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DEPLOYMENT TRENDS OF THE INTERNET OF THINGS

Laura Berisha

Programi për Shkenca Kompjuterike dhe Inxhinierise

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Laura Berisha

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Mentori: PhD. Naim Preniqi

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Ky punim është përpiluar dhe dorëzuar në përmbushjen e kërkesave të pjesshme për Shkallën Bachelor

ABSTRACT

The Internet of Things (IoT) is the internetworking of physical devices, vehicles and other objects which consists of an embedded system with sensors, actuators and network connectivity that enable to collect and exchange data. The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more integration of the physical world into computer-based systems, and result in improved accuracy, efficiency and economic benefit. The IoT is a rapidly increasing and promising technology which becomes more and more present in our everyday lives.

We can say that Internet of Things (IoT) is a new revolution of the Internet. It makes Objects themselves recognizable, obtain intelligence, communicate information about themselves and they can access information that has been aggregated by other things. The Internet of Things allows people and things to be connected anytime, anyplace, with anything and anyone, ideally using any path or network and any service.

Different applications of IoT have been developed and researchers of IoT well identified the opportunities, problems, challenges and the technology standards used in IoT such as Radio-Frequency IDentification (RFID) tags, sensors, actuators, mobile phones, etc.

GRATITUDE/ACKNOWLEDGMENT

I would like to express gratitude and thanks to some of the many people who helped me successfully complete my journey through these three years.

First of all, I would like to thank and express my gratitude to the family I owe a lot to, especially my parents for the continued support they have given me throughout this time. I couldn't do it without you so thank you from the heart you believed in me!

Thank you to my mentor Naim Preniqi for your guidance, support and effort during these months. I have gained a great deal of knowledge from you, so thank you very much for your patience and contribution in finalizing this thesis. Also to all the UBT College staff who supported us during these three years of study with good will and energy.

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Thank you everyone !

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DICTIONARY OF TERMS

IoT - Internet of Things

RFID - Radio Frequency Identification

LAN - Local Area Network

MAN - Metropolitian Area Network

WAN - Wide Area Network

LTE - Long Term Evolution

HTTP - HyperText Transfer Protocol

M2M - Machine-to-Machine

M2H - Machine-to-Human

UI - User Interface

UX - User Experience

ATM - Automated Teller Machine

AI - Artificial Intelligence

1 INTRODUCTION

The world around us is getting smarter and more connected as technology becomes a common sight in many areas.

Digital devices are not just in our pockets or our offices, but increasingly in our homes, buildings, and many places and cities. Helping collect, analyse and monitor data and information about their surroundings, these devices are able to communicate with each other through the 'Internet of Things'.

Often shortened to the IoT, this worldwide, interconnected network allows devices to talk to each other and to us, delivering reams of data through smarter processes that will greatly increase the quality of life around the world.

The Internet of Things is predicted to revolutionise the way in which we live our lives, with many industry experts tipping it to have the biggest technological impact since cloud computing, as more data than ever before can be collected, stored and analysed.

By definition, the IoT is "the interconnection via the Internet of computing devices embedded in everyday objects, enabling them to send and receive data." In other words, the IoT is connecting your stuff to the internet or to other stuff so it can do new stuff outside of the stuff it can already do (like control your stuff remotely and receive alerts and status updates).

So in another words Internet of Things, or IoT, refers to the billions of physical devices around the world that are now connected to the internet, collecting and sharing data. Thanks to cheap processors and wireless networks, it's possible to turn anything, from a pill to an aeroplane to a self-driving car into part of the IoT. So basic is that if a device has an on and off switch then chances are it can be a part of the IoT.

This thesis provides an introduction to what IoT is and how it can be used and how the IoT has developed in years.

2 LITERATURE REVIEW (HISTORY)

Everything in our lives is related with smart devices. Starting from our smartphones and everything else. We try to control everything from those smart devices to make our life easier. And all of this can be accomplished by The Internet of Things.

Internet of Things is a new revolution in the capabilities of the endpoints that are connected to the Internet, and is being driven by the advancements in capabilities (in combination with lower costs) in sensor networks, mobile devices, wireless communications, networking and cloud technologies.

The scope of IoT is not limited to just connecting things (devices, appliances, machines) to the Internet. IoT allows these things to communicate and exchange data while executing meaningful applications towards a common user or machine goal. Data itself does not have a meaning until it is contextualized processed into useful information.

Internet of Things span a wide range of technologies that are used in homes, cities, environment, retail, health, agriculture, industry etc.

2.1 History of The Internet Of Things(IoT)

The Internet of Things, as a concept, wasn't officially named until 1999. One of the first examples of an Internet of Things is from the early 1980s, and was a Coca Cola machine, located at the Carnegie Melon University. Local programmers would connect by Internet to the refrigerated appliance, and check to see if there was a drink available, and if it was cold, before making the trip.[1]

But the actual term "Internet of Things" was coined by Kevin Ashton in 1999 during his work at Procter&Gamble. Ashton who was working in supply chain optimization, wanted to attract senior management's attention to a new exciting technology called RFID. Because the internet was the hottest new trend in 1999 and because it somehow made sense, he called his presentation "Internet of Things".

Even though Kevin grabbed the interest of some P&G executives, the term Internet of Things did not get widespread attention for the next 10 years.[2]

After years go by, everything in our lives was more depended by the Internet. Starting from our house, our office and everything else. So by the years in some way our life got easier by controlling everything through devices with the ability to transfer data over a network. All of this was provided by Internet of Things.

Today Internet of Things (IoT) is a term describing a vision that everything should be connected to the Internet. IoT will be fundamental in the future because the concept opens up opportunities for new services and innovations. All facilities will be connected and able to communicate with each other by sharing data.

Figure 1. The Circle of the Internet of Things

2.2 What IoT includes and how it works?

The Internet of Things includes every device that is connected to the internet. So in another words Iot includes everything that surrounds us.

But we ask ourselves how does The Internet of Things works?

Applications on IoT networks extract and create information from lower level data by filtering, processing, categorizing and contextualizing the data. IoT devices through sensor, antenna and microcontroller collect the information.

This information obtained is then organized and structured to be transfered through IoT hub or IoT gateway. Then the next step is to analyze the data that is transferred and understand the relationship between pieces of information to infer knowledge which will be put into action.

