their own needs and capabilities, while the doctor who prescribed the training program can monitor patients better and provide better treatment. (24)

4.1.1 Smart energy and smart energy systems

An interesting application of IoT is smart energy systems.

As of late, the expressions "Smart Energy" and "Smart Energy Systems" have been utilized to express a methodology that achieves more extensive than the expression "Keen matrix".

Where Smart Grids centre basically around the power segment, Smart Energy Systems take an incorporated comprehensive spotlight on the consideration of more segments (power, warming, cooling, industry, structures and transportation) and takes into account the distinguishing proof of more feasible and reasonable answers for the change into future inexhaustible and economic vitality arrangements.

As indicated by writing audit, the term Smart Energy Systems with respect to the issues of definition, distinguishing proof of arrangements, demonstrating, and mix of capacity. The end is that the Smart Energy System idea speaks to a logical move in standards from single-part thinking to a rational-vitality framework comprehending on the best way to profit by the reconciliation everything being equal and foundations.

4.1.2 Smart metering

Under the concept of smart grids, smart metering can be applied to buildings of any scale, like smart homes or smart municipal buildings, in order to measure the consumption of electrical energy, gas or water usage.

As mentioned above, smart metering can be applied bidirectionally in cases of buildings with renewable energy systems installed. For example, smart metering can measure the amount of ingoing energy from the public grid towards the building as well as the amount of outgoing energy from the renewable energy system towards the public grid and the amount of renewable energy which is being produced and consumed simultaneously.

A possible extension of smart metering is to apply automatic payments for utilities, via an IoT system which will be able to communicate with a banking environment, in order to pay bills automatically.

As far as the smart water usage metering is concerned, the benefits for users are much more than just measuring. In cases of buildings where the water supply should meet firm criteria, smart metering can be used in order to control an automatic water sanitation system, in case the water provided is out of standards, as we can see in figure 10.

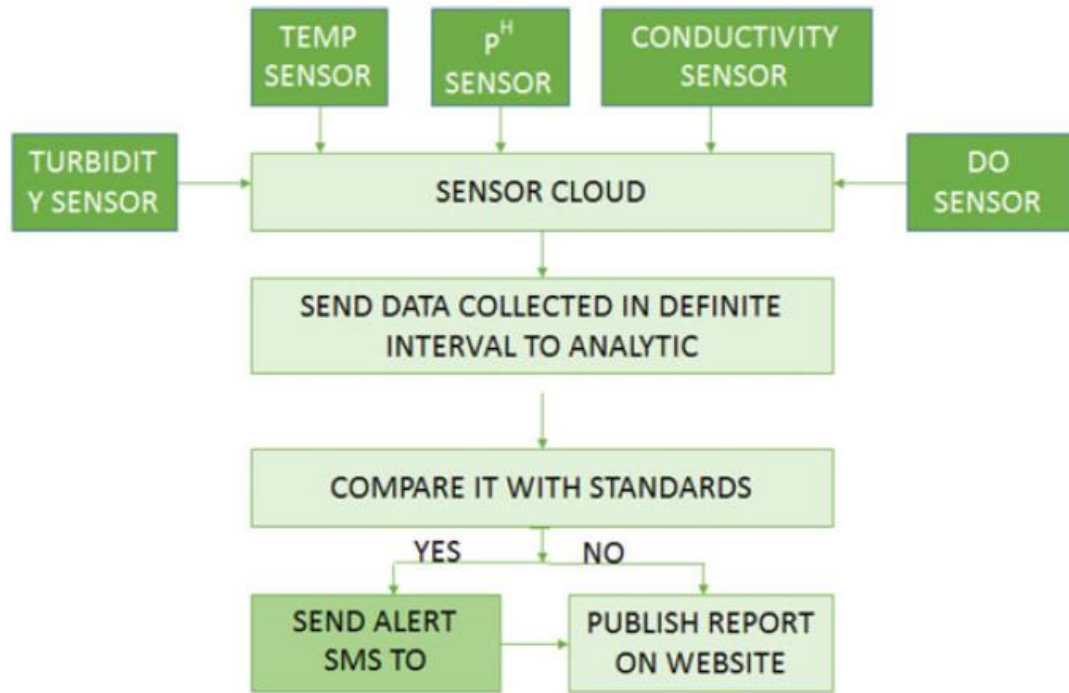


Figure 10: IoT smart metering system for water usage and quality (33)

4.1.3 Smart system for children's chronic illness monitoring

Ill kids require a ceaseless checking; however, this includes surprising expenses for the government and for the guardians.

