SLEIMAN ABDULLAHI ALI A framework for the Emerging Smart infrastructure In the IoT Era NEU 2021

# A framework for the Emerging Smart infrastructure in the IOT Era

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**BY**
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## DECLARATION

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this works.

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Finally, I would like to express my gratitude to my parents and well-wishers for their support and encouragement during our effort

I love you all.

## DEDICATION

**To my parents…**

## ABSTRACT

People are becoming more interested in utilizing the internet to manage and monitor many sorts of devices due to the rapid growth of internet technology and smart embedded systems. Nowadays there is an increasing need for automation and intelligent systems, which leads to reduced human interaction.

The Internet of Things lies at the heart of the smart building idea essentially the monitoring and management of household appliances are carried out through a sophisticated network of interconnected devices. The traditional homes/building don't have ability to control the home appliance remotely like the TV, fan ,lights and etc. in other words they are not convenient and comfortable for elderly and handicapped people because they can't use the building appliance without help.

The primary goal of this project is to design and build an internet of things based Smart infrastructure for homes. We implement and design a low cost, flexible, wireless solution to the buildings. The benefit of this system include energy savings, home safety, and user convenience. Furthermore, this mechanism could be used in different application such as offices, universities, banks, residential flats, houses, streets, poultry farms, greenhouses, and other similar building. In a word, this method can be applied to a variety of building and sectors in order to optimize their operation and make them smart. Consumers will be more aware of their power usage as they are able to monitor their energy consumption



**Keywords:** Smart infrastructure, IOT, Remote control, Smart Appliance

# ÖZET

İnternet teknolojisinin ve akıllı gömülü sistemlerin hızlı büyümesi nedeniyle insanlar birçok türde cihazı yönetmek ve izlemek için interneti kullanmaya daha fazla ilgi duyuyor, otomasyon ve akıllı sistemlere artan bir ihtiyaç var, bu da insan etkileşiminin azalmasına ve gelişmeye yol açıyor akıllı karar verme teknolojilerinin

Nesnelerin İnterneti (IoT), akıllı bina fikrinin (IoT) kalbinde yer alır. Esasen, ev aletlerinin izlenmesi ve yönetimi, birbirine bağlı cihazlardan oluşan karmaşık bir ağ aracılığıyla gerçekleştirilir. Geleneksel evler/binalar, televizyon, eğlence, ışıklar ve diğerleri gibi ev aletlerini yönetme ve uzaktan kumanda etme yeteneğine sahip değildir. mesafe, yani yaşlılar ve engelliler için uygun ve rahat değiller çünkü inşaat aletini yardımsız kullanamıyorlar.

Bu projenin birincil amacı, evler için bir nesnelerin interneti tabanlı Akıllı altyapı tasarlamak ve inşa etmektir. binalara düşük maliyetli, esnek, kablosuz bir çözüm uyguluyor ve tasarlıyoruz. bu sistemin faydaları arasında enerji tasarrufu, ev güvenliği, kullanıcı rahatlığı sayılabilir. Ayrıca, bu sistem ofisler, üniversiteler, bankalar, konutlar, evler, sokaklar, kümes hayvanları çiftlikleri, seralar ve diğer benzer binalar dahil olmak üzere çeşitli ortamlarda kullanılabilir. Kısacası, bu yöntem, operasyonlarını optimize etmek ve onları akıllı hale getirmek için çeşitli bina ve sektörlere uygulanabilir.

***Anahtar Kelimeler***: Akıllı altyapı ,IoT, Uzaktan kumanda ,Akıllı Cihaz

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| | |
|---|---|
| IOT | Internet of thing |
| HEMS | Home energy management systems |
| ENISA | European Union Agency for Cybersecurity |
| RFID | Radio Frequency Identification |
| M2M | Mobile-to-machine |
| SC | Smart Cities |
| ICT | information and communications technology |
| BMIS | building management and information system |
| PANs | personal area networks |
| LANs | local area networks |
| NANs | neighborhood area networks |
| WANs | wide area networks |
| WPANs | wireless personal area networks |
| 6LoWPAN | IPv6 over Low-Power Wireless Personal Area |
| NFC | Near Field Communication |
| BLE | Bluetooth Low Energy |
| PLC | powerline communication |
| AC | alternating current |

| | |
|---|---|
| IP | Internet Protocol |
| (G.hn | Global Home Networking |
| LAN | local area network |
| MoCA | Multimedia over Coax Alliance |
| IR | Infrared Sensors |
| CAGR | compound annual growth rate |
| GUI | graphical user interface |

# CHAPTER ONE

# INTRODUCTION

## 1.1 BACKGROUND

With the use of newly developed smart systems, technological advancements make human daily life easier. People are becoming more interested in utilizing the internet to manage and monitor many sorts of devices due to the rapid growth of internet technology and smart embedded systems. The Internet of Things (IoT) ushers in a new era of sophisticated intelligence computing, bringing in a creative evolution of the technological world(Mahmud, Ahmed, & Shikder, 2019)

We all wonder of having the entire work completed automatically. Home automation is one of the solutions that fits this circumstance perfectly. Home automation or a smart home is a term that refers to technology that is utilized in the home environment to bring comfort, protection, accessibility, and energy efficiency to the user or residents. Home automation is a term that refers to the process of controlling and monitoring various household appliances in real time(H. K. Singh, Verma, Pal, & Pandey, 2019).

IOT was coined in 1985 by Peter T. Lewis and literally translates as "internet of things." "The Internet of Things, or IoT," he explained in his presentation, is the integration of people, processes, and technology with connectable devices and sensors in order to enable remote monitoring, status view/manipulation, and trend analysis of such devices and sensors. When gadgets, automobiles (sometimes referred to as "connected devices" and "smart devices"), and other objects are combined with electronic components and software, as well as sensors, actuators, and network connectivity, it is referred to as the Internet of Things (IoT).The Internet of Things enables these items to gather and share information with one another. In addition to the term "Internet of Things," the Internet of Things (IoT) is sometimes referred to as the

"Internet of Things." "Devices that are connected to the Internet of Things" (Internet of Things devices)." (Jerabandi & Kodabagi, 2018) .

Nowadays, there is an increasing need for automation and intelligent systems, which leads to reduced human interaction and the development of intelligent decision-making technologies. The expense of just forgetting to switch off lights and electric appliances in your classroom may quickly pile up. Temperature and lighting control based on the time of day or occupancy can significantly decrease energy expenditures. By automating your heating and lighting systems, for example, can be handed to a smart system, allowing you to avoid the costs associated with human error and saving money. The advantages of intelligent building efficiency are not confined to the office environment alone. As energy prices continue to rise and household budgets become more constrained, home automation systems will become more tempting investments as their efficiency improves and costs fall as a consequence of technological advancements and economies of scale, among other factors(Gupta & Chhabra, 2016).

The Internet of Things is useful in a wide variety of applications, including administration, environmental management, practical surveillance, infrastructure, commercial applications, power management, medical applications, smart homes, and transportation infrastructure. A great deal of attention is being paid these days to the development of Internet of Things-based technologies for home automation, and numerous researchers are working in this field. Remote monitoring and management of household appliances is made possible via the use of portable devices and computers connected to the internet, which are known as home automation systems.

### 1.2 Problem statement

Building accounts a significant portion of the world's energy consumption, with electricity accounting for more than half of all energy consumed in households. In addition, all most half of the global carbon dioxide emission are emitted from the electricity and contributes the global warming that is increasing dramatically.

The traditional homes/building don’t have ability to manage the home appliance like the TV , fun, lights and others and they can’t control them in a remote distance ,in addition they are Unable to detect and eliminate waste of electricity resource and that has big impact the electricity bills of the households and big buildings . In other words, they are not convenient and comfortable for elderly and handicapped people because they cannot use the building appliance without help.

Getting the advantage of internet of thing it is possible to make the household and building smart thus, the smart building can have the ability to control household and building appliance in remote and alerts the users when energy theft occurs. Furthermore, it is convenient and comfortable and gives the elderly and handicapped people ability to control the building appliance without asking help just by using their mobile, voice or tablet.

**1.3 Motivation**

One of our reasons for writing this thesis is to discover the practical relevance of implementing IoT in buildings. As a result, to provide users, project developers, businesses, and academics with an overview of the present development in the IoT area of smart building. The analysis of the pros and drawbacks, technologies, frameworks, platforms and so on . Smart infrastructure and home automation is a continuous research topic, but we discovered in the literature that there is a need for fresh research to address gaps in the present systems study.

As a result, we are interested in learning about the services that are suitable to home automation . Making numerous valuable services available at home is made possible by the Internet of Things. In order to make life simpler, it is possible to create an automated house that is useful to the economy and society as a whole. The impact of integrating smart infrastructure into the consumer's home was also something we were interested in learning about!

## 1.4 Thesis Aim

In this thesis, the primary goal is to study the design and assessment of a contextual authentication framework for smart building infrastructure. This framework includes a user authentication model that protects smart home IoT devices from unauthorized access.

One of the primary goals of this project is to design and create a Smart infrastructure for houses that is based on the Internet of Things. We execute and develop a low-cost, adaptable, wireless solution for the buildings that is both functional and aesthetically pleasing.The approach discussed in this project is simple and the target is to control home appliances remotely the benefit of this system include efficiency gains, home security, user convenience, and improved control. be more economical, efficient, and is able to solve problems independently. Consumers will be more aware of their power usage as they are able to monitor their energy consumption. Hence, this avoids overloading and unnecessary uses of electrical appliances

## 1.5 Research Contribution

This thesis's main contribution is a contextual authentication framework for smart home contexts, as well as the individual contributions that comprise the framework.