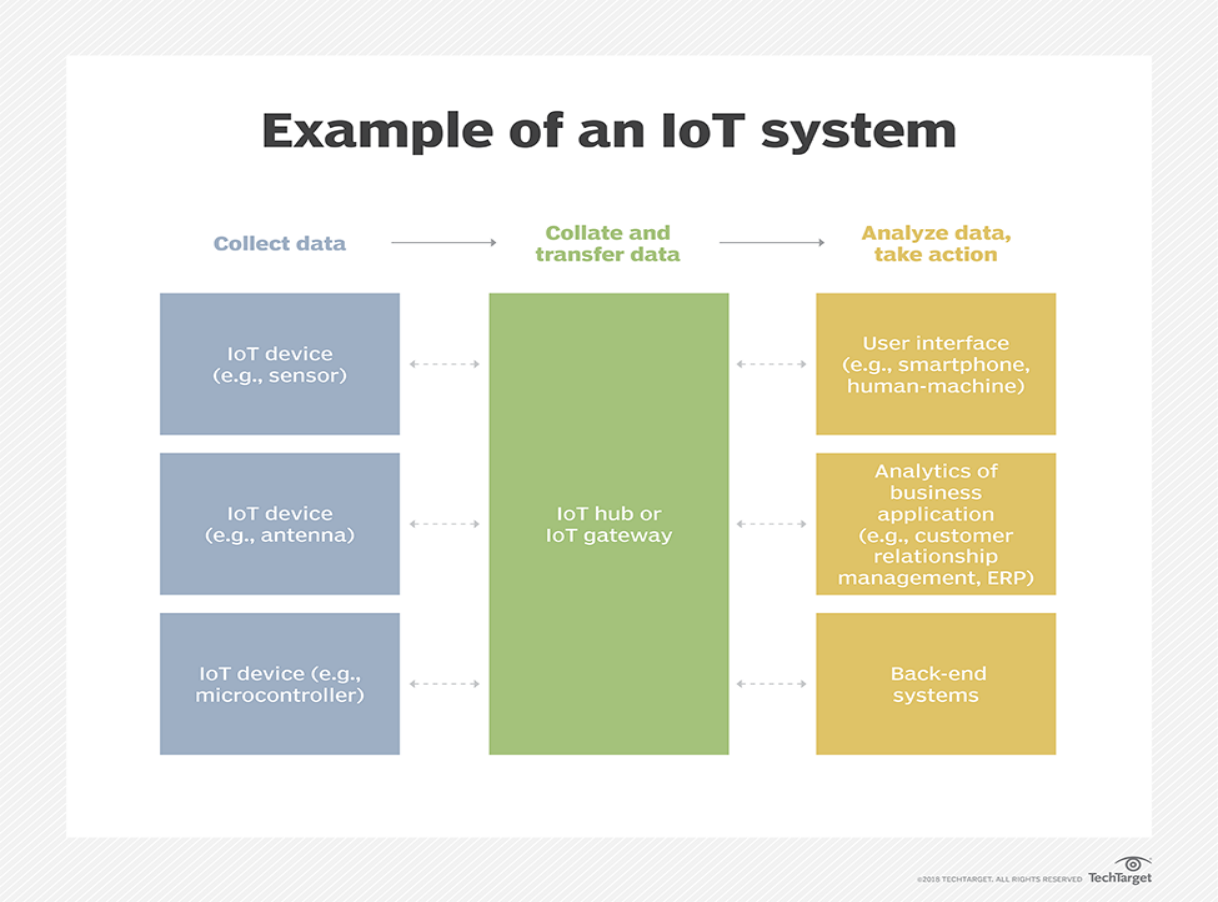

Figure 2. IoT System

2.3 IoT Components and Their Functions

Internet of Things (IoT) is the network of physical objects - vehicles, buildings, and other objects that are connected to electronics, software, sensors, and network connections, which enables these objects to collect and share data. Implementing this concept is not an easy task for many reasons including the complex nature of the various components of the IoT ecosystem. To understand the importance of this task, we will explain all five components of IoT implementation.

Components for IoT implementation

- Sensors
- Networks
- Standards
- Intelligent analysis
- Intelligent actions

Figure 3. IoT Components

2.3.1 Sensors

Sensors are one of the key building blocks of the Internet of Things which can be deployed everywhere from military battlefields to vineyards. A sensor is an electronic device, which detects senses or measures physical stimuli and responds to it in a specific way. The data collected from the sensors is electronically transformed into output that is useful for making decisions from smart devices or people.

So sensors converts signals from stimuli into an analogue or digital form, so that the raw data about detected parameters are readable by machines and humans. Sensors can also be implanted under human skin, in a purse or on a dress. Some can be as small as four millimeters in size, but the data they collect can be received hundreds of miles away.

Sensors have the key advantage that they can anticipate human needs based on information collected about their context.

We have two sensor types: Active sensors and passive sensors

The choice of sensors is influenced by many factors, including:

- Purpose
- Accuracy
- Security
- Laying down
- Level of intelligence

The driving forces behind the use of sensors in IoT today are new trends in technology that make sensors cheaper, smarter and smaller.[3]

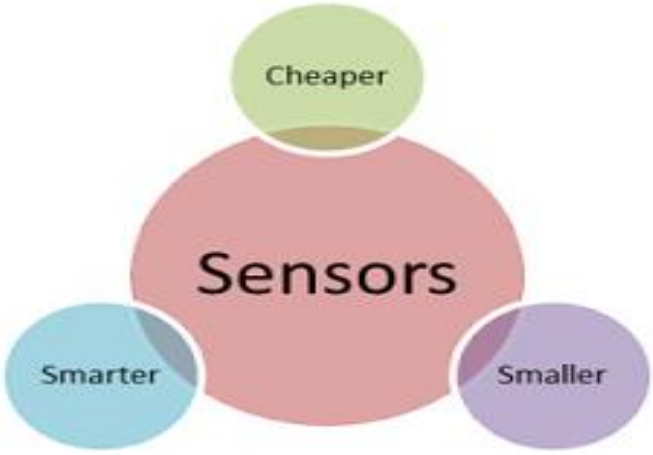

Figure 4. IoT Sensors

Figure 5. Sensors over the years

2.3.2 Networks

The second step of this implementation is to transmit signals collected from sensors over networks with all different components of a typical network including routers, bridges in different topologies, including LAN, MAN and WAN. Connecting different parts of sensor networks can be done through various technologies, including Wi-Fi, Bluetooth, Low

Power Wi-Fi, Wi-Max, Regular Ethernet, Long Term Evolution (LTE) and the latest promising technology of Li-Fi (using light as a means of communication between different parts of a typical network including sensors).[4]

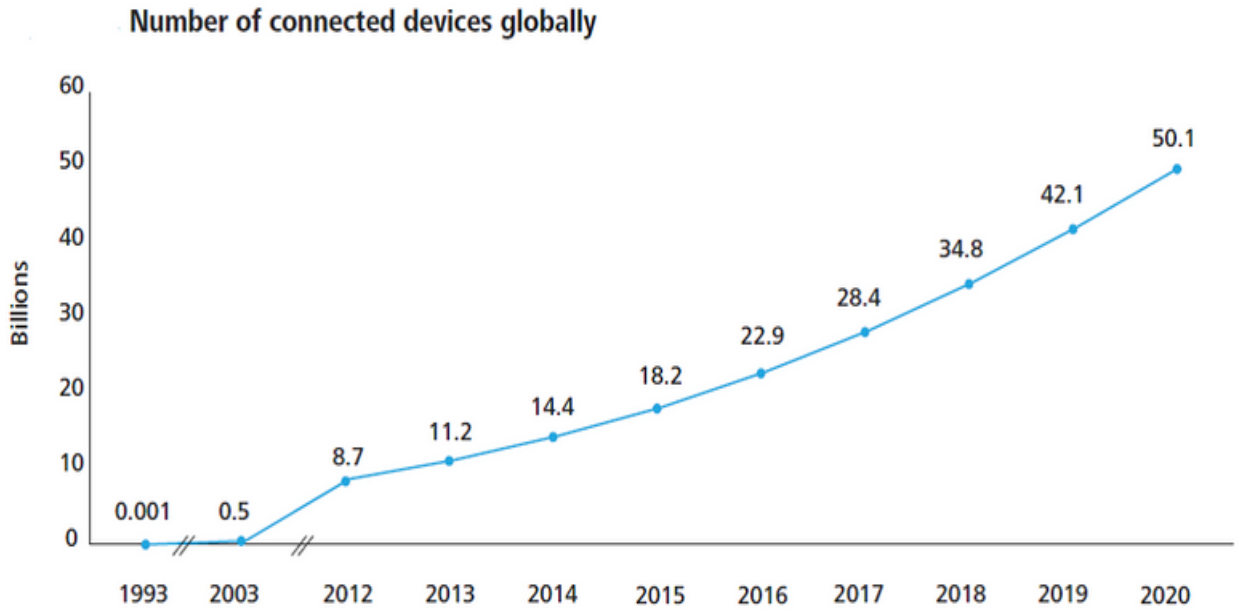

Figure 6. Number of devices connected to the network

2.3.3 Standards

The implementation process includes the sum of all data handling, processing and storage activities collected by the sensors. This aggregation increases the value of the data by increasing the scale, space, and frequency of the data available for analysis, but aggregation is only achieved through the use of different standards depending on the IoT application used.

2.3.3.1 Types of Standards

Two types of standards relevant to the collection process; technology standards (including network protocols, communication protocols and data collection standards) and regulatory standards (related to data security and privacy, among others). [5]
Technology Standards

- Network Protocols (e.g. Wi-Fi)
- Communication Protocols (eg HTTP)
- Data Collection Standards (eg Transform, Upload)

2.3.4 Intelligent analysis

The fourth stage in IoT implementation is data mining for analysis, Analytics is driven by cognitive technologies and associated models that facilitate the use of cognitive technologies.

With advancements in the ability of cognitive technologies to process different forms of information, vision and voice are also usable.[6]

2.3.5 Intelligent actions

Intelligent actions can be expressed as M2M and M2H interfaces for example with all the advancements in UI and UX technologies. [6]
Factors that support the adoption of intelligent actions within IoT:

- Low machine prices
- Improved machine functionality
- Cars "influence" human actions
- Deep Learning Tools.