The utilization of data and correspondence advancements (ICT) together with man-made consciousness and brilliant gadgets can lessen these costs, encourage the kids and help their folks. This paper introduces a brilliant design for children's incessant ailment observing that will let the (guardians, educators and specialists) to remotely screen the strength of the youngster's dependent on the sensors installed in the cell phones and savvy wearable gadgets.

The proposed design incorporates a savvy calculation developed to shrewdly distinguish if a parameter has surpassed a limit, accordingly it might infer a crisis or not. To check the right task of this framework, we have built up a little wearable gadget that can quantify the pulse and the body temperature.

We have planned a safe component to establish a Bluetooth association with the cell phone. Likewise, the framework can play out the information combination in both the data packetizing process, which adds to im-demonstrate the convention execution, and in the deliberate qualities blend, where it is utilized a stochastic methodology.

Therefore, our framework can combination information from various sensors progressively and identify consequently interesting circumstances for sending a notice to the guardians. At last, the expended transmission capacity and battery self-sufficiency of the developed gadget have been estimated.

4.1.4 Context-aware system to assist wheelchair users

The propagation of smartphones and tablets has promoted a extensive adoption of Mobile Computing. (34), (35)

Additionally, the use of devices for location acknowledgment, such as the GPS technology, has been stirred by an increased accuracy combined with a decrease in prices. Location determination systems have been embedded into mobile computers, allowing the development of Location based. (36), (37), (38), (39), (40)

Location coupled with time and other strategic information support Context-aware computing. In turn, the context awareness enables the development of Adaptive Computational Systems. (34), (42), (43)

We have located a proposed application, with context-aware characteristics, in order to assist people using wheelchairs.

We are going to describe the key elements of the proposed application architecture and hardware integration in order to build the smart wheelchair, while we will be analyzing the context awareness characteristics of the proposed system.

The proposed application and smart chair are named TrailCare. The TrailCare software architecture sits on four different layers:

- a server
- a client
- the appliance middleware
- the wheelchair firmware
-

The TrailCare Server utilizes web administrations to give openness assets in settings and to perform trails the board. The TrailCare Client is a versatile (application) that underpins the interface with clients, demonstrating setting mindful availability assets as indicated by their relocations.

Moreover, the application sends the area data (indoor and out-entryway) to the server for putting away the trails created by clients' displacements.

The open-air area is gotten by GPS. The indoor area is acquired by the application each time the wheelchair ignores a sticker on the floor. The sticker has RFID cards that are perused by the apparatus. The TrailCare Appliance runs an Arduino middleware with four main elements:

- communication with the app via Bluetooth
- reading RFID cards to operate in indoor environment
- communication with the wheelchair firmware software via RS-232 protocol
- proprietary firmware of the motorized smart wheelchair.

The latter layer incorporates a communication protocol based on UART/RS232 to exchange messages between the Arduino middleware and the motorized smart wheelchair.

In Figure 11Figure 12, we summarize the context-aware recommendation realized by the Accessibility Assistant.

The TrailCare Client sends the trail point (indoor or outdoor) to the Assistant which in turn registers this information in the Trail Management (step one). The Assistant uses the Profile System to obtain the users' preferences (step two).

After, it uses the Context System to identify the contextualized resources available in the region (step three). Finally, the Accessibility Assistant notifies the user about available resources in the region that are compatible with the profile (step four).

