

A Short Literature Review on the Internet of Things: Research and Development Projects

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Abstract - There have been cases, where projects implemented the technological innovation early upon after introduction, while the technology field was still new and knowledge was not matured. The projects were predicted to fail, since the technology was still undeveloped, and that prediction came true. The same downfall has been suspected to happen to the field of IoT as well. This paper carries information on measures that have been taken in the areas of research, innovation and deployment IoT Solutions, an overview of projects funded by the European commission such as the iCORE project, COMPOSE project, the SmartSantader project and the Open IoT project, and how the Thing Commandment principles can be implemented to ensure better deployment of IoT solutions leading to the success of IoT projects.

Index Terms - Internet of Things (IoT); IoT architecture; project development

1. Introduction

Information has been an important part of our lives for centuries. This information gradually has been converted to knowledge, and people used that knowledge to improve their lives in various ways. It is the fuel on which the world is running on, today. The existence of the internet has been an important addition to the communication technologies, such as the television and the radio in the sharing of information. With the internet, individuals can choose the type of information they would like to access, and their knowledge on various topics is not subjected to control from the media. The internet can be compared to the circulatory system of the world. From it, information from every topic can be shared and is made accessible for everyone to use. This circulatory system has evolved over the years is no longer connecting people and sharing their information, but “things”, which are various forms of computers [1].

These days, computers are taking over jobs that humans have been doing originally; mostly, for manual labour that is done routinely. However, it is said to be possible for some cognitive tasks as well. For example the Enlitic's system that is used to determine if patients have cancer tumours by examining and comparing their CT scans is said to be better at the job than real doctors, with a 0% error rate, while real doctors are said to have an error rate of 7% [2]. According to a study by Benedikt Frey et al. (2013) on the computerization of jobs, it was found out that 47% of American jobs had a chance of being automated using computers. Especially those under transportation, logistics, sales and services as well as support jobs. While in Britain and Japan, this probability was 35% and 49% respectively [3].

Even though job automation and computerization is creating a threat to the job security of people in these countries, the benefits obtained from this is increased productivity, efficiency and accuracy and reduced cost for businesses or organizations [3]. This exceptional job performance has encouraged the connection of these computers to the internet, allowing them to communicate and increasing those benefits even more. The result is a new world where computers and people are all connected and share information. It is what is now called "The internet of things" (IoT).

A research conducted by Gartner; a popular information technology research and advisory company, about 20 years ago, predicted that most organizations that implemented new technology innovation soon after their introduction were going to fail in future due to the immature knowledge about the new technologies. This prediction came true, and many of those projects failed. This trend is suspected to also happen to IoT as well, reported by Sushil Pramanick, an IoT Leader for IBM analytics [4]. IoT is getting implemented rapidly to develop smart cities, industries, and very soon, homes, health and other domains will catch up. The aim of internet of things is to connect the environment, people, and objects. If IoT architectures fail just like some other previous projects, in the future, then it will create a domino effect of problems across all application domains involved that can lead catastrophic disasters. If the knowledge about IoT is improved, then all stakeholders will be able to avoid being affected.

2. IoT Architecture

The network architecture of IoT consists of 4 main layers [5]. It consists of the sensing layer also known as the device layer, the network and communication layer and a service support and application support layer. Fig. 1 depicts the architecture of IoT, briefly.

The sensing layer/ device layer is the interface where interaction between the physical world and the whole IoT network architecture is found [5]. The key components of the sensing layer are sensors. The sensor can detect either the presence of light , proximity or position, motion, velocity, and displacement, temperature, sound, pressure or load, gas, chemical substance and electricity [6].

Application layer is a layer that holds software applications that process data collected from sensors. These applications can vary depending on the type of data that is

collected by the network. The software can be fall in the domain of healthcare for example medical monitoring software, precision agriculture, transportation, supply chain management, disaster monitoring [5].

Key technologies that make up the IoT architecture include cloud computing, wireless communication, RFID technology, sensor technology, and advance internet protocol IPV6 [5]. Network layer that provide networking and transport capabilities to the IoT network [7]. Service support and application support layer is the part that deals with IoT service resolution [7].