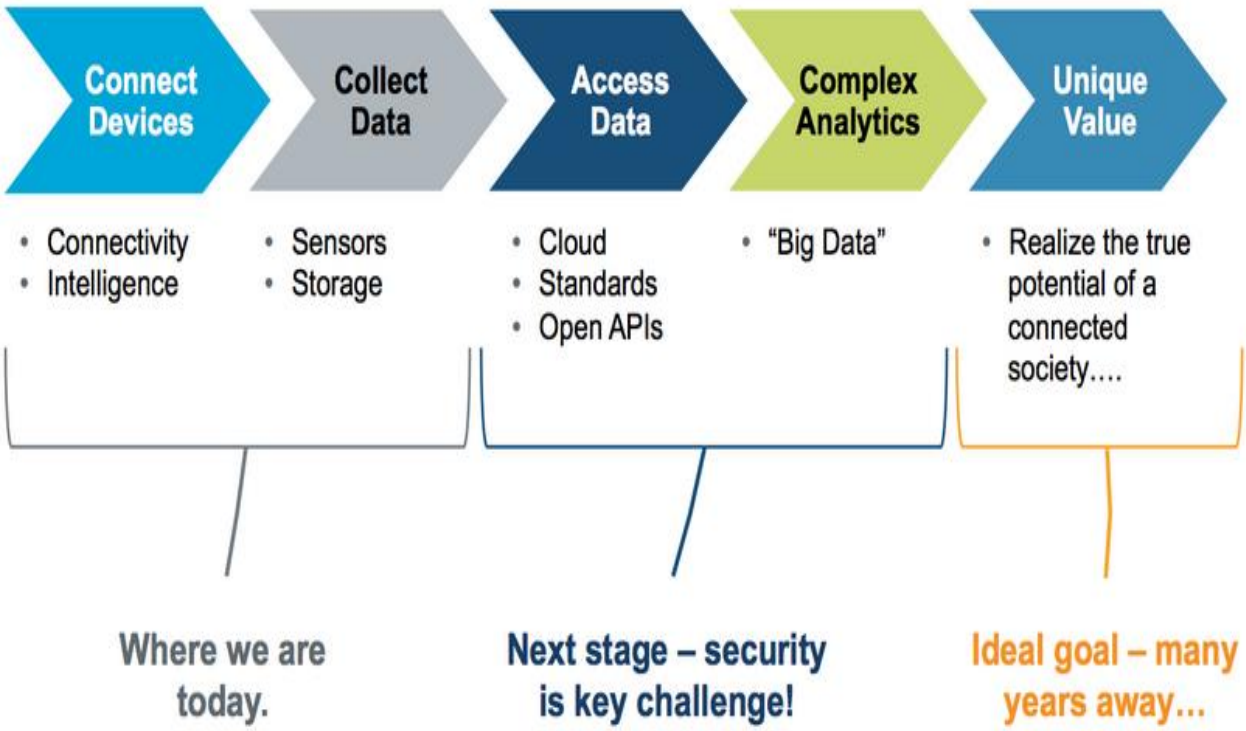

Figure 7. IoT Actions

2.4 Communication between IoT Devices

The most essential part of IoT realization is communication, because in order to interconnect the different devices they need to be able to communicate. All other properties, such as sensing, maneuvering, being able to capture, store and process data are unnecessary; unless your device specifically requires one of these.

However, the ability to communicate is essential when labeling a device as an IoT device. How this communication is done is less important, as communication of the physical layer and the actual connectivity in IoT can be accomplished in many ways.

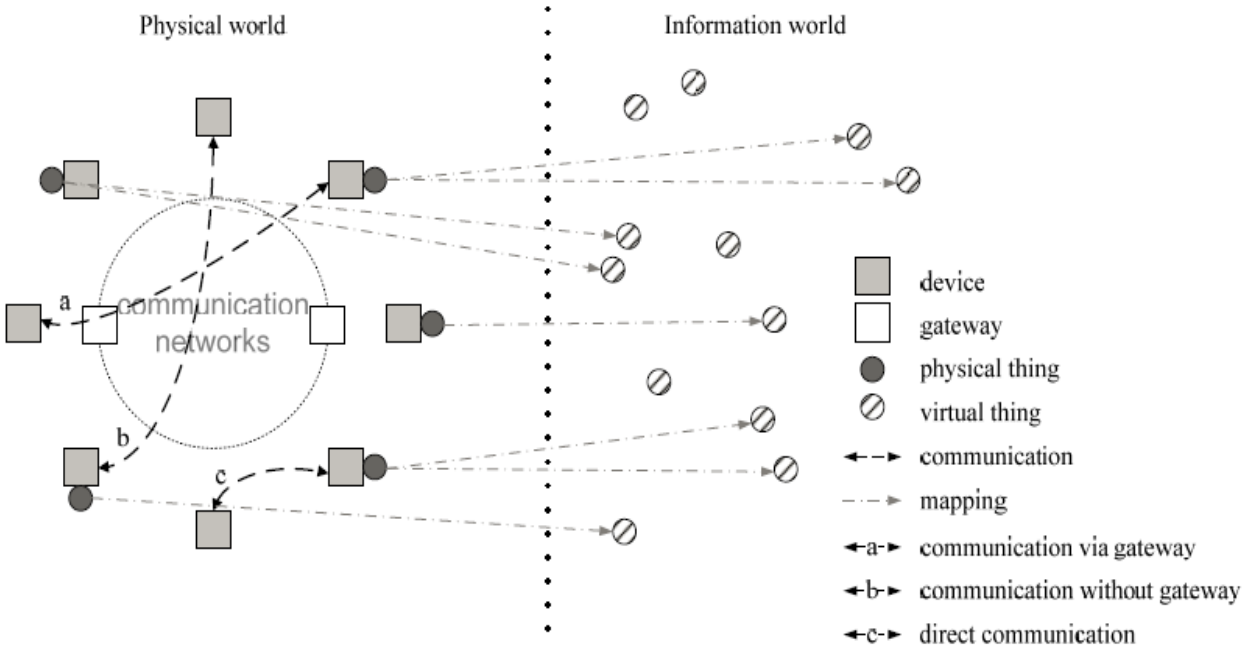

Figure 8. Communication between IoT devices

The figure shows that devices are not always needed to communicate through a communication network. For example, if two devices are close to each other, it may be

simpler to communicate directly through the use of technologies such as Bluetooth or ZigBee (protocols that enable direct communication).

In contrast, in Case A in the Figure, a device can communicate via a port using a protocol (an IPv6 over Low Power Wireless Personal Area Networks (6LoWPAN)) and then the gateway can communicate using a protocol (e.g. IPv4) such as the Internet.

Case B in the Figure illustrates two devices that communicate directly with each other without requiring a gateway where the two devices are directly connected to the communication network and thus able to communicate even if located in different locations.

A physical thing can be defined in the information world through one or more virtual things, while virtual things do not necessarily need to be associated with anything physical and can exist independently of any physical existence. For example, one physical thing can run multiple applications and thus have multiple identities in the virtual world. Similarly, a virtual thing can also have many identities in the virtual world.[7]

2.5 PROs and CONs of Internet of Things

By now we have learned the definition of The Internet of Things (IoT) and how everything started. Now let us see that is everything in our profit or not.

The vast amount of intelligence and services brought to the table, have the potential to significantly shape our everyday lives – how we manage our cities, healthcare and even how we grow our food. To date, there are over 20 billion things connected to the internet, with that number expected to jump to 50 billion by 2021. Surprisingly, many people use Internet of Things(IoT) every day without even knowing it. Connected thermostats, ATM machines, wearables and even traffic lights all make up the IoT.

Below we discuss the pros and cons of the IoT and how it could change your everyday life, very soon.

PROs

- *Automation*
    - Automation leads to uniformity in tasks, quality of service and control of day-to-day tasks without human intervention. Machine-to-machine communication also helps maintain transparency throughout the process.
- *Efficiency*
    - Machine-to-machine interaction provides for better efficiency, enabling people to focus on other jobs.
- *Cost Savings*
    - In addition to the optimal utilization of energy and resources, the IoT helps alleviate the problems associated with bottlenecks, breakdowns and system damages.
- *Communication*
    - IoT allows physical devices to stay connected and better communicate, which creates greater quality control.
- *Instant Data Access*
    - More available information helps simplify the decision making process, making life easier to manage.