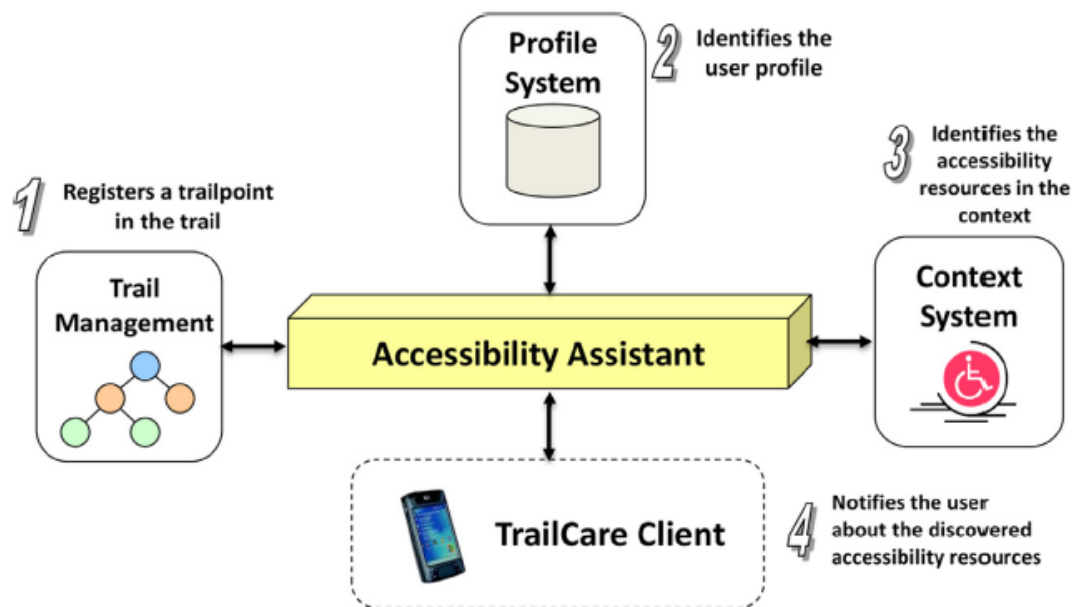


Figure 11: Context-aware system resources (44)

In Figure 12 we can see the overview of the smart wheelchair system integration.

The user interface is a mobile device running specific management software that monitors the outdoor location through GPS. In addition, this software uses the Internet access to communicate with a server so as to obtain contextualized accessibility resources and in order to manage to record trail information.

The appliance is a dedicated hardware embedded in the wheelchair that communicates with the mobile device. In addition, the appliance monitors the indoor location and communicates with the wheelchair hardware.

The motorized wheelchair is a Model S manufactured by the Brazilian company called Freedom with the addition of a mechanical support to hold the mobile device.

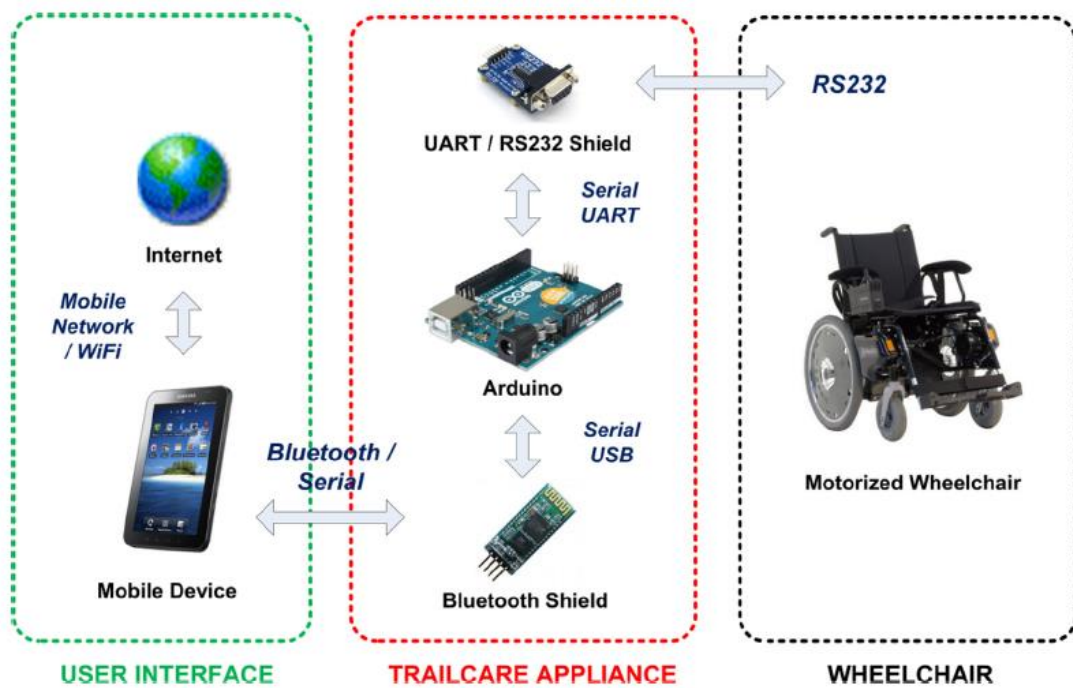


Figure 12: Architecture of the proposed context-aware system to assist wheelchairs (44)

The trail configuration, as we see in Figure 13, is a significant aspect of the prototype. All trails are stored on the server on demand, according to trail points uploaded to the application.