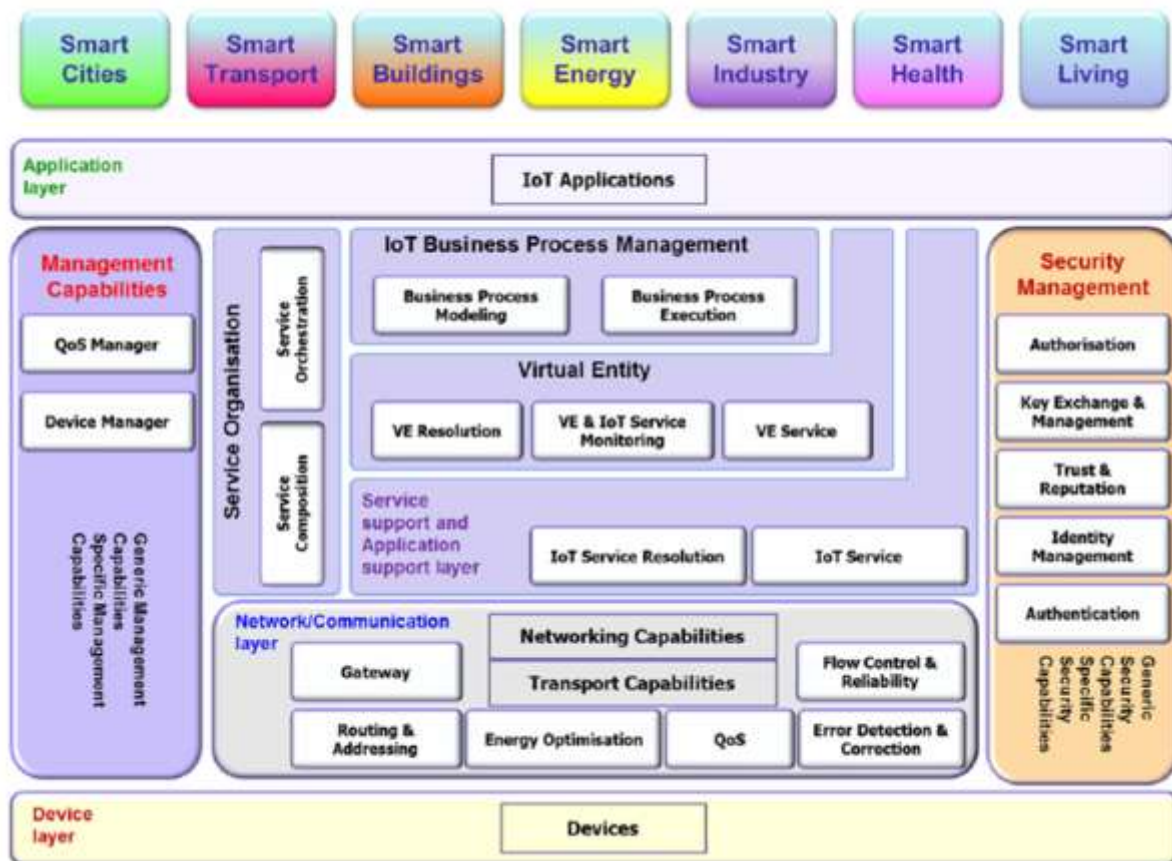


Fig. 1: IoT Architecture [7]

The internet of things (IoT) is now the solution to many world problems. It is applied in various domains such agriculture, healthcare, home, industries. Most of IoT solutions have been implemented in industrialized or developed nations such Japan, some countries in Europe, the USA. Examples of these IoT solutions include smart homes, smart cities, smart health, smart buildings [6]. Coming up with IoT solutions requires research into problems from an application domain, and research in available technologies to invent a solution. If the solution is deemed successful it is then deployed into a market relating to that domain [7].

3. Early Adoption of Innovative Technology

When new technology creates a "hype" once introduced to the public, people would want to use it [8]. In this century, the use of computer technology has become a vital part of many lives. Businesses are the ones that demand technology the most to maintain their competitive edge. This demand urges developers of technology to produce quick solutions to meet that high demand, once the idea of that technology catches their interest. According to the research by Gartner on several projects from organizations that did an early adoption of new information technology innovations, predictions were made that these projects were likely fail after a period of time, because the knowledge behind that technology was not mature enough. Developers and engineers chose to dive into the development of these technology solutions due to the high demand from businesses organizations without conducting enough research to ensure that the solution they are providing, was going to guarantee them a long-term success [9].

According to Gartner, about 20 years ago, there used to be a "hype" about data warehouse and business intelligence [4]. Many organizations were deciding to use decentralized reporting solutions, basic analytic solutions, or a combination of both. Unfortunately, after implementation, lots of problems relating to the quality of data were created, since they had built data warehouse platforms that were disconnected. This led to integration problems as well. Based on findings in 2005, half of these data warehouse projects had failed [9]. More projects continued to fail and by 2012, only 30% were found to exist [4].