CONs

- *Privacy and Security*
    - As many of our everyday appliances, machines and services become connected to the internet, much more information is readily available. It makes it harder to keep confidential information out of the hands of hackers and other unauthorized users.
- *Compatibility*

    - Currently, there is not international standard of compatibility for the IoT which can make it hard for devices from different manufacturers to communicate with each other.
- *Complexity*
    - Because the IoT is such a vast, diverse network, a single failure in either the software or hardware can have disastrous consequences.
- *Less Jobs*
    - As IoT brings in more consistent automation, we could see a decline in the need for unskilled employees in the workplace.
- *Technologically Dependent Life*
    - As our lives become more and more dependent on technology, basic human interaction skills will be reduced across society.

The IoT has already become a huge part of everyday life, without many of us even realizing it. As technology continues to grow and develop, so too will the use of IoT for many of our basic interactions. It is up to us to decide how much of our daily lives are we willing to be controlled by technology. If done correctly though, it will automatically adapt to our needs and benefit society as a whole.[8]

2.6 The Security Problem of IoT

When we are connected to the Internet, opportunities for others to see, hear and control our devices have been greatly enhanced through the use of IoT.

Furthermore, privacy and personal integrity concerns arise when more data is collected about our activities and personal information, in the form of locations, financial accounts, and so on. In addition, many of the decisions and actions to be taken using IoT will have real-world costs, risks and benefits. For these reasons, we need to make sure that security considerations are part of the design process and not something added at the end of any IoT device development.

When setting up things that are able to connect to the Internet, it will be important to implement them correctly, otherwise their systems and information may be exposed to attacks.

For example BMW, a major vendor in the car industry, had recently discovered an internet security error. The problem was caused by careless implementation. The fault was an optional feature called “ConnectedDrive” which connects to the Internet via the public mobile phone network using a SIM card. This feature allows the owner to remotely control heating or air conditioning and to lock or unlock the car using their smartphone.
The problem was in the communication of the machine which was unencrypted, which enabled other people to open the locked car and leave 2.2 million cars exposed. Fortunately, a German automobile club called ADAC (Allgemeiner Deutscher Automobil-Club) discovered this and notified BMW before any offense was caused by this problem.

Although the source of the problem was small and the solution was simple, this example shows how a small mistake can be extensive and expensive.

Communication encryption may not be relevant in all cases. It depends on what elements of information security are important in each specific case. If integrity, availability, and authenticity are important, then encryption is a vital part of the communication process.[9]
The security is only one of the problems that IoT has, but in the future IoT is going to be essencial in our lives, so we expect that every issue that IoT has, to be resolved and to provide all of IoT users bigger security in data sharing.

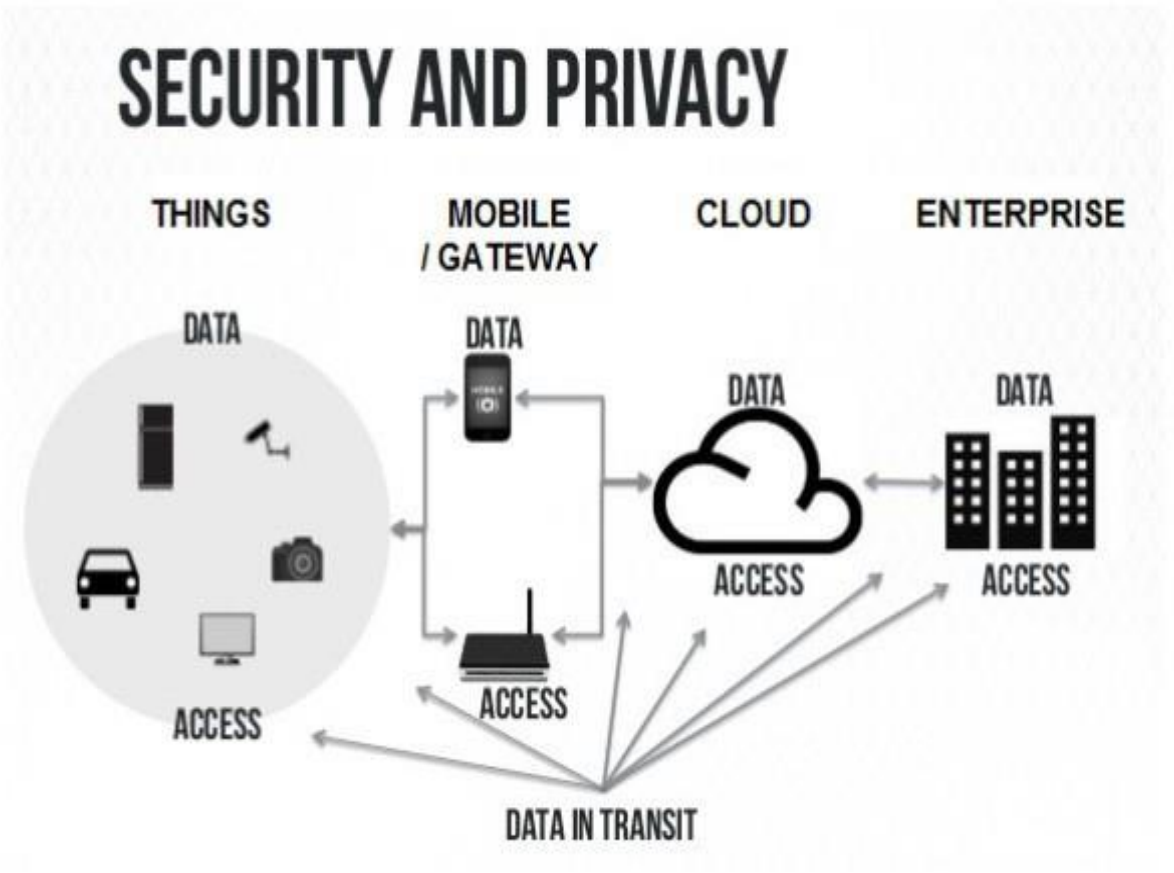

Figure 9. Security and Privacy of IoT

2.7 How is guaranteed data security in IoT

De-perimeterization involves protecting an organization's systems and data with a mix of protocols, systems, and data-level "authentication", with the lack of a distinct boundary between the organization itself and the outside world. In relation to IoT this describes a scenario when an organization for example uses weather sensors that collect information on wind, precipitation, etc. And send this information to the company server.

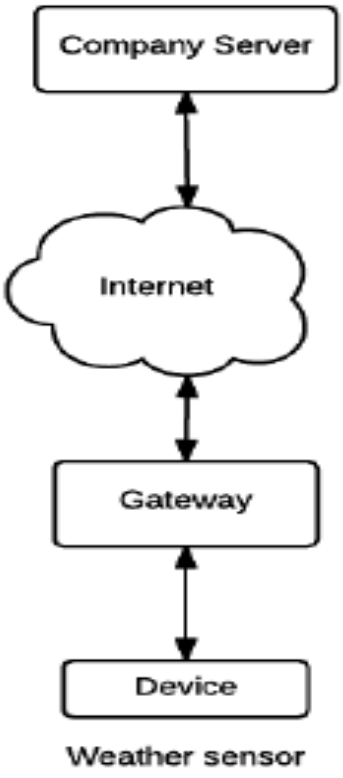

Figure 10. IoT Flow

Providing information in IoT requires systems and data to be able to protect themselves without relying on network protection, such as firewalls. Firewalls effectively work as a perimeter to secure company resources from intruders, which in most cases are irrelevant to IoT. To simplify deploying more "things", these things must be able to apply their security policy levels (for applications, network access, devices and individuals) even in an unconditional environment or network.[10]

Another requirement is that security mechanisms are simple and easy to administer that simplify the definition of their limitations since not all solutions are adapted to all environments.

IoT security issues are easily divided into two areas: virtual and physical threats. Physical threats increase as things become increasingly de-perimeterized. Virtual threats are closely linked to threats in any IT environment today and mainly consist of receiving data and

information or taking control of the device itself. In addition, the application of the methods used to provide an IoT environment are limited as many devices are limited when it comes to performance and power.

By looking at the different points of attack, it is easier to identify which threats are IoT-related and also which vulnerabilities need to be counteracted in order to secure each part in an IoT environment.
The two identified points of attack are: the communication that occurs between objects (IoT devices) and the IoT devices themselves.