When outdoor, the application transmits location points on a fixed time interval. Currently, the app is using by default a time of approximately 20s, but this value can be configured and even automatically adapted according to the situation.

The indoor points are sent every time the wheelchair passes over a sticker. A relevant feature is the switching between sending indoor and outdoor points. By default, the system uses a specific sticker to indicate this switching in both directions. For instance, when the wheelchair is outdoor and passes over a sticker located in a building's, the indoor mode is turned on.

On the other hand, the outdoor mode is turned back on when the wheelchair is in an indoor environment and passes over the same entrance or exit sticker.

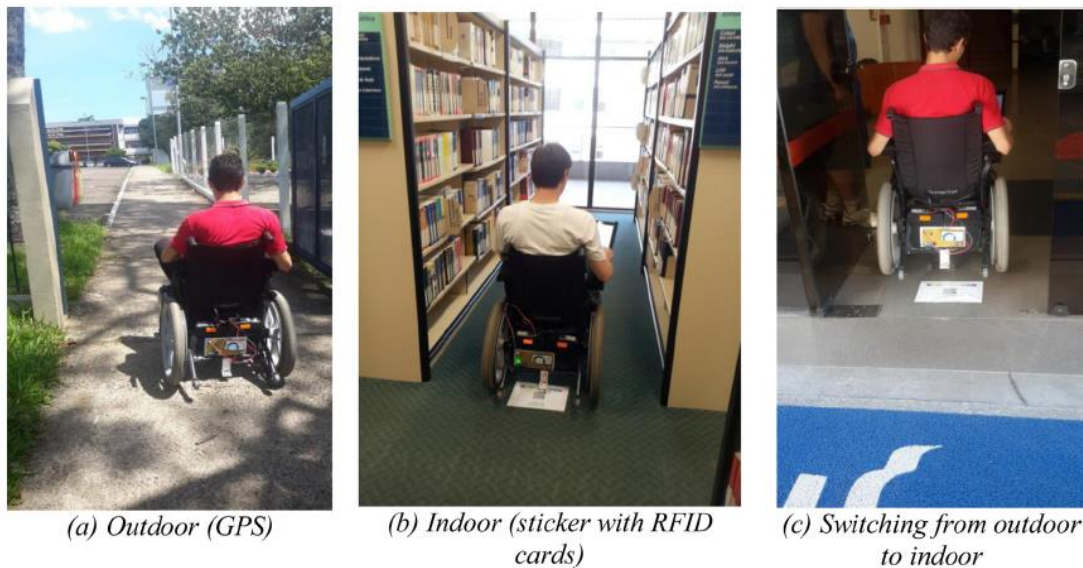


Figure 13: System operation in various environments (44)

4.1.5 Analyzing user location discovery methods in smart homes

The objective of a smart home is to create such an environment where the inhabitants can live in comfort with a minimum effort to maintain their preferred home environment.

In order to provide a variety of services to the inhabitants, smart homes need to process as much context as possible. The context is defined as the information that can be used to characterize the environment of an inhabitants.

Context information can include the location of humans and objects within the particular environment, inhabitant's action and behavior, for instance at what time the inhabitant is moving, interaction history between inhabitant and objects, etc. (45)

The smart home inhabitant's location is a critical factor and is most of the times the first step for context-aware service provisioning. An inhabitant's location information is required for many indoors applications such as home entertainment and automatic device control. (46), (47), (48), (49), (50), (51)

In addition, healthcare systems have recently attracted enormous attention worldwide in this field, and many localization methods have been proposed in this area for medical tele-monitoring. (52), (53)

Activity of Daily Life (ADL) measurements, elderly monitoring, and child monitoring. (52), (53), (54), (55), (56)