Contributions Overall, our main contributions to the research community with this thesis are summarized as follows:

A taxonomy and quantitative study of smart linked home devices

A threat agent model for the smart connected home;

Designing and implementing in real life an IOT based smart infrastructure.

Comparing the model with similar others approaches and standards.

The implementation and evaluation of a proof of concept prototype as well as the utilization of contextual information for context-based

Detailed review of the role, impact, and challenges and recommended solutions for

Implementing IoT in building environments.

## 1.6 Proposal Organization

The dissertation is divided into five chapters, plus references and appendices.

Chapter 1: Provide an overview of the research and its context. The study's reasoning (aims, goals, research methods, dissertation outline and organization)

Chapter 2-Literature Survey: Include a review of the literature on the major subject of research. This chapter introduces the conceptual framework that will be used to comprehend the remainder of this thesis. This contains a brief history of smart houses, market studies, the benefits of smart building, smart building components, and many other subjects.

Chapter 3-Research Methodology:

Include a brief overview of research techniques and a description of the methodology used in this study.

Chapter 4- Results Analysis and discussion .

Chapter 5– Conclusions and Recommendations: summarizes the thesis and identifies some opportunities for future work.

# CHAPTER TWO

# LITERATURE REVIEW

This chapter summarizes the literature on smart homes, home energy management systems (HEMS), the Internet of Things (IoT), and the electricity market. In general, the information contained in the smart home offers the technology, tool, and algorithm necessary to construct an energy-efficient system. The significance of these resources and their autonomous operation will be explored later in the thesis. This literature review analyzes previous research and its relevance to the present investigation or task. The previous research will identify research gaps in order to include a part on research motives in the present works.

Smart home's has software and hardware components such as Home Energy Management System (HEMS), machine learning, Multi-Agent System (MAS), Internet of Things (IoT), and electricity market. These components are further elaborated in the following sections

## 2.1 Overview of Internet of thing

John Romkey created the first Internet gadget, a toaster that could be operated remotely through the Internet, in 1990. Steve Mann invented the WearCam technology in 1994. Using a 64-processor machine, it was able to achieve near-real-time performance. In 1997, Paul Saffo provided the first concise explanation of sensors and their potential future course of action, which was published in Scientific American. Kevin Ashton, executive director of the Auto-ID Centre at Massachusetts Institute of Technology, invented the phrase "Internet of Things" in 1999. In the same year, they also developed a worldwide RFID-based item identification system that is still in use today. In 2000, the electronics company LG revealed intentions to unveil a smart refrigerator that would be able to identify whether or not the food products kept in it needed to be refilled. This was a significant step forward in the commercialization of IoT. RFID was first implemented at a large scale in the United States Army's Savi program in 2003(Dvali & Belonin, 1966)

IoT, according to the European Union Agency for Cybersecurity (ENISA), is "a cyber-physical ecosystem of interconnected sensors and actuators that enable intelligent decision making." (enisa.europa, n.d.). The Internet of Things, as defined by the International Telecommunication Union, is "a global infrastructure for the information society that enables advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies"(Villamil, Hernández, & Tarazona, 2020)

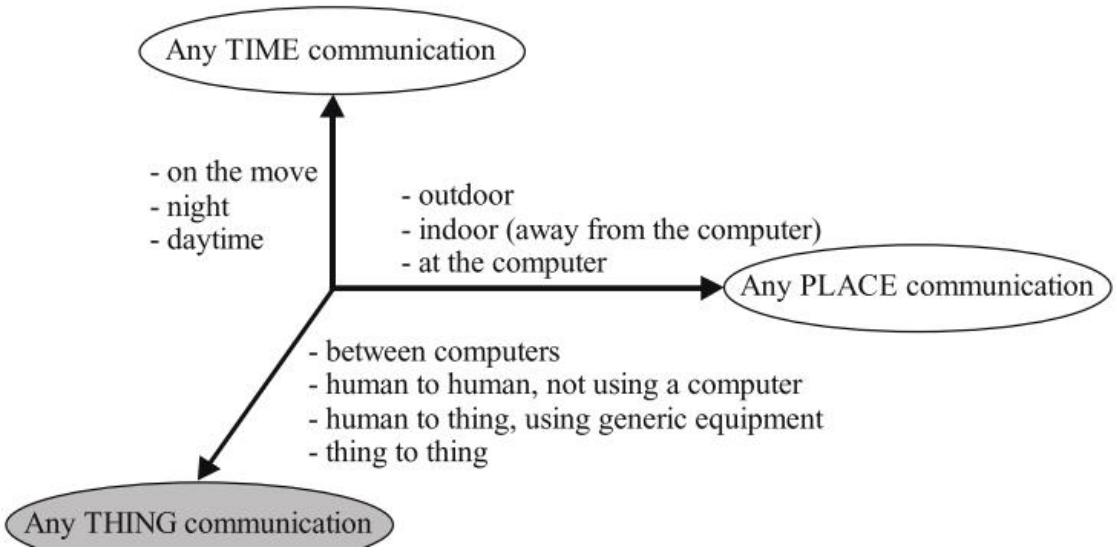


Figure 2.1 Overview of internet of thing(Villamil et al., 2020)

### 2.1.1 IOT applications

The Internet of Things (IoT) has numerous and diverse applications in many aspects of people's day-to-day lives, which extensively span society, industry, and the environment, among other things. Internet of Things (IoT) applications are becoming increasingly popular around the world. Countries in Western Europe, North America, and China are among the most important drivers of this trend. From 5.6 billion connections in 2016 to 27 billion connections in 2024, the number of machine-to-machine (M2M) connections is anticipated to rise significantly.

this growth confirms the Internet of Things as a major future market with the potential to become a cornerstone of the fast growing digital economy. The Internet of Things is expected to grow

in revenue from $892 billion in 2018 to $4 trillion by 2025. M2M connections are utilized in a broad variety of applications, including smart cities, smart environments, smart grids, smart retail, and smart agriculture. (Hassija et al., 2019)

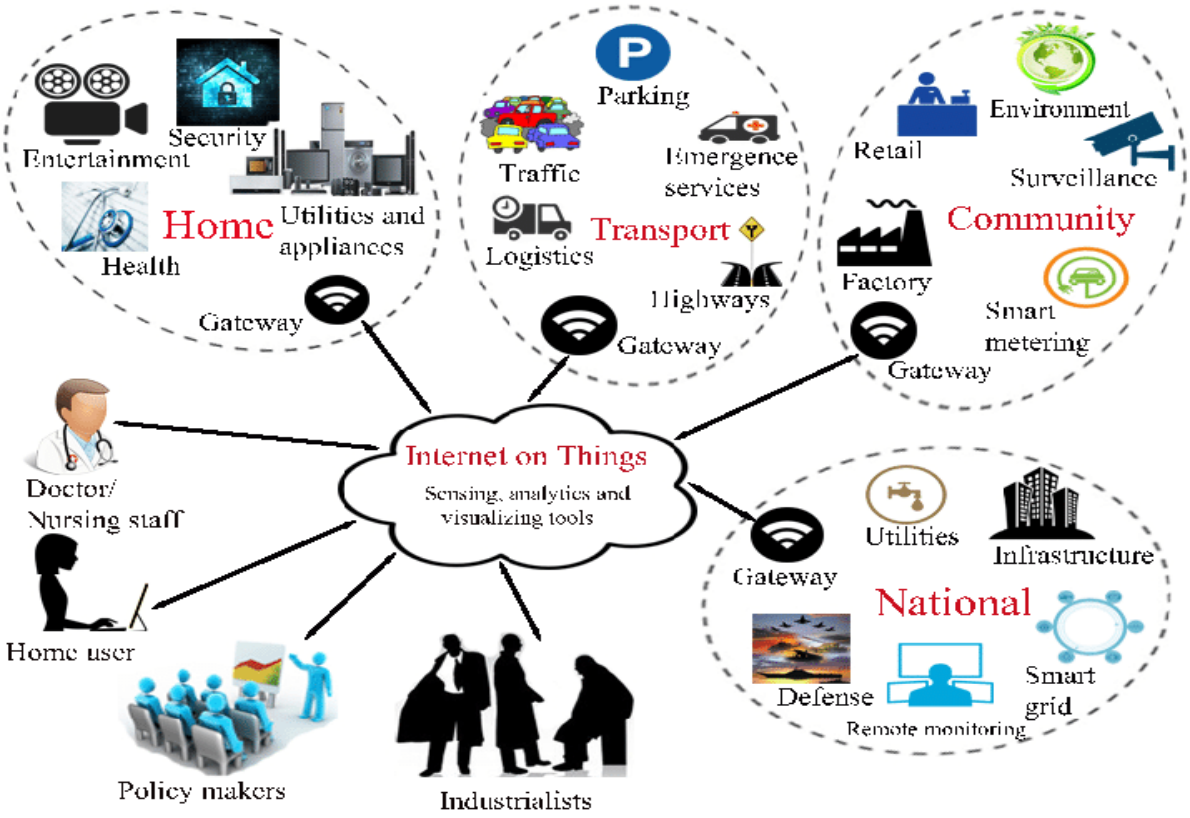


Figure 2.2 IOT applications in a nutshell (Bhuvaneswari & Porkodi, 2014)

### 2.1.2 IOT in Smarts cities

When we talk about Smart Cities (SC), we are talking about the use of information and communication technology (ICT) to improve the overall quality, connectivity, and performance of numerous urban services. The Internet of Things (IoT) is considered one of the most important models of information and communications technology (ICT) used for the next generation of computing and promoted by SC technologies. Smart mobile devices, sensors, and

RFIDs (Radio Frequency Identification) provide the real-world user interface. The Internet of Things (IoT) is a concept that brings together elements such as sensors, microcontrollers, actuators, and RFIDs to form a network that connects communication interfaces and computational capabilities(Saleem, Zeebaree, Zeebaree, & Abdulazeez, 2020)

Development in computer-procedural systems (CPS) will provide characteristics such as adaptability and scalability, resilience, safety, security, and usability that will greatly surpass the capabilities such as adaptability and calability, as well as the usability of today's fundamental embedded systems. When it comes to how people engage with built systems, CPS technology will fundamentally alter the way they do so, Similarly to how the Internet altered how individuals engage with information in recent years. Agriculture, energy, transportation, building design and automation, healthcare, and manufacturing are just a few of the industries where the new smart CPS will foster innovation and competitiveness, the Capitol Building reports.(Jara et al., 2015).