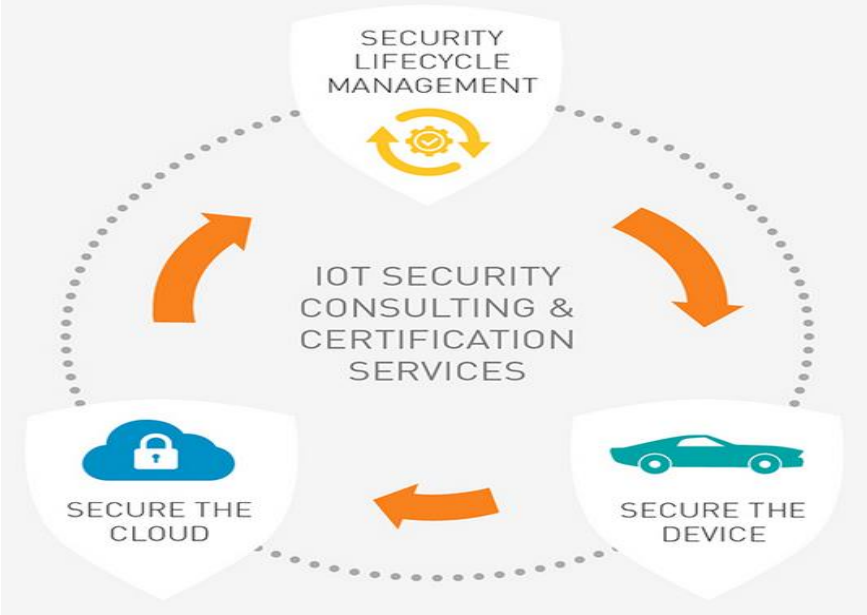

Figure 11. IoT Security Services

2.8 Artificial Intelligence (AI) in IoT

Artificial intelligence and the Internet of Things are both unique technologies on their own, but what makes them even more interesting is where they intersect. As the applications of IoT and AI are independently fascinating, their combined use cases hold even more captivating potential.

We have said that the devices connected in an IoT network are linked via sensors and actuators wrapped with software and hardware to provide humans with logical inputs.

So the foundation of IoT is machine learning and artificial intelligence because it allows these devices to make sense of the data collected through them.

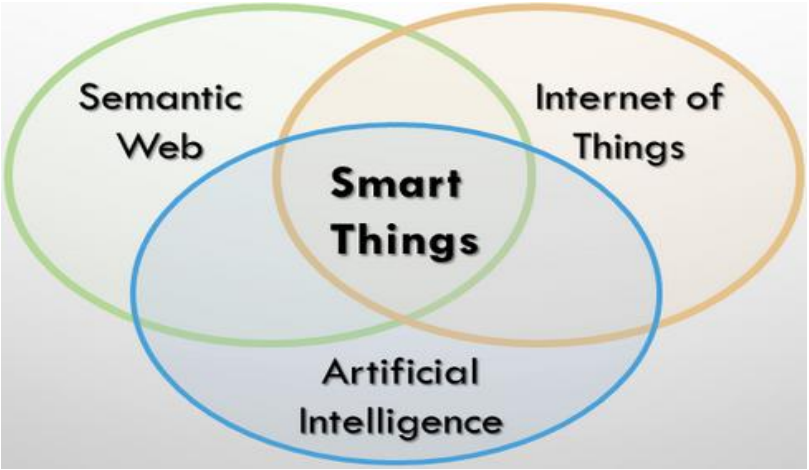

Figure 12. AI in IoT

Artificial Intelligence (AI) can spread to IoT and does not need all the activities to happened in the same place. In IoT, gathering all the activities is what creates AI.

The flow of data regarding sensitivity and processing can be presented in different ways. The flow can be as simple as an object receiving data through a sensor, which is then processed and finally transmitted in the form of a data packet, as shown in the figure

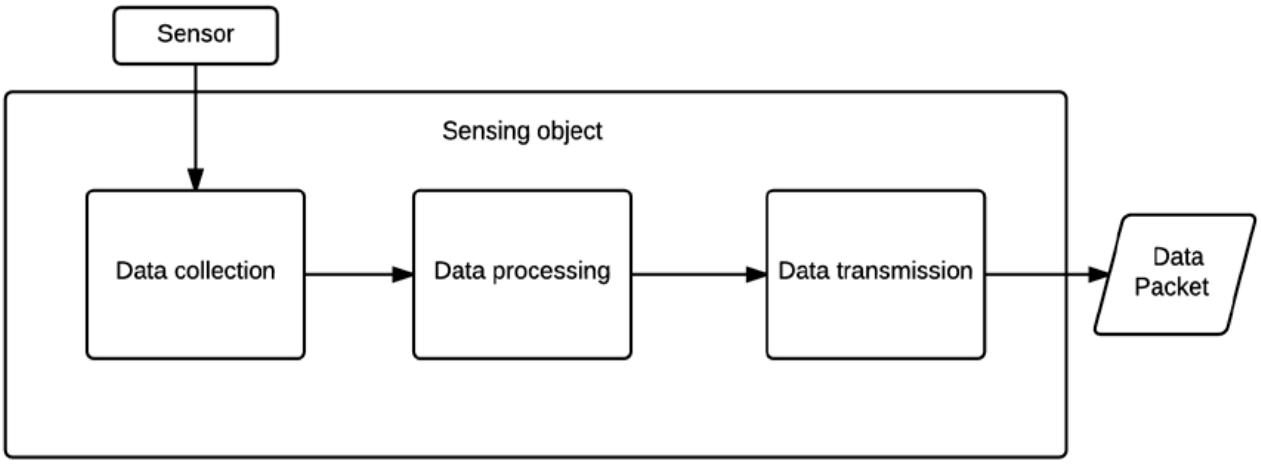

Figure 13. Data FlowChart

The simplest way to describe the data processing flow is a monitoring object that collects data that is sent to a calculator that processes and analyzes the data. The calculator then sends the result to a terminal which executes a result-based command or simply presents the data.

This data processing flow can be seen in Figure :

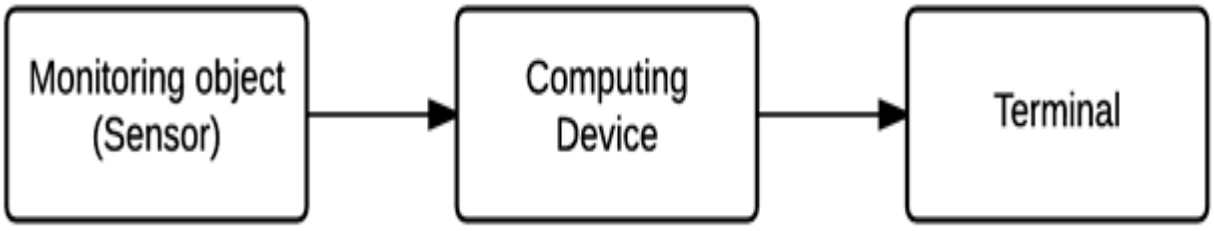

Figure 14. Data Flow

The sensor itself can do some processing before the data is sent to a larger collection point from which the data is sent to a processing point. The use of remote processing is especially important when the system consists of multiple objects that together provide the data needed to decide whether or not to execute a command.

For example, BigBelly Cloud presents all the data it receives to the user in various ways such as the location of the sensors and their status.

In this case the terminal only presents the data to the user without executing any command based on the results.

Then the user decides what commands should be executed to resolve the problem. [11]

Figure 15. IoT Example

2.9 Impact of IoT in Industry

The Internet of Things is affecting a variety of industries across the world in a number of creative ways. Now that it isn't just computers connected to the Internet, a world of opportunity has opened up, ranging from agricultural usage, energy industries, and financial planning.

The idea was for IoT to reach out to everyday devices and exactly such is the case. Quite a few industries have shown the courage to include this service in their respective domains and are very happy with the decision. This inclusion has transformed their business infrastructure and also cleared their vision.[12]

At first, it was only computers that were connected to the Internet. That changed the way people lived and industries functioned. Today, everything from mobile phones to watches, electric meters, surveillance cameras, industrial production units, and even air conditioners are connected to the Internet.

IoT is fundamentally changing the way we do business. By connecting devices and sensors to the internet, we are entering an age where data analytics, connectivity, and automation are creating innovations and progress previously out of reach. As the Industry 4.0 and home automation movements gain more traction, we will see IoT devices and embedded systems become more and more prevalent in our daily lives. The businesses that understand the use cases and potential of IoT are the businesses that will likely drive innovation over the next 10 years.[13]

Industries like energy, agriculture, and cryptocurrency face an ever-increasing demand from our rapidly growing population and are under the most stress to deliver better outputs.