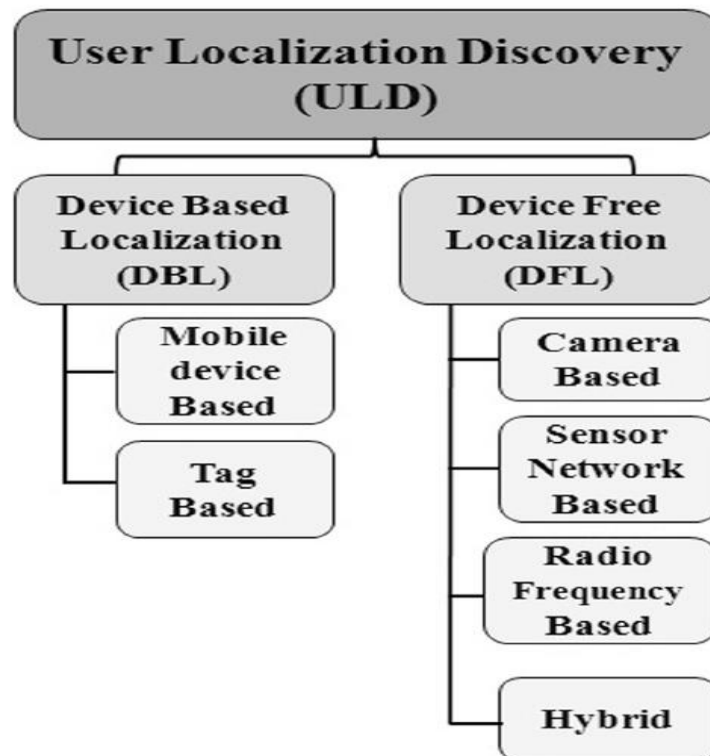


Figure 14: The proposed location discovery methodology

According to literature another scientific categorization with an expansive inclusion of ULD strategies is proposed as far as client fulfilment and specialized highlights. Also, we give a best in class study of ULD strategies and apply our scientific classification to delineate techniques. Mapping con-tributes to hole investigation for existing ULDs and furthermore approves the relevance and air conditioning curacy of the scientific classification. Utilizing this methodical methodology, the highlights and characteristics of the current ULD strategies are distinguished (i.e., hardware and calculations).

Next, the shortcomings and points of interest of these techniques are investigated using ten imperative assessment measurements. In spite of the fact that we chiefly centre around smart homes, the aftereffects of the proposed can be summed up to different spaces, for example, keen workplaces and eHealth conditions.

4.2 Expansion to smart cities

Apart from smart homes, the IoT technology can be applied in many fields such as industry, energy and even logistics. However, among the above mentioned fields, cities are expected to play the role of the global economy engines. Moving from conventional cities to smart cities via the IoT technology is expected to have multiple positive impact in three main aspects.

First of all, the public resources, in the urban context, allocation will be optimized in order to achieve maximum effectiveness and efficiency for citizens. Secondly, along will cities public resources being used more efficiently and more effectively, the city's operational costs are expected to be reduced signifiantly. Finally, apart from the economic benefits, the citizens' quality of living will eventually be improved, in correspondence with smart home end users' quality of living improvement due to smart homes. (32)

Moving to a smart cities era is critical, because cities actually play a significant role in global economy. Apart from the fact that, since the establishment of the first city, cities have been the core of civilization and more specifically, more than 50% of the globe's population lives in cities currently, while this percentage is expected to reach more than 70% by 2050. At the moment, more than 60% of the land planned to be utilized for urban purposes has not been utilized yet. (2)

Finally, it is worth noticing evidence that cities are at the field of major tech innovation. Twentytwo cities all over the world were ranked at the forefront of the global technology industry according to a 2017 report. (3)

5 Smart cities

As mentioned at the closure of chapter 3, expanding the idea of smart homes to a bigger scale, such as smart cities, is expected to generate significant profit, both for citizens and for governments.

In this chapter, we are presenting smart cities and the fundamental units that could compose a smart city: smart neighborhood.

5.1 Smart city definition

There are many definitions for smart cities. We provide with a characteristic below, while we are depicting the fundamental structure of a smart city in Figure 15:

“Smart cities are cities applying ICT (information and communication technologies) and other digital technologies in order to improve the citizens’ quality of life, the city infrastructures’ efficiency and the city competitiveness in a sustainable way, setting as a

first priority to meet all the citizens needs and with due respect to the enviroment and the city specific social economical status.” (16)



Figure 15: Smart city structure clustered in four major categories (16)

Smart cities are a compendium of smart solutions applied in various sectors of society.