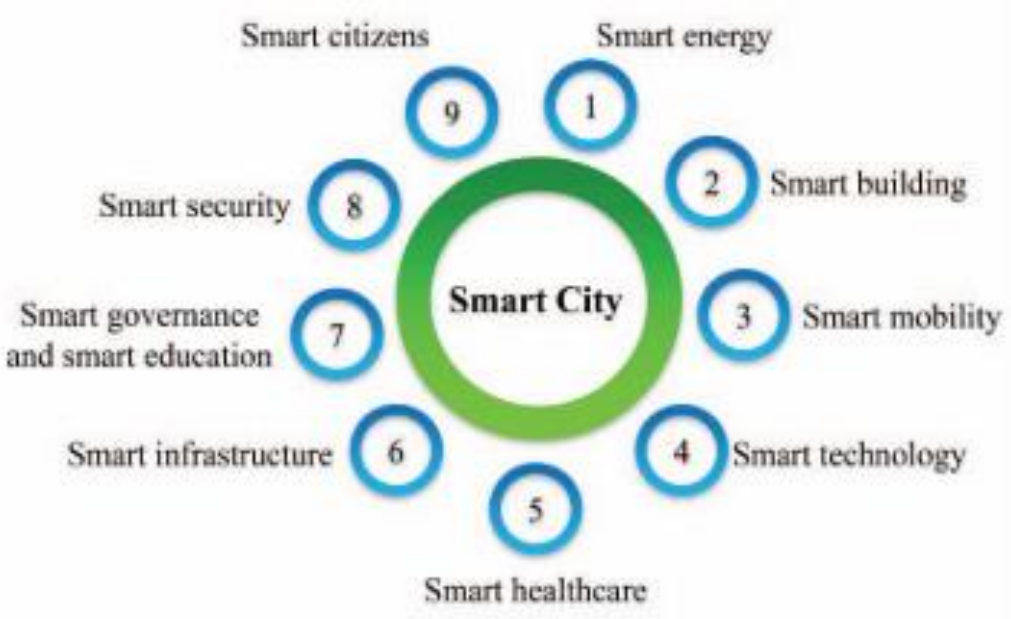


Figure 2.3 smart city overview (Arasteh et al., 2016)

### 2.1.3 IOT hardware

The Internet of Things (IoT) is a type of platform via which any sort of activity may be watched online, and it is becoming increasingly popular. In this platform, the hardware development platforms for Internet of Things-based hardware, software, and the user for monitoring are connected, and the user may monitor physical activity while also regulating other activities. Nowadays, the need for smart devices is rising at a rapid pace, and many types of Internet of Things hardware and software are being created to meet this need. Each module's development platform, communication protocols, and other specifications (D. Singh, 2020).

Major IT firms and organizations such as Microsoft, Cisco, Intel, and certain hardware makers have forecast the rapid expansion of the Internet of Things idea. As a result, he has a large selection of embedded operating systems, many of which already include development tools, as well as platforms that can support a variety of processing speeds, RAM sizes, and extra features like as Wi-Fi/Ethernet modules, input/output ports, and so on(Polianytsia, Starkova, & Herasymenko, 2017).

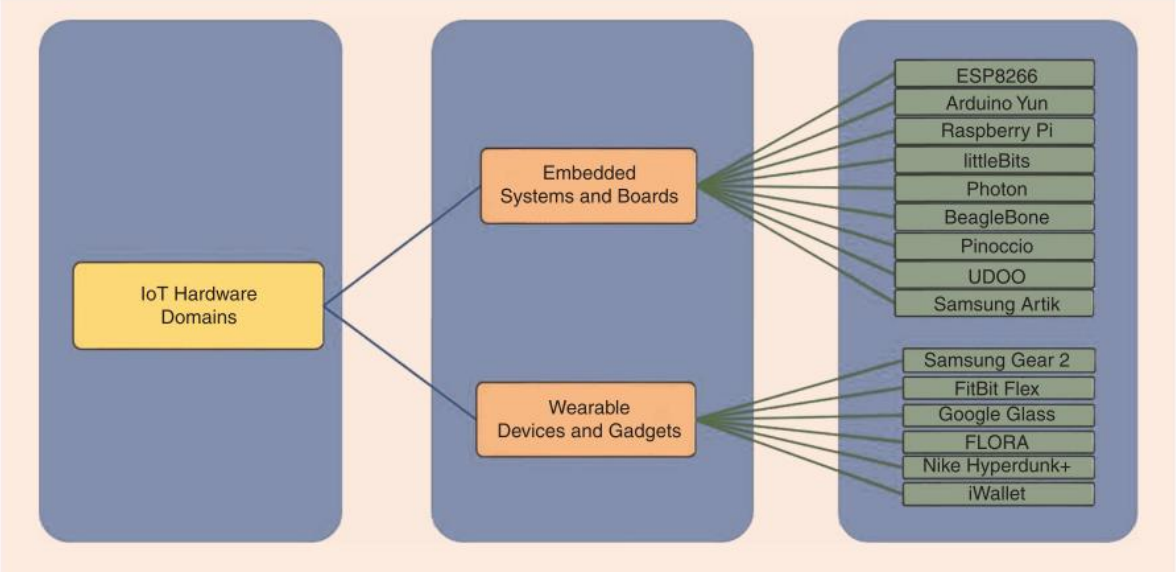


Figure 2.4 *IOT Hardware* (K. J. Singh & Kapoor, 2017)

#### 2.1.3.1 Raspberry pi

In the years after its release in 2012, the Raspberry Pi has garnered widespread recognition as a computer board that is tiny and powerful, yet reasonably priced, hackable, and geared toward education applications. (See Illustration 1) On the surface, it operates in a manner similar to a normal personal computer, with the addition of a keyboard for command entry, a display unit, and a power supply. This credit card-sized computer offers a variety of capabilities and is the appropriate platform for interacting with a wide range of devices and peripherals. It has numerous functions and is priced between $25 and $35 dollars, making it an excellent value. The central processing unit (CPU), graphics processing unit (GPU), audio and communications equipment, and a memory chip with a capacity of either 256 MB (Model A) or 512 MB (Model B) are all included in a single component (Model B). There are two types of components on the Raspberry Pi board shown in Figures 1 and 2. A mandatory component (the CPU, graphics chip, and random access memory - RAM) and an optional component (additional optional devices) are both present. (A number of different interfaces and connections for peripherals.) When it comes to the Raspberry Pi's central processor unit (CPU), it's a 32-bit, 700MHz System on a Chip (SoC) that's based on the ARM11 architecture and can be overclocked to give it even more power. SD Flash memory performs the same function as a hard drive in terms of the Raspberry Pi's CPU performance(Maksimović, Vujović, Davidović, Milošević, & Perišić, 2014)

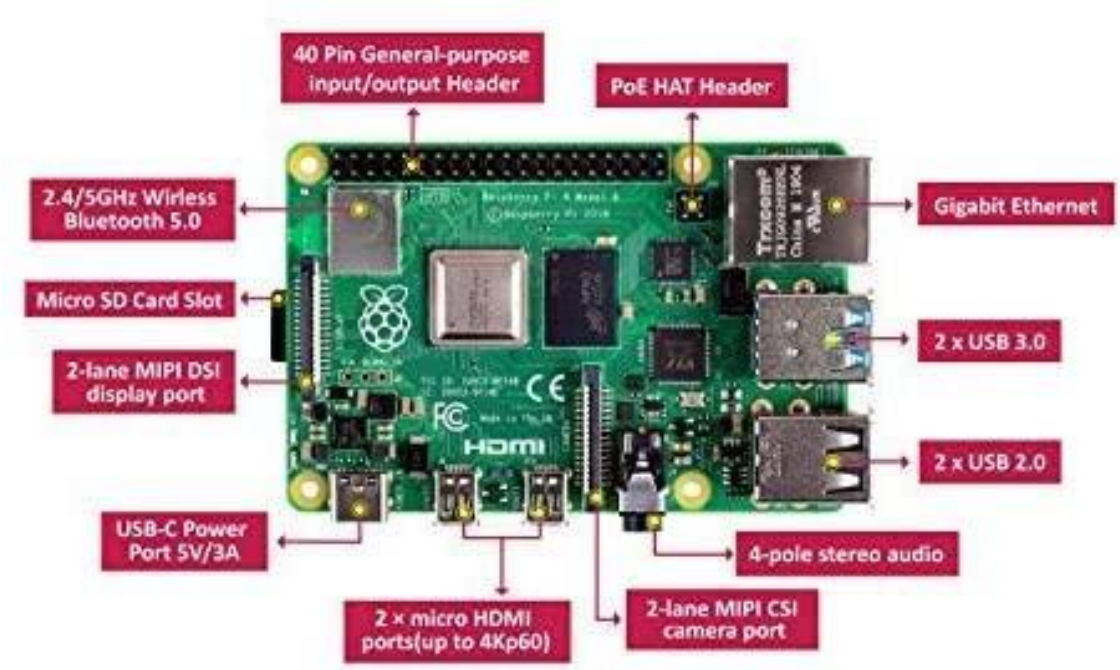


Figure 2.5 Raspberry pi

## 2.2 Overview of smart building /infrastructure

In order for the smart building concept to work, it has to be connected to the Internet of Things (IoT). Monitoring and control of household appliances are carried out primarily through a complex network of interconnected devices that are connected to one another. Connecting a range of electronic devices to a wireless network, the Internet of Things (IoT) offers customers with adequate information to make informed decisions. In the sector of building management, the Internet of Things has made it possible to deliver a more cost-effective and efficient solution. Working in tandem, the building management and information system (BMIS) and the Internet of Things (IoT) produce what is referred to as a "building internet of things" or "building internet of things" The development of the Internet of Things Buildings themselves are intelligent, energy efficient, environmentally friendly, and sustainable, among other attributes. The Internet of Things allows you to control your interior physical equipment from anywhere in the world, and the building itself is intelligent, energy efficient, environmentally friendly, and environmentally sustainable. (Verma, Prakash, Srivastava, Kumar, & Mukhopadhyay, 2019).