Embracing the IoT is helping these industries perform in a more effective and efficient manner.

The Internet of Things is already larger than ever, and it's still growing rapidly. Global research indicates that the number of devices connected to the internet will increase from 26.66 billion in 2019 to 75.44 billion worldwide by the year 2025.[14]

2.10 Deployment trends of IoT

The Internet of Things has been evolved in a tremendous way over the past decade and still IoT is an emerging trend for researchers in both academia and industry.

The implementation of IoT is possible through sensors, actuators, computers and smart phones etc., and the use of services over the internet.

The Applications of the IoT are numerous and diversified in all areas of every-day life of people which broadly covers Transportation, Smart Home, Smart City, Lifestyle, Retail, Agriculture, Smart Factory, Supply chain, Emergency, Health care, User interaction, Culture and Tourism, Environment and Energy.[15]

2.10.1 Retail and Logistics

Implementing the IoT in Retail/Supply Chain Management has many advantages which include monitoring of storage conditions along the supply chain and product tracking for traceability purposes and payment processing based on location or activity duration for public transport, gyms, theme park, etc. In the shop itself, IoT offers many applications like guidance in the shop according to a preselected shopping list, fast payment solutions like automatically check-out using biometrics, detection of potential allergen in a given product and control of rotation of products in shelves and warehouses to automate restocking processes.

The IoT in logistics includes quality of shipment conditions, item location, storage incompatibility detection, fleet tracking, etc.

The combination of all these developments made the effective and efficient communications on IoT applications.[15]

2.10.2 Health Care

Many benefits provided by the IoT technologies to the healthcare domain are classified into tracking of objects, staff and patients, identification and authentication of people, automatic data collection and sensing.

Tracking is the function used to identify a person or an object in motion. This includes the case of patient flow monitoring to improve workflow in hospitals. The identification and authentication includes patient identification to reduce incidents harmful to patients, comprehensive and current electronic medical record maintenance, and infant identification in hospitals to prevent mismatching. The automatic data collection and transfer is mostly aimed at reducing form processing time, process automation, automated care and procedure auditing, and medical inventory management. Sensor devices enable function centered on patients, and in particular on diagnosing patient conditions, providing real-time information on patient health indicators.

The elements of IoT in Health Care significantly improve the measurement and monitoring methods of vital functions such as temperature, blood pressure, heart rate, cholesterol level, blood glucose, etc.[15]

2.10.3 Smart Cities

The IoT play a vital role to improve the smartness of cities includes many applications to monitoring of parking spaces availability in the city, monitoring of vibrations and material conditions in buildings and bridges, sound monitoring in sensitive areas of cities, monitoring of vehicles and pedestrian levels, intelligent and weather adaptive lighting in street lights, detection of waste containers levels and trash collections, smart roads, intelligent highways with warning messages and diversions according to climate conditions and unexpected events like accidents or traffic jams. Some of IoT smart cities applications are smart parking, structural health, noise urban maps, traffic congestion, smart lightning, waste management, intelligent transportation systems and smart building.[15]

2.10.4 Smart Agriculture

The IoT can help to improve and strengthen the agriculture work by monitoring soil moisture and trunk diameter in vineyards to control and maintain the amount of vitamins in agricultural products, control micro climate conditions to maximize the production of fruits and vegetables and its quality, study of weather conditions in fields to forecast ice information, rail, drought, snow or wind changes, control of humidity and temperature level to prevent fungus and other microbial contaminants. The role of IoT in water management includes study of water suitability in rivers and the sea for agriculture and drinkable use, detection of liquid presence outside tanks and pressure variations along pipes and monitoring of water level variations in rivers, dams and reservoirs.[15]

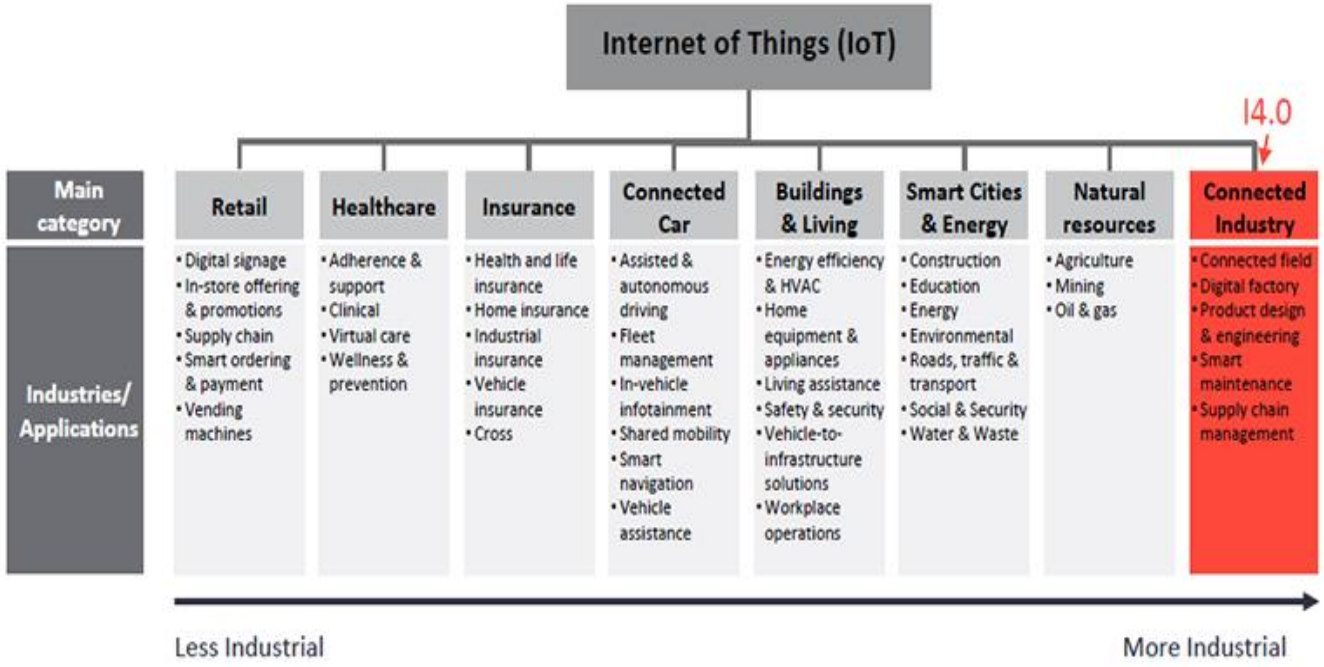

Figure 16. Deployment of IoT

2.11 The Future of IoT

The Internet of Things (IoT) is transforming the everyday physical objects that surround us into an ecosystem of information that will enrich our lives. From refrigerators to parking spaces to houses, the IoT is bringing more and more things into the digital fold every day, which will likely make the IoT a multi-trillion dollar industry in the near future. While the IoT represents the convergence of advances in miniaturization, wireless connectivity, increased data storage capacity and batteries, the IoT wouldn't be possible without sensors. Sensors detect and measure changes in position, temperature, light, etc. and they are necessary to turn billions of objects into data-generating "things" that can report on their status, and in some cases, interact with their environment. Because sensor endpoints fundamentally enable the IoT, sensor investments are an early indicator of the IoT's progress. Maybe one day we will see "IoT as a Service" technology offered and used the same way we use other "as a service" technologies.[16]