The potential smart services in smart cities are listed below:

- Smart Mobility
- Smart Safety
- Smart energy, water and waste treatment
- Smart buildings and living
- Smart health
- Smart education
- Smart finance
- Smart tourism and leisure
- Smart retail and logistics
- Smart manufacturing and constructing
- Smart Governance

The ultimate goals of implementing IoT, in the context of a smart city, in any service or sector is to achieve sustainable economic growth, reducing cities' ecological footprint simultaneously, and to improve people's quality of living, offering them an augmented living experience.

Of course, challenges and barriers come along benefits. More specifically, the effective implementation of any of the above mentioned smart solutions, in the context of smart cities should overcome the following challenges.

The phenomena of job losses, since they were made obsolete, first occurred after the third industrial revolution, which was related to automation. Since smart cities are mainly based on automation, it is highly critical to avoid a potential labor market deregulation due to jobs cut down because of automation. Furthermore, the social cohesion should be reassured, by avoiding social exclusion of people unfamiliar with new technologies. Moreover, creating and preserving a secure environment for personal data transmitted over the WEB is prerequisite.

Finally, we are noticing a newborn competition between cities and metropolitan areas to lead in the smart city implementation. The latter is not a challenge to overcome, but an opportunity that will be generated via the further penetration of smart cities. (17)

Conclusively, we can state that a smart city is a complex system that consists of the following four functions:

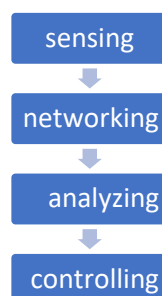


Figure 16: Fundamental smart city functions

5.2 Smart cities technologies and subsystems

As mentioned above, a smart city is a compendium of separate smart subsystems. Some key urban operations that can be transformed by the adoption of smart subsystems are listed in the paragraphs below.

The public transport can be improved by implementing smart solutions. Smart buses, trams, subways etc can be realised by installing a network of sensors on all moving vehicles in order to collect data. That data can be afterwards processed in central computing unit, most likely located in the public transport headquarters, and the processed data can be served to people as information in bus stops, for example, so that they can be aware of the next inbound vehicle as well estimated arrival times to designated destinations.

In the same context, that is mobility, there are some very innovative smart solutions which can be implemented such as smart vehicles, even autonomous ones, smart parking systems and smart traffic lights. These could facilitate drivers seeking a parking space in city centers and ultimately alleviate any congestion by giving green a green light to streets with more moving cars. For these to be applied, a vast network of sensors on vehicles, cross sections and parking spots should be installed in order to collect and transmit data for processing and, with respect to the previous paragraph, serving to drivers.

As far as the energy saving is concerned, there is a bunch of solutions that could add up to a city's energy consumption reduction. A smart grid could provide the public electricity grid operator with all the necessary data in order to enhance the electrical system's stability and reliability. Moreover, if the smart grid is implemented in smaller scales, by creating smart neighbourhoods and smart communities, serious¹³ energy consumption saving could be achieved. For the smart grid, in any scale, to be realised, cities should acquire a vast network of sensors, mostly smart meters, in order to collect data about energy demand and, if applicable, energy production, in cases of buildings that have renewable energy production systems.

¹³ smart neighbourhoods and smart communities will be presented in detail in a following chapter

Apart from smart grids, since a big fraction of urban energy is consumed in municipal lighting, installing a network of smart municipal lighting could provide extra energy savings. These could operate automatically, according to the presence of physical light or according to the number of pedestrians or cars passing by, and remotely via a central server, in order to manage them. Finally, such a system could also cut down maintenance costs, since faulty lighting fixtures could be identified earlier and the amount of money spent in reactive maintenance could be diverted to proactive maintenance when needed. Except for smart electrical grids, a city could adopt a smart water system in order to monitor and control both the demand and the quality of the water reaching people's houses.

As mentioned above, in chapter two, smart homes and smart buildings are a miniature of a smart city. The more smart buildings in a city, the more, accumulatively, benefits in terms of energy saving can be generated in the city level.

Healthcare is a crucial sector for cities is, not only for cost related reasons but mainly for social ones. Adopting smart healthcare, by offering citizens with smart e-health applications could reduce the waiting time in hospitals and could cast a positive impact on fatalities by reducing the time an emergency vehicle needs to reach a patient. Along with time and fatalities, the energy consumed for building in the health sector can be reduced, since more people would not have to visit a hospital, by getting diagnosed over an e-health app and the energy consumed in smart hospital buildings would be managed more efficiently.