The significance of building automation is especially crucial for operations aiming for continuous interior comfort with energy-efficient control of building systems.This is because it helps to identify and eliminate energy waste by only utilizing energy when it is needed (ii) by implementing the appropriate control function level for the appropriate application at the appropriate location. To ensure that the residents of a building have a productive, healthy, and safe working and living environment, it is critical that the building's heating, ventilation, and air conditioning systems be properly controlled and maintained. In addition to having a well-designed structure and an efficient HVAC system, Smart Home Systems are the term used frequently in the residential market to refer to building automation. the idea behind it is to link sensors, appliances, and gadgets over a communications network in order to remotely monitor, access, and manage the home environment (Fabi, Spigliantini, & Corgnati, 2017)

Several intelligent building management systems, including Intel's Building Management Platform and those from other businesses, have developed in recent years. Home automation is becoming increasingly popular. 'Smart buildings' make use of a variety of sensors and communication equipment that allows the building's occupants to automatically control and monitor the actuators in the building while they are away from the building. To make the building intelligent, a combination of electronic devices such as sensors and actuators, network communication devices, and a central processing unit is used, which allows for remote monitoring and control of the actuators in the building while away from the building(Havard, McGrath, Flanagan, & MacNamee, 2019).

The smart building allows for the collection of environmental information, the analysis of that information, and the implementation of control. According to IBM study, smart buildings have the potential to reduce water use by 30 percent to 50 percent, as well as CO2 emissions and energy consumption by 50 percent to 70 percent. Energy management and home services are the two most important areas where the Internet of Things may give a range of benefits. (Gebbran, Chapman, & Verbic, 2018)

### 2.2.1 components of smart building

There are three types of hardware components that are typically utilized in a building automation system: sensors, actuators, and controllers. Sensors are devices that measure and record essential variables such as temperature, humidity, and occupancy, as well as monitor and record occurrences such as fires, such as abnormal activity, security breaches, and fire outbreaks. Sensors are used in a variety of applications, including fire detection and suppression. Devices that generate output include: Devices such as relays, actuators, and other similar devices that react to and carry out instructions supplied by the controllers are referred to as actuators. Controllers are specialized computers that process the data gathered and trigger the necessary reaction or action as a result of such processing. They connect with one another using predefined communication protocols, and the user has access to and interaction with them through dashboards and graphical user interfaces installed on their workstations.
The smart building/home automation system is comprised of four major components.

The first component is the user interface or end device, which is where the user sends instructions, orders items, or monitors home appliances by pressing a button in a smart home, using a laptop, a desktop, or simply using voice commands. The second component is the control system. The second component is the medium or communication channel that transmits information from the end user to the central hub. This channel can be either wired or wireless in operation. The third component is the microcontroller, which serves as the system's brain, storing and executing instructions. All of the electrical appliances are connected to the central hub by actuators, some of which include the Arduino, Raspberry Pi, and Node MCU, among others. Sensors and actuators are the fourth component of a smart building; they are the components that interact with the environment and gather information (Paul, Ganesh, & Sunitha, 2018)

### 2.2.2 Communication technologies in smart building

The range of a network is generally divided into four categories: personal area networks (PANs), local area networks (LANs), neighborhood area networks (NANs), and wide area networks

(WANs). Personal area networks (PANs) are networks that are limited to a single computer or device (WANs). PANs are typically wireless and have a range of around 10 meters. A typical wireless personal area network (PAN) consists of a smartphone that is connected by Bluetooth® to a small number of peripherals such as a wireless headphone, watch, or fitness gadget. Small batteries and limited radio transmission power are typical characteristics of wireless personal area networks (WPANs). LANs can be either wired or wireless in nature (or a combination of the two). Wireless LANs (WLANs) are often capable of providing a range of up to 100 meters. A common example is a home Wi-Fi network that provides internet connectivity to personal computers, cellphones, televisions, and Internet of Things devices such as thermostats and household appliances. NANs are typically wireless and have a range of more than 25 kilometers. They transmit at high power levels while relaying just a small amount of data traffic. A smart grid network, for instance, sends electric meter readings from houses to utility firms using a proprietary protocol over a 900MHz radio frequency. Finally, wide area networks (WANs) are dispersed across a very broad region – as vast as the entire planet. The internet is referred to as a wide area network (WAN), and it is made up of a complicated mix of wired and wireless connections.(Lethaby, 2017)

The equipment used in smart buildings, such as sensors, routers, and actuators, must communicate with one another using specialized communication technology. The type of communication they use can be either wired communication or wireless communication, and the range of the wireless communication can be either short range or long range wireless communication. In this part, we'll go through the communication technologies that are employed in smart building construction.

#### 2.2.2.1Wireless communication

**Z-Wave** is a proprietary wireless communication technology that may be utilized in both home and light commercial environments, according to the manufacturer. It was initially intended for use in home automation applications, specifically remote control applications, but it has since been adapted for a variety of other purposes. Lights, home access control, entertainment

systems, and household appliances are just a few of the applications that make use of low-power radio frequency (RF) transmitters, amongst other things. The low power consumption and cheap manufacturing costs of Z-Wave make it a simple technology to include into consumer electronics goods such as battery-operated devices such as remote controls, smoke alarms, and security sensors, to name a few(Musewerx, n.d.).

Due to the fact that **Thread**'s development is primarily focused on home automation, it is capable of supporting a wide range of home-use applications such as appliance control, access control, climate control, and energy management, amongst others. Thread is currently in the early stages of development. Thread, in addition to assisting with lighting settings, also provides aid with safety and security measures. As a result, a variety of home-use applications are enabled, including appliances, access control, climate control, energy management (including lighting), and security. As well as business applications such as warehouses and distribution centers, the system is capable of supporting a wide range of residential applications as well. It was formed by a consortium of seven businesses, including ARM (Softbank), Big Ass Fans, Freescale (NXP), Nest Labs (Google), Samsung Electronics, Silicon Lab's, and Yale Locks. Thread Consortium, Inc. is a for-profit corporation. Thread Group, Inc. is a for-profit business enterprise. Thread Group, Inc. is a privately owned business with its headquarters in the city of San Francisco, California. Thread Group, Inc. was founded in 1999 and is headquartered in San Francisco(Unwala, Taqvi, & Lu, 2018).

Individual personal area networks (PANs) comprised of small, low-power digital radios can be established through the use of the **ZigBee communication protocol**, which is one of the communication protocols that can be used to construct PANs and is one of the protocols that can be used to construct PANs. In networks where a low data rate as well as a long battery life are necessary in order for the network to function effectively, it is based on the IEEE 802.15.4 standard and is utilized. Its consistent communication rate of 250 kbps makes ZigBee an excellent choice for data transfer that occurs on a regular or intermittent basis. ZigBee technology is used by a wide range of enterprises, and it includes wireless switches, meters for

a HAN, and other equipment that requires short-range wireless data transfer at low rates, among other things. While current wireless premises area networks, such as Wi-Fi, are quite complex and costly, the ZigBee standard states that the technology specified by the specification should be simpler and less expensive than the technology described by the specification. ZigBee networks are protected by symmetric encryption keys with a key length of 128 bits, which are used to protect the networks' data transmissions and data storage..(Bian, Kuzlu, Pipattanasomporn, Member, & Rahman, 2014).

**6LoWPAN** is connecting a growing number of items to the cloud on a daily basis. With its low-power, IP-driven nodes and interoperability with huge mesh networks, this technology is a great choice for Internet of Things (IoT) applications. IPv6 over Low-Power Wireless Personal Area Networks (also known as 6LoWPAN) is a networking method or adaptation layer that allows IPv6 packets to be carried successfully inside small link layer frames, such as those defined by IEEE 802.15, without requiring additional power(Olsson, 2014)

**Wi-Fi is** a wireless Internet and network communication technology that allows users to connect to the Internet and other networks at high speeds without the need for a physical connection. Its standard is based on the IEEE 802.11 standard, and it is capable of working at frequencies of 2.4 GHz, 3.5 GHz, and 5 GHz. It is also capable of functioning at a range of other frequencies. Typical Wi-Fi coverage ranges from a few meters to more than 100 meters, with data rates ranging from 2 Mbps to 600 Mbps in most situations. Wi-Fi provides connections that are reliable, secure, and capable of supporting large data rates. As a result, Wi-Fi devices are both more costly and waste more energy than alternative short-range wireless technologies, such as ZigBee, which are also used for home automation5.(Bian et al., 2014).