According to Sushil Pramanick, companies are trying to embark on Internet of Things initiatives using very narrow, point-focused solutions with very little enterprise IoT strategy in place, and in some cases, engaging or building unproven solution architectures [4].

Since the motion has already been set and many organizations have done an early implementation of IoT technology, it is less likely that they will go back to old technology. No company would want to do that especially if there has been high profit obtained from it and they were leading among other companies in a market. It is also not possible for these organizations would want to abandon their implemented IoT solutions until proven ones have been made available, or until some planned strategy for the IoT enterprises exist.

4. Challenges in IoT

There are lots of challenges (shown in [Fig. 2](#)) that must be tackled in IoT. Under the technical category, there are challenges relating to reliability, and connectivity. In the policy category, there are issues relating to data, and legacy regulatory models. The third group of issues overlap between the both categories, such as standards, interoperability, and security [6].

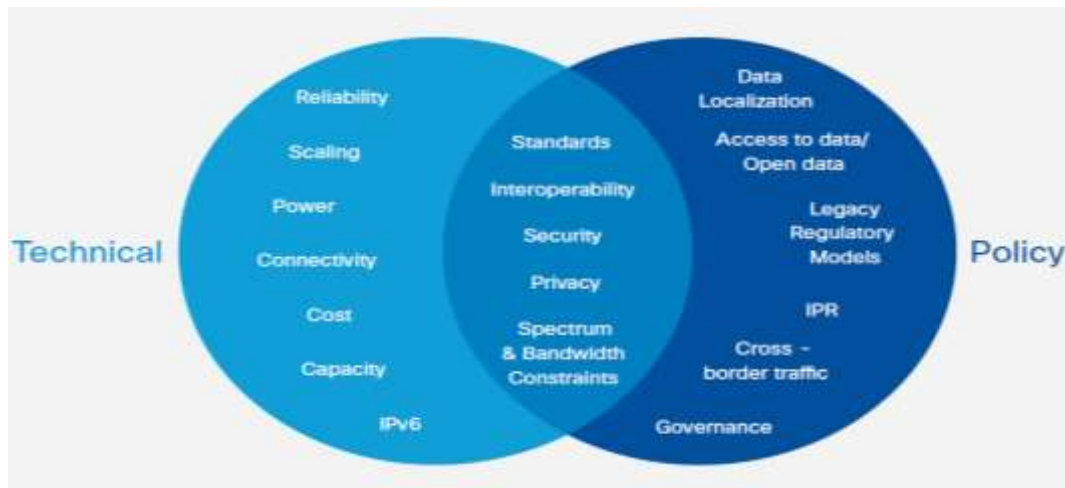


Fig. 2: Challenges faced in IoT [6].

When an IoT solutions comes into existence, it means there was a problem that needed solution. To solve any kind of problem, one needs to define it well, list down all possible solutions, and then choose the best of those solutions for implementation. To produce new IoT solutions, all these steps would require research.

Research can be performed at all layers of the IoT architecture. There are problems that require IoT solution in various application domains like healthcare to improve quality of services, environment management and monitoring, for example to ensure sustainability of resources, home and city automation to improve security, comfort, and efficiency in managing the cost of electricity and water, manufacturing industries to reduce the cost of manufacturing processes and to improve their efficiency [10].

Fortunately, in Europe, the European Commission (EC) has been trying to get people from different domains to work together so to promote the growth of joint research projects, as well as new innovations. This is a valuable strategy, because by placing people from different domain, all forms of research questions can be asked, and answered, producing more efficient results that will lead to more reliable innovative IoT solutions. Their biggest concern is to remove the problems caused by fragmentation found across technologies, for example network technologies, cloud computing technologies and application domains such as agriculture, environment, and health care. The EC has created a research and innovation agenda that holds all the all discussions about IoT project they are working on. Trends in technology are document in the agenda, application of those technologies, list of technology enablers, and lists of prioritized research[7].

It also holds the stakeholders taking part in the IoT European Research Cluster (IERC); which is an organization in Europe that tries to direct their attention and effort towards areas that hold great potential for IoT-based capabilities (IERC 2016).

5. IoT Project Development

Vermesan and Friess state that projects have four phases. The design phase; which is what happens before starting the project, the executions stage; what happens during the project, the result phase; which is what happens when a project ends, the acceptance and sustainability phase which is what happens after the project ends [7].

Design phase: Main problems or issues will be given special attention to, depending on what the purpose of the project is.

Execution phase: During the project, plans get to change based on the type problems that are encountered, or based on rising opportunities.