In accordance with the e-health benefit regarding ambulances reaching patients in need faster, a smart city could adopt a smart municipal safety system, consisting of surveillance cameras and a central processing unit to process all collected data. This data could be used in order to dispatch emergency vehicles in case of crime incidents, fires and any type of crisis, timely.

Furthermore, another potential application for smart cities is the adoption of a smart waste management system consisting of smart waste bins that can inform a central processing unit about the level of trash inside each waste bin. This way, the smart waste management system could plan more efficient routes for waste collecting vehicles, by prioritizing bins and areas where waste bins are reaching their capacity. Such a system could not only improve citizens' quality of living but it could also cast a positive impact on energy consumed by trash trucks.

Other applications, in the context of smart cities, may include smart weather stations and smart public buildings informing citizens about the weather or the average waiting time in public services, accommodated in smart public buildings, via smart information kiosks and electronic signs.

Finally, the most significant element of cities, people could "go smart" by wearing smart wearables in order to receive any of the above mentioned information at any time and also to transmit valuable data, such as their location or health status to the central municipal process unit. Conclusively, the smart city is a complex circular system, in which all subsystems communicate one with another in order to feed other smart subsystems or a main smart system with raw data and get fed by the same with process data.

The following picture shows a smart city implementing some of the above mentioned smart subsystems:



Figure 17: Smart city subsystems applied (18)

6 Research methodology

The purpose of this thesis is to explore the potential measures an organization can adopt in terms of information security, the consequent changes in the organization and finally provide with an assessment method for potential changes adopted.

This scope of study has been triggered by two main events:

- the rapid evolution of the IT technology and the high value of information for organization
- the increasing need for concerted adoption of information security management

This thesis stands upon two main pylons:

- change management
- information security management

In this chapter, we included a study of the methods and tools used for this thesis to be produced. Furthermore, an assessment of the results of surveys upon the two main pylons of this research are included.

For the conduction of this research, we used a combination of quantitative and qualitative research methods. Moreover, analysis has been done via secondary data and via utilization of traditional strategic tools. The approach we adopted, plays the role of an important clue for the author to be able to enhance this research rationality. (Creswell, 2014)

The research methodology stands on four major pylons:

- literature review
- analysis of surveys results
- simulations
- linear programming

In the first chapter we conducted a thorough research upon the change management aspect. As far as change management is concerned, we highlight the reasons that indicate an organizational change is essential, the methods used to make a proposed change successful. Finally, we present the reader with both success factors and obstacles to change in an organization.

Having provided the reader with all the necessary background regarding change management, we proceed with a literature review upon information security management. We firstly clarify the information term as well as the value of information and then point out the need for the adoption of information security measures. Following, we present the reader with potential threats an organization faces, and we propose some countermeasures an organization can deploy.

Having established the background for both change management and information security we conduct a literature review on information security policies assessment method used broadly by organizations. We also present the opportunities and the barriers an organization will face when adopting such policies. Upon elaboration on the above-mentioned terms, we propose the dominant assessment methods a modern organization could put in use in order to assess information security policies. (A. Charnes, 1959), (Dotzauer, 2014)

6.1 Research methods

A research method is defined as a specific strategy on the analysis. It is a way of gathering observational data. Every research method is constructed upon a combination of philosophical assumptions, while picking the proper research method may influence the ways used for the author to collect data. (Myers, 2007)

Various research methods also demand different research skills and practices. There are three pylon research approaches: (Creswell, 2014)

- the quantitative
- the qualitative
- a mix of quantitative and qualitative

6.2 Literature review – written sources

Written sources, such as scientific papers, books, surveys e.tc., are this thesis main source of qualitative data. We used them in order to investigate the advances in information security technology and the penetration of the I.S. technology in organizations. Secondary data, such as academic abstracts, internet search engines and databases have been used as well.

6.3 Data collection

Data can be collected via different types of strategies:

- Experiments
- Surveys, using questionnaires
- Qualitative research, via personal observation on literature review

For this thesis we collected qualitative data through literature review and observations made on published surveys relevant to the scope of the study. (Patton, 2005)

6.3.1 Primary data sources

Primary data are data that have been collected directly from people or people engaged in an organization. Its main advantage is that they reinforce qualitative researches validity by adding extra value, since the data collected is unique.