This technology is a member of the low-power wide-area network **(LPWAN)** family of technologies, which is used primarily for the development of IoT networks when the volume of data sent (which is oftentimes taken from sensors) is low (ranging from a few bytes to hundreds of kilobytes), the operating range is large (reaching tens of kilometers), and the current consumption is extremely low (less than a microampere) (in the order of mA or tens of mA per

transmission). It is necessary to use D-BPSK modulation when sending a message using SigFox since the message has a fixed bandwidth of 100Hz and must be carried at a speed of 100bps in Europe and 600bps in the rest of the globe else the message will not be delivered (for the United States)(Lavric, Petrariu, & Popa, 2019).

**RFID** International organizations such as ISO, IEC, ASTM International, the DASH7 Alliance, and EPC-global govern radio frequency identification (RFID) technology. A radio frequency tag system consists of a reader and a tiny radio frequency transponder, referred to as an RF tag, which communicates with the reader through radio frequency transmission. Despite its little size, this tag has been electronically encoded with unique data that can be deciphered from a great distance. RFID tag systems are classified into two types: active reader tag systems and passive reader tag systems. The use of active reader tag systems is more prevalent than the use of passive reader tag systems. In terms of RFID tag systems, the most popular type is the active reader tag system. In comparison to active tags, which are battery-powered and hence more expensive, passive tags operate at lower frequencies and lack an internal power source. Additionally, active tags are more costly. Due to the fact that RFID information is static and must be programmed into the tag prior to usage, it cannot be utilized quickly to collect measurement or diagnostic data. Commerce, health care, national security, and agriculture are just a few uses of the Internet of Things that leverage radio frequency identification technology...(Al-sarawi, Anbar, Alieyan, & Alzubaidi, 2017)

**NFC (Near Field Communication)** is a wireless communication method with a very small range that enables data to be sent between devices just by touching them or bringing them within a few inches of one another.. It is most commonly used in mobile phones and other small electronic devices. Regarding technology, RFID and NFC are both built on ideas that are comparable to one another in terms of their foundations. When it is employed at the 686 level, however, it is not only utilized for identification, but it is also used for more sophisticated two-way communication that is more difficult to decipher. The NFC technology provides a tag that may store a very little amount of data when it is used. Depending on the configuration, this tag

can be either read-only (akin to RFID tags used for identifying purposes) or rewritable, allowing it to be modified by the device at a later time (Al-sarawi et al., 2017)

**Bluetooth** Low Energy (BLE) is a wireless technology that transmits data at a low power level (LE) As a connection-oriented technology, Bluetooth has historically been used in conjunction with other devices and is not capable of connecting directly to the internet on its own. The establishment of a connection does not preclude the continuation of that connection even if no data flow occurs. Bluetooth low energy (BLE), commonly known as WI Bree, is a subset of the Bluetooth v 4.0 standard that was announced in 2013. It is a subset of the Bluetooth v 4.0 standard that was launched in 2013. This version includes new protocol stacks and profile designs, as well as bug fixes. As of June 2010, this version has been formally accepted by the government. Through the use of a unique advertising mechanism, fast dissemination, and connection enablement, asynchronous connection-less MAC is able to deliver a low latency rate and speedy communication. Due to the introduction of the New Generic Attribute Profile, which is more user-friendly than the previous version, Bluetooth 4.0 is considered to be user-friendly.. (A.ur-Rehman1, 2013)

**Table 1** Comparison of Communication protocol

| variables | Wifi-halow | BlE | zigbee | Z wave | thread | NFC | sigfox | lorawan |
|---|---|---|---|---|---|---|---|---|
| standard | IEEE 802.11ah | | IEEE 802.15.4 | IEEE 802.15.4 | IEEE 802.15.4 | | | IEEE 802.15.4 |
| Data rate | | 2 Mbps | 250 kbps | | 250 kbps | | | |
| range | 100m | 750m | 150m | 50m | 100m | 20cm | 25km | 50km |
| frequency | 2.4GHz | 2.4GHz | 2.4GHz | 900MHZ | 2.4GHz | 2.4GHz | 2.4GHz | 2.4GHz |
| Alliance | Wi-Fi Alliance | Bluetooth SIG | Zigbee Alliance | Z-wave Alliance | Thread group | | | Lora Alliance |
| Power | High power | Low power | Low power | Low power | Low power | Low power | Low power | Low power |

#### **2.2.2.2** Wired **communication technologies**

in this section we will briefly discuss commonly wired communication technologies used in smart infrastructure let's start by listing the most used ones

**Powerline communication** In smart infrastructure and building systems, powerline communication (PLC) has become a popular communication technique since it makes use of existing domestic electrical wiring to transmit information. To put it another way, power line communication (PLC) is a technique that employs power lines as the physical medium for data transfer. Because the infrastructure has already been created, PLC provides a solution that does not need the installation of additional cables. Power line communications (PLC) modems are used for transmitting data at high speeds over a power line in a home or office, a building, or a factory, among other places. When information is sent from a transmitter or control station to one or more receivers, the alternating current (AC) power cables already in place act as a transmission medium.(Dange & Gondi, 2011).

**X10** to transmit and receive commands, X10 makes use of your current electrical wiring, which allows you to use your current electrical lines to automate your house. It is a technique that uses electricity lines. Pico Electronics invented the protocol in 1975, and it is still in use today, despite the fact that technology has not progressed to keep up with newer systems. X10 may be readily integrated into existing houses, eliminating the need for extra communications infrastructure. The use of wiring is more dependable than wireless technology and allows it to interact with any site that has an electrical outlet, socket, or switch.

**Knx** There are no restrictions on how it may be utilized in the control of houses and structures. Almost every technology now in use in home communications is utilized, including twisted pair (TP), power line (PL), radiofrequency (RF), and Ethernet, which is a system that makes use of the Internet Protocol (IP), among others**.**(Orfanos, Kaminaris, Piromalis, & Papageorgas, 2019)

**ITU G.hn** Global Home Networking (G.hn) is a standardization project established by the International Telecommunication Union (ITU-T) in 2006 to produce a consistent next generation networking technology that can function across all types of in-home wiring and can be deployed anywhere in the world (phone line, power line, coaxial cable, and Cat-5 cable).

International Telecommunication Union (ITU-T) Recommendation G.9960, which acts as the G.hn foundation and specifies system design, was approved in December 2008 by the ITU-T. Specifically, the technology is designed for use in residential houses and public locations such as modest homes and offices, multi-family dwelling units, and hotels, among other places(Oksman & Galli, 2009)

**Ethernet** They were known as the "Ethernet pioneers" when they developed a local area network (LAN) technology in 1972 to connect stations, servers, and peripheral devices within a single building using a shared bus system, which was developed by Robert Metcalfe and his colleagues at the Xerox Palo Alto Research Center in California. This marked the commencement of the first version of the Ethernet protocol, which was released in 1990. The evolution of Ethernet from a niche technology to the most commonly used local area networking (LAN) technology has occurred over the previous several decades. Aside from LAN deployments, Ethernet has been more popular in a wide range of other sectors of application, spanning from industry to aviation, telecommunications, and multimedia transmission. The increased use of this technology is mostly owing to its several advantageous characteristics, which include its low cost, backward compatibility, flexibility, and expandability.. (Sommer et al., 2010)

**The Multimedia over Coax Alliance (MoCA)** , a multi-industry standardization body, is creating technology for the connected house that runs over existing coaxial cable in the home and offers the home network with high-quality performance and reliability. The MoCA is a multi-industry association dedicated to standardization. The MoCA is a not-for-profit organization dedicated to the advancement of industry standards. MoCA 1.1 and 2.0 are the current versions of the specification, which are the standards that are used and implemented by the vast majority of service providers in North America and are the most widely adopted and used standards globally. Additionally, it is gaining popularity in other regions of the world, most notably Asia. It is possible to reach net throughputs of over 400/800 Mb/s with packet error rates of one in a million packets per second using MoCA, which enables very resilient, low-latency, and secure communication..(Mendes, Godina, Rodrigues, Matias, & Catalão, 2015).

## 2.3 Sensors

To help smart homes become more energy efficient, sensors connected to the Internet of Things (IoT) are essential to their operation. Homes may be equipped with Internet of Things sensors that allow homeowners to actively modify their energy supply as needed. This helps to reduce energy waste while also creating savings. Additional to this, Internet of Things sensors contribute to home environment monitoring by actively detecting the presence of pollutants or other potentially hazardous substances in the home environment and notifying the homeowner so that they can take appropriate remedial action as soon as possible(Bedi, Venayagamoorthy, & Singh, 2016) A sensor is a device that is capable of measuring a physical phenomenon and converting it into an electronic signal.

### 2.3.1 Smoke and Fire Detectors

a smoke detector is a device that detects smoke as an early warning sign of a fire. Alarms that are loud or visible in the immediate vicinity of the detector are generally delivered by smoke alarms from the detector's position. The vast majority of smoke detectors operate either through optical detection (photoelectricity) or through a physical process (ionization); however, some smoke detectors employ both detecting methods in order to increase sensitivity to smoke emissions..(Yadav & Johri, 2016)

### 2.3.2 Temperature and humidity sensor

These are one of the most popular types of sensors that are used to detect the temperature or heat of a particular medium. The temperature of an object may be determined and quantified by using a variety of techniques by these sensors. Humidity is defined as the presence of water in the air. The volume of water vapor in the air, as well as the efficiency of various manufacturing processes, can have an impact on human health. It is consequently critical for industrial operations and human life control systems to monitor and manage humidity levels. Humidity control and monitoring are essential in a wide range of industrial, agricultural, and household applications.(Amalraj, Banumathi, & John, 2019).