Result phase: A summary of what had been achieved is made, then they will be compared against expected results of the project. Special attention will be given to any lessons learned.

The acceptance and sustainability phase: This is the stage that is important to ensure success of the IoT solution into the market. There will be a sustainability plan prepared for problems that arise due to involvement of various stakeholders in IoT. Depending on what type of domain the IoT solution was designed for, this is will to help prepare for economic, social, or production process related problems.

6. Review of EC projects

The EC has funded many project for the advancement of IoT, but 3 projects have been highlighted to be most successful. These include the COMPOSE project, Smart Santander, and Open IoT [7].

6.1 The iCORE Project

It was a project that was enable the use of more cognitive technologies in IoT and making IoT based applications responsive to the need of users and adaptable to changes of those needs.

6.2 COMPOSE

The aim of this project was to enable integration between IoT and the Internet of Services (IoS) through a platform, where data from objects connected to the internet can be published, shared and used by other applications and services. It is a great tool that can be used by developers interested in developing smart applications that can communicate with smart "things" or devices, and accessing information from external sources.

6.3 SmartSantander

This project was created for the purpose of testing architectures under research or being experimented, testing important enabling technologies, as well as services to be used in IoT. This project had made Europe a leader in Internet of things technologies, as it enabled people in the science community to perform their experiments and do evaluations of services and applications for smart cities under real-life conditions.

6.4 Open IOT

This is a project that had been developed to encourage open source contributors and IoT researchers to work together. There are lots of community building activities. This project has been used to provide training services, support services.

Some researchers have tried to collect information on what it takes to move from research and innovation to market deployment using the above-mentioned projects [7]. However, there has been detailed information and emphasis on the research and innovation than deployment. Perhaps it is due to the extensive technical detail that would have to fill the documentations.

7. The Thing Commandments

Even though these can be considered new, a set of principles that can be applied to the internet of things had been proposed by Edewede Oriwoh, Paul Sant, and Gregory Epiphaniou from the University of Bedfordshire, UK. The aim of these principles is to give a guideline from which people can refer to, to make the right decisions and making them aware of the requirements for making the right choices, however these principles are focused on security. The principles can be applied by manufacturers and developers, and individual consumers. These principles are known as the Thing commandments [1].

Principle 1: Your thing is your thing

This principle states that objects belong to their owners, and owners should be responsible for them. In case, that object performs something wrong, the owner should be held responsible. This is to ensure that in a case a crime is committed using that object, the owner should bear some form of responsibility.

Principle 2: Your thing should have a relationship with all other things

All things of a particular owner should fall under one network, and they should be able to identify one another. Application of this principle will ensure that access is denied to any other objects that do not belong to the owner.

Principle 3: Your thing should be able to identify communication between each other by the use of an established method

The purpose of this principle is to make sure that no foreign objects are permitted access to the owner's network, and they should be detected as they try to communicate with the network.

Principle 4: Usability and ease of use

Owners should be able to perform configurations seamlessly, and make modifications such as adding new objects or "things" and removing them when they wish to. There should be no need for training, or service requirements from specialist vendors.

Principle 5: All things should be controllable by their owner

Vendors should apply this principle. They should ensure that all technologies used by the owners can be controlled fully by them. Those technologies should be user-friendly and should be easy to understand.

Principle 6: Everything should have an owner

Everything should hold a form of identification pertaining to the owner. The purpose of this is to help law enforcement agencies as they try to perform investigations in case a crime occurs.

Principle 7: Refusing, disabling and destroying or disposing of things

A person should not be forced to use objects that they do not approve of, and that it should not be difficult for people to dispose their objects when they need to. Once the object is destroyed, all data contained in that object should be destroyed as well.

8. Conclusion

Statistical research has shown the negative impact that early adoption of innovative technology had on previous information technology projects 20 years ago. Organizations such as the EC are working towards funding research and innovation projects to ensure the field of IoT technology stays successful. This shows awareness of the past failing technologies and importance of what role IoT will play in future for business and individuals. Various challenges faced in IoT are being given attention to by the European commissions. They do have a great involvement in the advancement of IoT such as encouraging stakeholders from the IERC in taking part in the endeavour, as well taking part in research. This has led to the existence of Innovative projects such as the iCORE project, COMPOSE project, the SmartSantander project and the Open IoT project.

Moreover, many scholars have also placed some efforts in contributing towards the success of IoT. Contributions from various sources will increase the chances of a brighter future in field of IoT. A list of principles that are worth of implementation for improved deployment have been proposed.

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