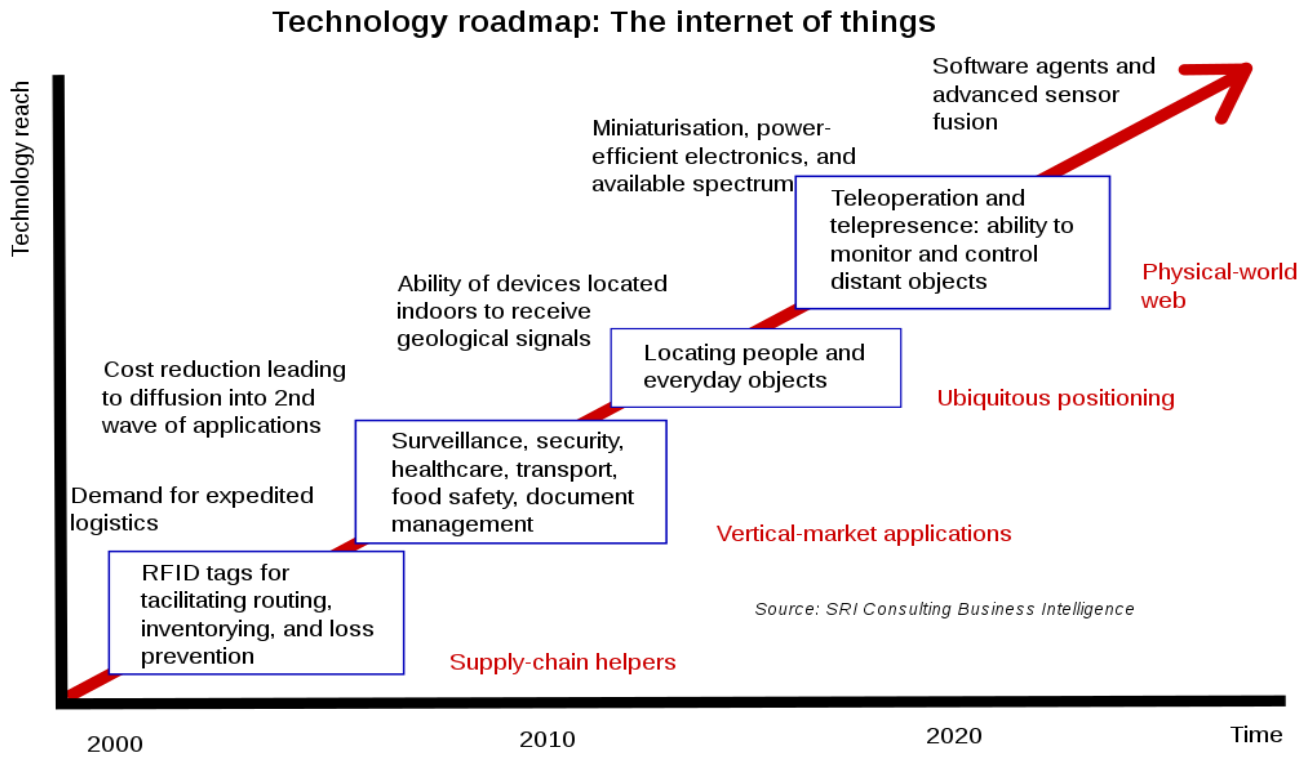

Figure 17. The Future of IoT

3 DECLARATION OF THE PROBLEM

In recent years, the development and deployment of systems and technologies that present a tight coupling between computing devices and the physical environment has grown considerably.

Being part of the internet it is difficult to manage all the daily processes at the same time. Big part of the difficulty is data security and privacy. Over the last decade Internet of Things (IoT) has evolved and things got a little bit easier to manage.

All the smart devices that we use daily, now can exchange and process the information that they want to share through IoT, which makes things more simple.

Even that Internet of Things has made things more manageable and to function better, the data security and privacy is still a problem.

The data that IoT devices share with each other is vulnerable to security attacks that can affect costumers because IoT is being used in health, smart cities, industry, agriculture etc.

One example in the Smart Transportation scenario is related to Intelligent Transport Systems where a security attack on the automatic car system for driving can produce car accidents and consequent casualties or harm to citizens.

In another scenario an automatic system to provide medicine to a patient can become compromised and deliver the wrong medicine to a patient. In all these systems, the physical environment provides information necessary for achieving many of the important functionalities of the ICT systems through sensors.

The main issue is that these devices are more and more embedded in our everyday life but they may not have the computing capacity to implement sophisticated security protection solutions.

IoT is expected to be further advanced in the coming years and more devices will be connected, therefore the main progress in IoT technology will be data security and privacy.

So the future of The Internet of Things has the potential to be limitless and we can use The Internet of Things as a safe technologie to share and exchange data information.

4 METHODOLOGY

This thesis is based on the collection of primary and secondary data, respectively through scientific articles and those found as part of books, journals or online publications that describe, discuss, interpret, analyze and evaluate the topic of this thesis.

The purpose of this thesis was to find information about the deployment trends of the internet of things and all its specifications.

This research is based on two basic forms:

- **Exploratory form -** which helps us identify and definiton a problem or question during exploration;

- **Constructive form -** which tests the theory and proposes possible solutions to a problem or question;

The research of this thesis is presented in several forms and has a mixed character between qualitative and quantitative research. It includes both qualitative and quantitative elements using secondary data. The quantitative approach required more efforts and more studies that would combine the literature review as well as field study and it was seen more challenging but meantime it produces more results.

The data used during the research and selection of information is mainly secondary data that we have obtained based on research on the different scientific articles and online publications. Research is of particular importance but it has taught me many things about this system that we will need in the future.

5 STUDY CASE : IOT APPLICATION IN INDUSTRY

The purpose of this case study was to look at how the industry is affected by the use of Internet of things, what are the advantages and disadvantages of using The Internet of Things in the industry and what the future holds for the industries with the use of IoT.

Talk about the Internet of things (IoT), and its ability to bring unparalleled efficiencies to all industries is intensifying.

But what exactly does it look like in practice? And how can different industries, from transport to utilities to councils and governments, access and implement true IoT solutions?

We will take some different examples to study better and to show how affordable, scalable and flexible it can be. In a lot of cases it is the same technology, that's been tailored to a different context.

5.1 Transport radio network performance monitoring

The industry that uses this is: Transport.

The challenge that forced to use IoT was that during civil construction works, radios are often used coordinate roadside signals to be displayed on signage. With any radio network, radio performance needs to be monitored to ensure the system, and transmitted data, is reliable. Because this was an isolated radio network, a remote secure connection was required to monitor the radio network performance. The clients wanted to trial an IoT monitoring solution.

The solution was that A remote secure 4G modem using a VPN connection was used to obtain the localised radio network performance and feed back in to SAGE's cloud based SCADA system 'STRATUS'. Every minute STRATUS collects each of the radios' performance data for analysis and alarming when required. Users can login to the SCADA dashboard via internet browser and view performance data live.

The outcome was that the road authority has the ability to see if their radio networks are working. This assurance means their on ramp signalling is reliable, and commuters and

civil works people are safe. A solution of this kind without a cloud-based SCADA would not be feasible in this context. The IoT cloud-based solutions offered the answer.

The technologies used to apply IoT in the transport radio network performance monitoring are VPN, 4Gx network, cloud-based SCADA, client side ClearSCADA, Amazon Web Services cloud-based platform.

5.2 Award winning recycling sorting and data system

Recycling is the process of converting waste materials into new materials and objects. It is an alternative to "conventional" waste disposal that can save material and help lower greenhouse gas emissions. Recycling can prevent the waste of potentially useful materials and reduce the consumption of fresh raw materials, thereby reducing: energy usage, air pollution (from incineration), and water pollution (from landfilling).

The challenge that forced to use IoT in recycling was that recycling depots have for many years experienced problems including long wait times for customers, theft and poor count accuracy due to manual counting and sorting. Plus, technology alternatives to the manual counting method have been limited; the European-made reverse vending machines on the market only accept and scan containers with intact barcodes – and one at a time. Anything slightly damaged or with no label cannot be refunded and accurate reporting remains a challenge.

So the solution was to develop four ‘smart’ container returns and refund systems. The solutions automatically sort, identify and count container types (even if they're crushed) using a smart vision system powered by machine learning. Container data is sent to the cloud for a faster processing and customer refund process, as well as historical reporting and greater probity of information across multiple sites, making it a true IoT solution.

The outcome was that combinations of the vision technology, sorting system and IoT data network are able to bring facilities faster and more accurate quality processes and data probity, at low implementation and operating costs.

The solution has also won Best Industrial IoT Application at the 2018 Endeavour Awards, and 2018 Design Innovation of the Year Award at the 2018 Packaging & Processing Innovation & Design Awards.

The technologies used to apply IoT in the award winning recycling sorting and data system are Single-Board Computers, Amazon Web Services (AWS) and Encryption, Beckhoff control and NORD drives.[15]

5.3 Connected Contact Lenses and Activity Trackers

The usage of The Internet of Things is also in health care. In medicine IoT is used for so many reasons in proffit of patient. One of them is this example with connected contact lenses and activity trackers.