### 2.3.3 motion sensor

PIR sensor The pyroelectric sensor is the most important component of a PIR sensor, and it is located beneath the plastic cover, as shown in Fig 1. It is really possible to split the pyroelectric sensor into two parts. Even when there is no movement, both parts of the device get the same quantity of infrared radiation from the surrounding environment. A target passing through the sensor results in a higher amount of infrared radiation being received on one side of it than the other half of the sensor as the target goes through it. As a result of this shift, the PIR responds by raising the output voltage. In operation, the detection range is up to 6 meters, and it may take a few minutes for the gadget to become stable in terms of its relationship with its immediate surroundings(Sahoo & Pati, 2018)

### 2.3.4 Gas sensor

A gas detector is a piece of equipment that detects the presence of different gases in a particular area. It is frequently employed as a component of a safety system designed to keep people safe. It is used to detect gas leaks and interface with a control system, allowing a process to be shut down promptly if a leak is discovered. Additionally, a gas detector can sound an alarm to notify operators present in the area where the leak is occurring, giving them the opportunity to escape before the leak worsens...(Yadav & Johri, 2016)

### 2.3.5 Ultrasound sensor

Presence detectors and other specific applications, for example, may measure distances of up to 11 meters. Ultrasonic sensors are frequently employed in automated tasks to measure distance, position changes, level measurement, and other parameters. The ultrasonic signal on the eighth interval serves as the basis for the sensor's measurement.(Koval, Vaňuš, & Bilík, 2016).

### 2.3.6 Pressure sensors

A pressure sensor is a device that has the capability of capturing pressure changes and converting them into an electrical signal, the quantity of which is determined by the applied

pressure. The devices are electro-mechanical and are used to detect the presence of force in gases or liquids, as well as to give control signals to display devices. Using barometric pressure sensors, for example, we can detect variations in atmospheric pressure, which is useful in the forecast of weather patterns and changes..(Kalsoom, Ramzan, Ahmed, & Ur-Rehman, 2020)

### 2.3.7 Flood sensor

Designed to detect water breaches in home situations, the flood sensor is a small electronic gadget. In order to meet the objectives for small efficiency, low cost, and low power dissipation, the wireless sensor node was designed. It functions in the same way as a typical water alarm, but it is connected to the user's home network and is capable of sending an alert to the user, therefore saving money on water damage restoration..(Teixidó et al., 2018)]

### 2.3.8 IR sensors

Infrared Sensors are devices that produce or detect infrared radiations in order to perceive specific properties of various things in their environment. They are also capable of measuring heat output. It is possible to use this sort of sensor for home automation, such as monitoring and regulating household appliances such as turning on and off lights. It is also possible to use this sort of sensor for smart security. (Sehrawat & Gill, 2019)

## 2.4 Advantage of Smart infrastructure/building

We are discussing the revolutionary potential of the Internet of Things (IoT) for home and building automation in this context. In the interior settings where we work and live, the increasing pervasiveness of low-cost sensors and wireless technologies is having a profound impact, enabling us to achieve better levels of efficiency, comfort, and safety.

In light of the numerous common use cases between a smart home and a smart building, such as climate control, lighting automation or security and fire safety, smart building  is one that is

equipped with a smart home system that communicates with your appliances to automate certain activities and can be controlled from a distance.

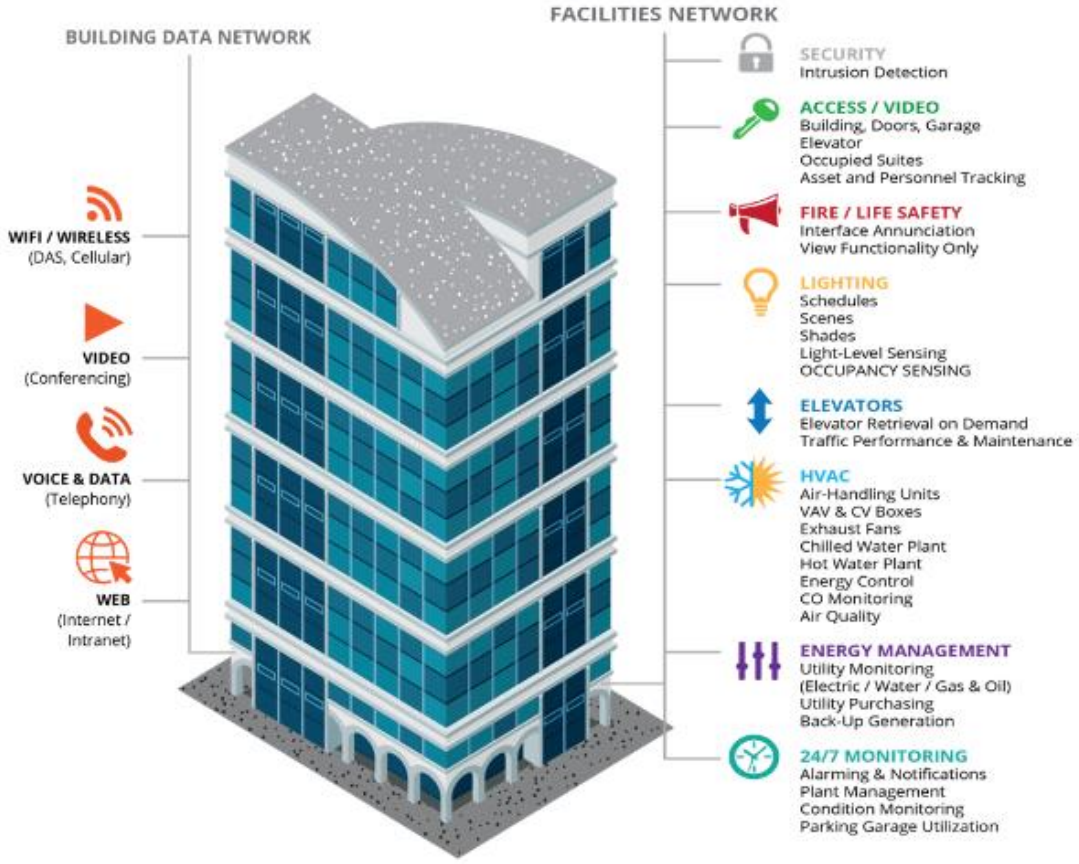


Figure 1.6 smart building (Smart Buildings Help Build Smarter Cities, 2019)

The system may be used to program sprinklers, configure and monitor your home security system and cameras, or operate appliances such as your refrigerator, air conditioning, and heating systems. Smart homes provide you better control over your energy consumption.

Generally speaking, the advantages of home automation may be divided into a few categories, which include cost savings, safety, convenience, and control. In addition, some consumers choose home automation to provide comfort and peace of mind to themselves and their families. A deeper look at some of the most significant advantages that home automation offers is provided here.

Simply said, smart homes can be more manageable and comfortable than conventional homes due to the fact that their systems may be tailored to meet your specific requirements and requirements.

The use of smart homes may save money and the environment since they conserve energy. When using smart appliances, you may reduce your energy use during peak hours, which helps the environment while also saving money on your utility bill.

Home security is made easier with home automation, which is also less expensive than traditional methods. which all allow homeowners to keep tabs on what is going on in their immediate surroundings using their smart gadgets

Accessibility: According to studies, smart homes provide a plethora of options for elderly and people with disabilities who need to live independently. The majority of smart home systems can be programmed to respond to voice requests, which may be used to lock and unlock doors, control lighting, and better operate digital equipment such as a microwave.

Last but not least, many customers engage in home automation technology to provide them with more peace of mind. Smart cameras and other technology allow a new mother or father to keep an eye on their child.

Beneficial to the Environment In an era when we are all becoming more environmentally conscious, home automation may be an excellent option for preserving our natural resources.

Protecting Your Family at Home An excessive number of accidents occur in the house as a result of insufficient illumination. Lighting in closets, stairwells, and other dark areas may be turned on automatically with home automation technology.

Increased resale value of your house: Smart home technology can assist you in increasing the resale value of your house. Several house-buying consumers are ready to pay a premium for the amenities that are associated with intelligent home technology**.**

## 2.5 Smart infrastructures market size

A total of USD 61.2 billion was generated by the worldwide smart building market in 2019, with a predicted total revenue of USD 150.6 billion in 2030, representing a compound annual growth rate (CAGR) of 10.9 percent during the forecast period of 2020-2030. For a variety of factors, the smart building industry is expected to expand. Building architecture that is innovative can assist to save operating costs, improve tenant management, improve security management, and improve performance management. Furthermore, organizations have used smart building technology in order to enhance the efficiency of facility workers while also promoting sustainability programs and initiatives (2021)

The energy management market is anticipated to expand at the highest pace of all throughout the projection period, regardless of the solution type. By building type, the commercial building sector is anticipated to be the most dominant section in the Smart buildings market by 2020. APAC smart buildings market is expected to expand at the fastest rate during the forecast period, accounting for the majority of total market growth during this time. (Global Smart Buildings Market, 2021)

Geographically, the market is split into five regions: Europe, Latin America, North America, Asia Pacific, and the Middle East and Africa. North America is anticipated to hold the biggest share of the smart home market in the future years, according to industry predictions. Because to the existence of well-known businesses like Control4 Corporation, Amx Corporation, Crestron Corporation, and Honeywell, the industry has expanded considerably. (Smart Home Market Worth $622.59 Billion at, n.d.)