On the other hand, collection primary data is a rather costly and time-consuming strategy. (Myers, 2007)

6.3.2 Secondary data sources

Secondary data are any kind of data that has been previously published and to which the researcher has access. This data might be books, newspaper, academic or journal articles e.tc.

Access to secondary data is possible via academic databases and academic search engines. Its main advantages are that this is cost-effective research strategy. By cost effective, we consider significantly shorter time needed for a research to be conducted, without any quality discounts. Furthermore, they accelerate the research procedure and expedite the research completion.

On the other hand, secondary data might not be the best fit for every research, since they are based on data collected for a totally purpose and aspect.

In this research context, secondary data has been used in order to assess various information security controls in terms of cost, benefits and applicability. We used academic and journal articles mainly accesses via the Internet, in academic search engines and databases. (Myers, 2007)

7 Conclusions

In this dissertation we have conducted a thorough literature review on the IoT technology and its application on smart buildings.

It has been clarified that the basic pylon upon which the IoT technology bloom has sit is the advance in other technological fields which provide IoT with the essential elements to thrive.

Moreover, the impact of the IoT technology is already important despite the fact that there has not been a complete adoption.

Despite the important benefits of the IoT technology, some serious challenges have to be addressed in order to take only the best out of the IoT technology.

A key challenge is the security issues, since via the IoT implementation, people's personal data will be transmitted over the WEB, thus that data will have to be secure.

The main objective of IoT for smart homes is to create an environment of ease and comfort, where the end users will have to spend the least possible effort in order to have their tasks completed.

More specifically, we have identified numerous tools and smart home applications that can be used collaboratively in order to take advantage of the evolution in the Energy sector and build up green smart homes.

Extending the latter to the level of a neighbourhood, the conversion of conventional neighbourhoods to smart ones, by creating energy communities and interconnecting various smart homes one to another can produce multi benefits.

Finally, a possible application of the IoT technology to the extent of a city, thus building smart cities will result in taking the advantages of a smart home to the scale of the city. People will have a better quality of living, while they will be performing their everyday tasks with enhanced efficiency and increased effectiveness.

As far as the governments are concerned, the benefits of IoT and smart building will be mostly economic, since smart cities will facilitate a better allocation of resources, therefore excess costs will be cut down.

All in all, the IoT is expected to be adopted to a bigger degree in the near future, closing the above-mentioned gap between the reality and the expectations and making all the fascinating benefits of the IoT technology accessible to all people.

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Appendix

School of Science and Technology thesis structure.

Chapters	Content	Length (pages)
Cover	See sample	1
Title Page	See sample	1
Dedication	Optional	1
Abstract	Explain the title/subject. A couple of paragraphs about the scientific area where the thesis belongs and a concise summary. Where was it written, who supervised it, acknowledgements etc.	1/2 - 1
Contents	Contents (Up to Heading 3)	3 - 4
1 Introduction	Extended version of the abstract. Include a section or a paragraph about each chapter of the thesis.	2 - 5
2 Lit Review	Short, concise and well documented survey of the field. How does your work compare to the work of others? (advantages, disadvantages, differences, elements of innovation or novelty).	10 - 20
3		10 - 15
4		10 - 15
5		5 - 10
6		15 - 20
7		2 - 5
Bibliography	Books, papers, articles, web links used and referenced in the thesis.	1 - 2
Appendices	Source code, user manual, data samples, etc.	30 - 40 max
TOTAL		80 - 120

Figures

Figure 1: Google trends – searches for IoT term globally (2004-present).....	3
Figure 2: Sensors cost forecast	4
Figure 3: Smart home architecture (1).....	17
Figure 4: Smart home power service system structure (13)	19
Figure 5: Smart home devices network (15).....	28
Figure 6: A typical smart neighbourhood framework (16).....	29
Figure 7: A typical smart-home electricity service system topology (13)	31
Figure 8: The Amazon Alexa smart home personal assistant	39
Figure 9: Sustainable physiological indicators data collection system structure (23)	45
Figure 10: IoT smart metering system for water usage and quality (33)	48
Figure 11: Architecture of the proposed context-aware system to assist wheelchairs (44)	52
Figure 12: Smart city structure clustered in four major categories (16)	57
Figure 13: Fundamental smart city functions.....	58
Figure 14: Smart city subsystems applied (18)	62

Tables

Table 1: Smart home tools in accordance with the Davidoff design principles (14)	34
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