In the sphere of medicine, the Internet of Things examples transformed the quality and accuracy of service delivery. Specifically, different tools can be used today to facilitate the treatment and improve the health state of the people all over the world. And here, connected contact lenses and activity trackers are the most interesting and powerful Internet of Things healthcare examples.

Even though the plot from a 'Black Mirror' episode (where the memories stored were on a lens) is still futuristic, the invasion of smart technologies into an eyesight is already impressive. As one of the most interesting examples of IoT from the healthcare area, connected contact lenses with inbuilt sensors can analyze tears and provide the information to doctors on a health state of their patients. Precisely, the technology empowered by Google can check the glucose level in patients with diabetes and work on an eye's focus in the case of presbyopia. In a team with this IT giant, Novartis is another company pioneering in the sphere. However, the risk analysis of this project didn't allow them to start testing the product actually — and because of that, the current research of Apple and EPGLMed concentrated on the entertainment possibilities of the innovation. But the very appearance of the idea means that connected contact lenses will soon become our reality.

In the sphere of oncology, the collaboration between Medidata (the provider of cloud solutions) and Memorial Sloan Kettering Cancer Center started the long adoption process for numerous activity trackers. Being used for treatment, various sensors and wearables entered this process to trace the main changes in a patient's body. With the instant access to the data on fatigue, appetite, and blood pressure, both the doctors have got accurate information to conduct proper analytics and the patients have understood the adjustments needed to improve their quality of life. In the given circumstances, the effect of a long-term therapy significantly improved, being both accurate and customized.

5.4 Smart Lock and Smart Mirror

One of the most appealing and popular applications of IoT is surely the range of devices designed for a smart house. In particular, they include safety systems, plugs, thermostats, and many other tools that facilitate the living. At the same time, among the various examples of Internet of Things devices, the cases of smart lock and smart mirror deserve special attention.

On the one hand, IoT can increase the level of safety and control over the home by introducing a smart lock. In the world of the Internet of Things examples, this tool is one of the most effective ones — basically, it can completely replace the keys and locks in the near future. For example, with August Smart Lock, you can provide the access to your house to the special people — and instantly limit it in one touch. In addition to a smartphone control, a password on a keyboard can be used to enter the door. Finally, the increased level of safety is granted by the remote control option: via viewing an activity log.

As another representative of IoT examples, a smart mirror is a very interesting case. Even though it won't repeat you that you're the fairest of them all every day (if you don't program it to do so!), it can still tell you many interesting things. In particular, it can show on a display the weather condition, time, date, and various notifications from your smartphone. Moreover, the connection to in-voice search features is available (so you won't touch the glass — just talk to it). In other words, fairy tales seem to come true![16]

6 RESULTS

The radical evolution of internet into a network of interconnected objects that create a smart environment is characterized by the term of The Internet of Things (IoT).

From all the examples mentioned above, the use of The Internet of Things has become necessary to facilitate and improve things in industry. Examples were the use of The Internet of Things in the industry, though in addition to industry, The Internet of Things is widely used in health, agriculture, smart cities etc.

The application of The Interent of Things in the industry is clearly seen to have made things more effective in their business, as well as to the benefit of the clients.

A common characteristic of IoT solutions in industry is that they are low cost and quick to implement.

The main aspects of the Industrial Big Data are not found only inside of one company but in a network of interconnected companies were different data should be collected and transmitted in order to process them and derive meaningful insights for adaptive and flexible decision-making.

It is an undeniable fact that Internet of Things (IoT) technologies have become a milestone advancement in the digital healthcare domain too, since the number of IoT medical devices is grown exponentially, and it is now anticipated that by 2021 there will be over 161 million of them connected worldwide.

From the example mentioned above we can see that the application of IoT in healthcare is very necessary.

All the use of The Internet of Things technology benefits the medical staff as well even for patients because almost all the equipment is now digitized and exchanged patient data can then speed up their recovery and be more efficient.

By implementing the solutions that The Internet of Things provide, we achieved to develop an innovative approach that can be interoperable and pluggable to different IoT platforms, regardless of the nature and the format of the data that they can manipulate.

7 DISCUSSIONS AND CONCLUSIONS

It is mandatory to adapt and evolve according to the changing circumstances, in order to stay in the race. And, when you are having the chance to improve the quality of your lifestyle and living, you should not let go off the chance. Indeed the applications of the Internet of Things have spiced up all the industries and will do so in future too.

Internet of Things (IoT) is an ecosystem of ever-increasing complexity, it is the future spirit of innovation that will humanize every object in our lives, which is the next level for the automation of every object in our lives. The convergence of technologies will make IoT implementation much easier and faster, which will improve many aspects of our home and work lives. This technology lets you assess your limitations, drawbacks and also provides you with the means to improve the same.

In IoT, many devices are being connected for the first time, and companies that haven't had to consider security in the past now find that their products are under attack. The first step towards security in IoT is to raise awareness of the threat and ensure that it is considered at every point in the infrastructure.

Our society is now totally dependent on the biggest ever network, the Internet; one of the major and most astonishing of human inventions. In this network, most of the information traffic is created and generated by people through email, the web and other user services. Now, after information digitization, transport and communication, ubiquitous computing is emerging. It relies on digitized information coming from the real-world environment, and allows us to build more task automation to better interact with the real-world environment.

Since The Internet of Things is a relatively new concept, it is still largely unknown and unexplored by many companies and employees in the industry. This limited knowledge may cause them to fear because they may be unaware of the potential security and privacy issues associated with their deployment.

This is why many businesses want to know more about the threats, benefits, disadvantages, and potential security-related solutions related to IoT. The Internet of Things comes with many risks, an attack by a hacker or the spread of malicious software can be disastrous.

But the components of IoT devices have in recent years become much more sophisticated and there are becoming less data and privacy issues, so the companies and businesses that are implementing The Internet of Things are more secure and have more data privacy in their systems.

We now have many ways in which these types of devices communicate, technologies like BlueTooth and Wi-Fi have opened up many possibilities for how these devices communicate and operate.

The IoT paradigm transform the industries into “cyberproduction systems” capable of being flexible and adaptive and fully aware on the production conditions. However, new way of filtering and processing the data should be considering in order to reduce the produced and transmitted data. The proposed work shows how the IoT paradigm in a simple case of a company of 100 machine tools considering different types of sensors can produce data and can lead to Industrial Big Data.

Implementing authentication modes have enabled these devices to be secure, but much more serious security work is needed.

The flexibility of IoT technology and embedded devices make them useful in a wide variety of applications and environments. By offering businesses an opportunity to increase automation and improve data processing and analytics, IoT is an attractive tool for organizations of all sizes. For these reasons, IoT devices will continue to drive change in a variety of industries over the next decade. As the technology matures and more vendors begin to compete, solutions will become more refined. Businesses that understand the opportunities IoT and embedded devices offer in their sector will be well positioned to benefit.

The above-mentioned industries are the top runners in the list that have used and are accustomed to IoT solutions. These industries with the proper knowledge have been able to improve and extend their business while providing better services to the people. However, these are not the only industries which can adopt the technology to bring the change. Industries like Hospitality, Financial Services, advertising etc. also have the capacity to embrace the idea and improve their services.

In conclusion, Internet of Things is the concept in which the virtual world of information technology connected to the real world of things, saves data and spreads different information. Users today can control anything from televisions to refrigerators through their smartphones.

The technologies of Internet of things such as RFID and Sensor make our life become better, more secure and more comfortable.

Finally, IoT is closer to implementation than people think. Most of the technological advances needed for it have already been made, and some manufacturers and agencies have begun implementing a version of it, such as Dell, GE (General Electric), Arm.

IoT has been a big influencer in fields like smart cities and homes, smart wearables, and enterprises where it has created a new level of convenience and increased opportunities for innovation. It has also made a huge impact on several key areas of modern-day industries. Today, devices embedded with dedicated sensors and software interact seamlessly with each other and with humans.

The Internet of Things changes your perspective and will let you be more productive in controlling your data and for the future of your business.

So i conclude this thesis by saying that the future of technology is inclusion of Internet of Things in our industry and in our businesses, by making them more profitable and more conveniet for the customer. After the identification of the main IoT-enabling technologies, issues and challenges, deployment and impacts, the next step is the design of the network architecture and framework to efficiently support the future IoT applications, and to provide security in data and privacy.

This will shape the future networking concepts and functionalities of the future Internet. Only the future will show how successful IoT services will be!

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