Major suppliers in the smart buildings industry are covered in this report, including The major companies profiled in the smart building market report include Honeywell International Inc., Johnson Controls, Cisco System Inc., Siemens, IBM, Schneider Electric, Intel Corporation, Huawei Technologies Co. Ltd., ABB, L&T Technology Services Ltd., 75F, Telit, Pointgrab Inc., Logicladder, Spacewell International, PTC, Avnet Inc., Softdel, Wirepath Home Systems LLC, HCL TECHNOLOGIES LIMITE, and HCL TECH

## 2.6 Existing studies

The authors (Ma May Thet Htar | Ma Hnin Yu Myaing, 2019) gave a presentation on their research. A GSM-based home automation system has been presented, and the system has been created with the help of an Arduino UNO and a GSM module, among other components. Text messages received from any mobile phone located anywhere in the world can be used to control electrical appliances, provided that the phone is connected to the internet through a GSM connection. As soon as a message is delivered from the GSM module of a mobile phone to the GSM module of an Arduino, the Arduino reads that message by extracting and storing the primary command from the received message in a variable, which is then read by the Arduino. Following that, Arduino compares the command to a command set that has been previously specified. If the instruction is correctly executed, Arduino sends a signal to the relay through the relay driver, which switches on and off the home appliance while simultaneously displaying the result on the LCD screen by utilizing the necessary commands. If the instruction is incorrectly executed, Arduino sends a signal to the relay through the relay driver.

This research (Chan et al., 2015) SMS-based control of home appliances is implemented utilizing the GSM architecture and the PIC16F887 microcontroller, which is integrated into the system. The proposed study effort is centered on the capability of the GSM protocol, which allows the user to manage the target system from a location other than their home by making advantage of the frequency bandwidths available. Towards the creation of a smart GSM-based home automation system, the notion of serial communication and AT instructions has been utilized. By executing the necessary commands, the instantaneous result is shown on the LCD.

This paper (Wadhwani, Singh, Singh, & Dwivedi, 2018) titled "Sensing and managing the world around you with Arduino and IOT" discusses embedded technologies as well as the internet of things (IoT) utilizing Arduino, and it makes use of embedded block and script programming for Arduino and sensors to accomplish its goals. This provides the possibility of home automation. The automation of the home involves the management of household appliances as well as the

intelligent control of the water system. Sensors such as flux sensors and fire sensors are used by the system to accomplish these goals. Arduino will be used to communicate with the sensors. Through the use of a wireless module, the status of our household appliances will be transferred to a cloud-based platform. The system and the mobile phone should both be linked to the same wireless network for optimal performance

This paper (Lalit Mohan Satapathy, Samir Kumar Bastia, 2018) offers a low-cost, versatile, and dependable home automation system with extra security that makes use of the Arduino microcontroller and IP connection over local Wi-Fi to allow authorized users to access and operate devices from anywhere in the world using a Smart phone application. The suggested system is not dependent on a server and makes use of the Internet of Things to manage human-desired equipment ranging from industrial machines to consumer products and beyond. The user can also operate the system through the use of various devices such as a web browser or a smart phone. In order to illustrate the efficacy and practicality of this system, we offer a home automation system based on the Arduino UNO microcontroller and the esp8266-01 connection module

In this article. (Park, Kim, & Seo, 2019) authors Propose an open source framework called S-mote, which can run all IoT operations in one application by adding an infrared module to ordinary household appliances, or by utilizing an infrared module in conjunction with a radio frequency module. An S-mote controller serves as the "gateway" for SMART homes, eliminating the need for several remote controllers with a single application. Appliances that are equipped with infrared or radio frequency modules can be utilized in SMART homes, as long as they are not too large. With the help of S-mote, one may easily manage household equipment that do not have any Internet of Things capability, such as televisions and stereos, using radio frequency modules.

This paper (Al-Kuwari et al., 2018)presents an end-to-end design of an Internet of Things Smart home automation using a sensor-based sensing and monitoring system .The suggested

architecture makes use of the EmonCMS platform for data collection and visualization, as well as for remote control of household appliances and devices, among other functions. The platform that has been chosen is extremely adaptable and user-friendly. The NodeMCU-ESP8266 microcontroller board is used to perform the sensing of many variables around the house. This board enables for real-time data sensing, processing, and uploading/downloading to/from the Emon CMS cloud server, as well as communication with other devices.

The home automation system is, in fact, a system that includes a mobile application that allows users to monitor the system from their smartphone or tablet. It has the ability to manage household equipment such as lights, fans, air conditioners, and smart security locks, among other things. Remote control of devices is accomplished through the use of Bluetooth or Wi-Fi. A smart home is precisely what it appears to be: automating the ability to manage items across the home with the simple press of a button or voice command(Alam, Salem, Alsharif, & Alhejaili, 2020)

The paper (Ali, Syafeeza, Ja'Afar, Abdul Hamid, & Mohamad Saleh, 2020) presents an RPi and GSM-based home automation application. To facilitate RPi operation, programming has been created in the Python environment. When utilizing the Raspberry Pi, this paper shows how to operate home automation equipment using SMS services. It was debuted in 2012, and it is a tiny computer with a lot of power.

This system(Mahamud et al., 2019) Based on a web portal that is managed by an ESP32 Wi-Fi module, this system implemented. In addition, a custom-built private home web server is being constructed for the purpose of keeping track of the present statuses of household equipment. Users may customize the load number in this suggested system to meet their own needs by logging onto a web site and making the changes. Furthermore, if the server is hosted on a public IP address, the user will be able to operate and monitor the server from anywhere in the globe.

This paper(Gill, Yang, Yao, & Lu, 2009) It is the goal of this project to identify the factors that have contributed to this delayed acceptance and to evaluate the ability of ZigBee to address these challenges through the design and implementation of a flexible home automation infrastructure. One home gateway may be used to link a ZigBee home automation system to a Wi-Fi network, providing for smooth integration between the two networks. Because of the usage of a single device, the home gateway is capable of providing interoperability across networks, a simple and flexible user interface, and remote access to the system. To ensure that the system's security and safety requirements are met, it is necessary to construct a virtual house that has been tailored for the system. Four devices have been built and tested in order to demonstrate the feasibility and efficacy of the proposed system: a light switch, a radiator valve, a safety sensor, and a ZigBee remote control, all of which have been integrated with the home automation system.

Bluetooth based smart home the accuracy level is quite good, and the method is rather quick. The working range of such devices, on the other hand, is around 10-20 meters, which is a major disadvantage. Smart home systems based on the Internet of Things (IoT) are regarded to be the most user-friendly and adaptable systems owing to the vast range of smart functionalities available. Because of their numerous restrictions, traditional smart home technologies such as GSM, Bluetooth, and GPRS are ineffective. However, Internet of Things (IoT) approaches circumvent these restrictions and present consumers with a plethora of benefits.

# CHAPTER THREE

## METHODOLOGY

The smart infrastructure system proposed in this thesis is based on the Internet of Things (IOT). The project consists of 3 main components which are home appliance, central processor and user interface via mobile app or web.in other words. The graphical user interface (GUI) and the web can be used to monitor, control, and pre-schedule the appliances in the building to operate at specified times as shown in the following figure 3.1 shows the proposed system..

The controller is the size of a credit card and costs approximately $40. The use of WiFi is made possible by the need to connect controllers to the household. It was then connected to the Internet through an appliance. The input signal conditioning circuits and output driving circuits of the room controllers are used to interact with the GPIOs of the home appliances in the room. Homeowners may use their mobile devices to access each of their home appliances, which is hosted on a platform database server.

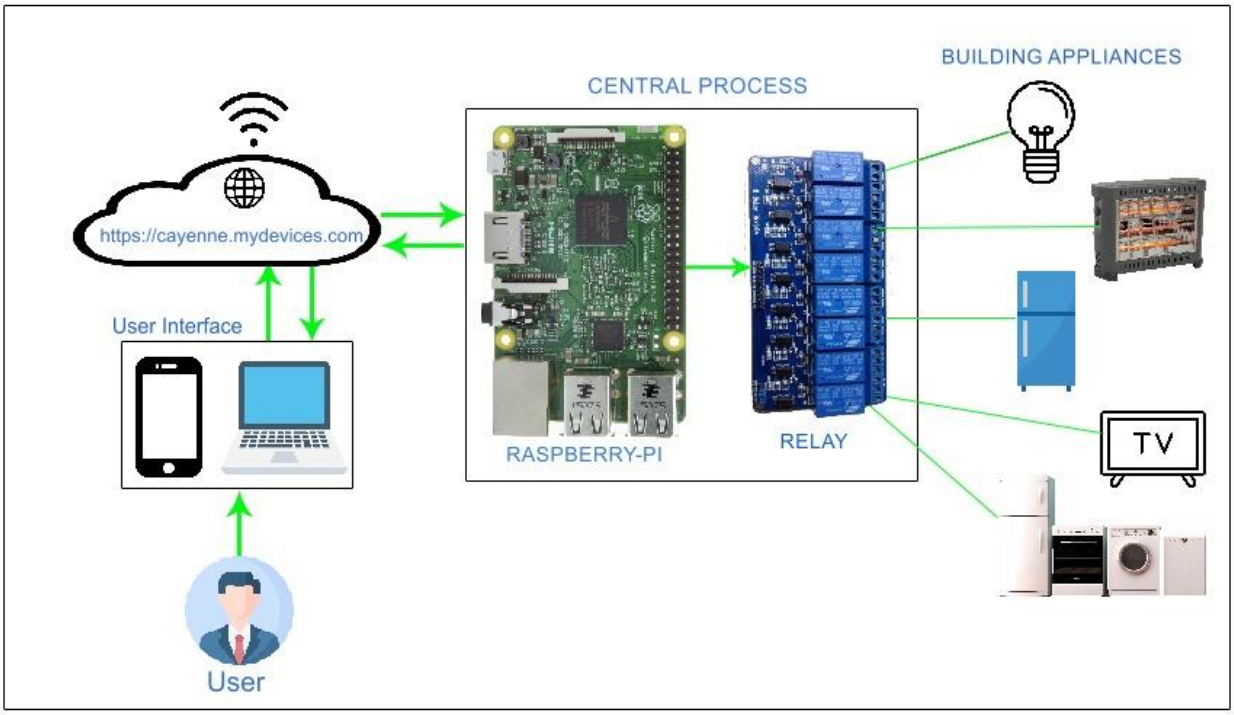


Figure 3.1: Proposed System

Connected to the household appliances that will be managed and linked to one another, the relay module system is used. The Cayenne app, which had a custom-designed layout and buttons, was used for the user interface, which made it easier to monitor and operate numerous linked objects. The home appliances may be managed and controlled from any remote place by pushing a virtual tap on the smart phone's screen. One benefit of this app is that it could be accessed between all of the members of the household's family members. If one of the members turns on or off an appliance, the action will be visible to all of the other members who are using the application..

The benefit of implementing a 5V relay in this project is that the relay's power supply may be supplied straight from the Raspberry Pi. Whilst a relay is a kind of switch which can be used to connect microcontrollers to alternating current loads.

Commands are entered through the mobile app, and the pi processor examines them for keywords associated with load switching. It looks to see if the user used any commands relevant to load switching; if the processor identifies a command in the user's phrase, it scans which load is being mentioned and which command is being used. Following the processing of these commands, the relay-based circuit is given the signal to switch on or off the loads. In addition, the automation is carried out in this approach.
The interoperable layer in this prototype is represented by the Internet. The following features are included in the proposed SHAS prototype:

a. Home appliances are monitored for their status (whether they are on or off) by this program..
b. The graphical user interface (GUI) enables observation of the status utilized for screening purposes.
c. It has the ability to regulate variables that define the Home Automation System, therefore assisting in the optimization of energy use.
d. the system helps the elderly and handicapped people
.

Furthermore, this system may be used in a variety of settings, including offices, universities, banks, residential flats, houses, streets, poultry farms, greenhouses, and other similar building . In a word, this method can be applied to a variety of building and sectors in order to optimize their operation and make them smart.

### *3*.1 Schematic circuit design

The designed circuit of the hardware element is simulated by utilizing the software program ‘Circuit ' to create a virtual circuit of the hardware component in question. The virtual circuit simulates a software test, during which errors are identified and resolved. Whenever an error occurs during the hardware simulation, troubleshooting is performed to identify and resolve the issue. Following that, if the circuit performs satisfactorily in the hardware simulation, it is ready to be transferred to the real implementation

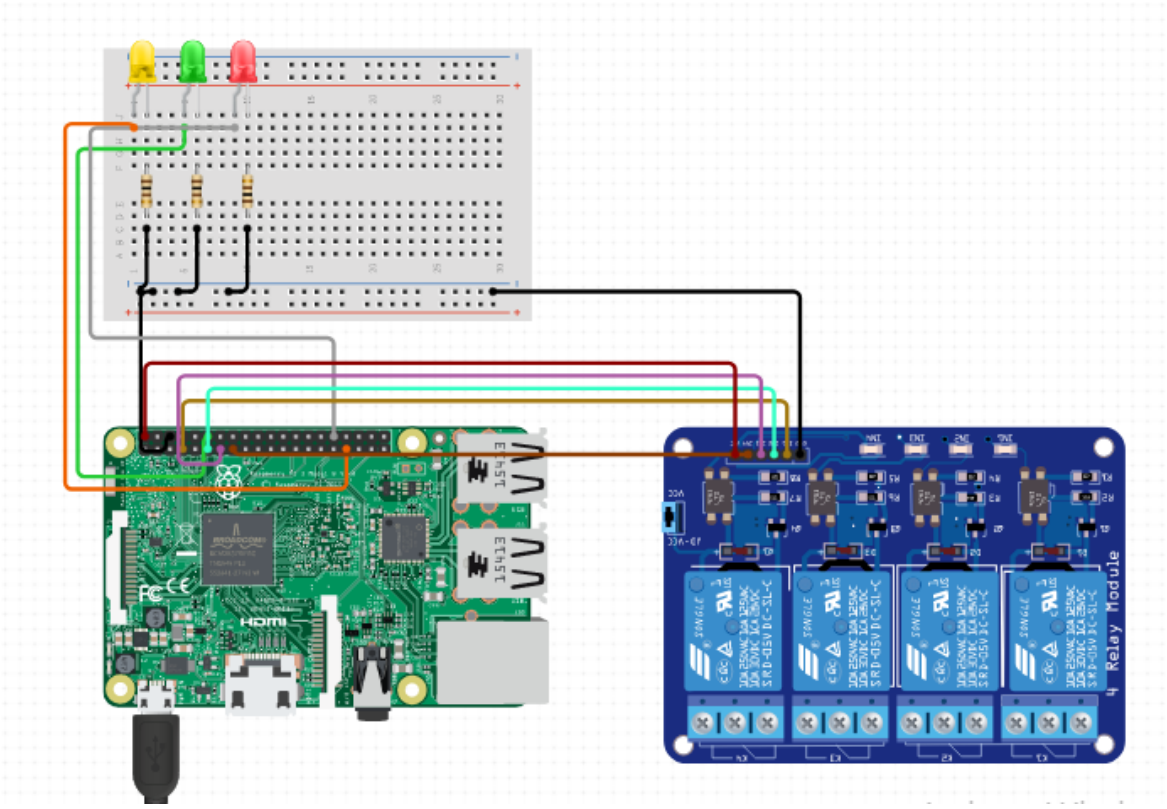


Figure 3.2: The schematic diagram of the proposed system

Prior to putting the system into operation, we create a schematic design that depicts how the various components are connected using a specific program. Afterwards, as seen in figure 1, the schematic diagram given above was translated to a prototype of the proposed system8.

## 3.2 Hardware Design

Both software and hardware design are key parts of the system's overall structure. Hardware configuration consists in the arrangement of microprocessor sensors and actuators, whereas software configuration consists in the programming of microprocessor sensors and actuators. The system is comprised of a credit card-sized computer that is linked to sensors and electrical equipment that will be monitored and controlled by the system. The design of various hardware components is demonstrated in this section. The following sections provide a detailed explanation of the specs and information in regards to the various components of this system.

### 3.2.1 Raspberry pi

Raspberry Pi is the brand name for a range of single-board computers developed by the Raspberry Pi Foundation, a non-profit organization located in the United Kingdom devoted to educating people about computing and making it more accessible to all. Since its initial debut in 2012, the Raspberry Pi has seen several revisions and changes. Its initial model had a single core CPU running at 700MHz and 256MB of RAM, whereas the most recent edition features a quad-core processor running at 1.5GHz and 4GB of RAM. This low-cost computer, which runs Linux, also has a set of GPIO (general-purpose input/output) pins for controlling electrical components used in physical computing and for investigating the Internet of Things. (What is a Raspberry Pi?, n.d.)

### 3.2.2 Relay

A relay is a switch that may be used to close and open circuits in both an electrical and an electromechanical fashion. Power relays, as well as switches for switching lower current values, are commonly used in control panels, manufacturing, and building automation systems. Large amperes and voltages, on the other hand, may be controlled with the aid of an amplifying supply,

because a low voltage supplied to the relay coil can cause a high voltage to be switched by the circuits when a high voltage is provided.. (Relay | What is a relay, its function, types and relay wiring, 2019).

### 3.2.3 Home appliance

It is common to use the term "appliance" in the domain of electric equipment, such as a gas appliance or an electrical appliance, to refer to equipment that is designed to perform a certain purpose. [9] Lamps, fans, and the refrigerator are considered basic appliances, whereas high-power appliances such as an extra air conditioner, an electric boiler, and a microwave oven are considered high-end.. (Exploring the different uses of household appliances, 2017)

## 3.3 Software Implementation

The development of the graphical user interface (GUI)-based application is the first step in the process. The application was created using the Cayenne platform. The interface makes this possible. This platform has two major features: a. authorized members may log in; and b. dashboards can be established for users who have registered with the system.

By choosing "Registered user," you will be sent to a dashboard that lists all of the appliances that have been added to the program for the purpose of monitoring and controlling the process. This feature enables users to create a customized dashboard for controlling and monitoring apps with a dynamic schema depending on their preferences, which can then be shared with other users.

The second option, "Create a Dashboard," guides the user through the process of creating a graphical interface by simply hitting the "Add Devices" push-button. This navigates the user to an interface where he or she may add functionality for controlling and monitoring a particular device or appliance. Assume a user adds a new device to the system, such as a fan or air conditioner. The program enables the user to do tasks such as adjusting the fan speed and monitoring the equipment's operational status in real time.

To design Internet of Things projects, Cayenne is the world's first drag-and-drop project builder. It allows developers, designers, and engineers to quickly prototype and discuss connected device ideas with one another. Cayenne was created to assist users in the creation of Internet of Things prototypes, as well as the subsequent transition to commercialization and manufacturing. The platform's most important component is: Use customized widgets to display data, set up rules, and schedule events, among other things, on the Cayenne Online Dashboard..

B. Circuito.io

Circuito.ioi is a web-based application for creating entire electrical circuits. Circuito produces precise schematics for electrical circuits. It features an intuitive interface that enables you to drag and drop various components together (2106).

# CHAPTER FOUR

## RESULTS AND ANALYSIS

We have completed the design and deployment of an interactive smart infrastructure based on the Internet of Things. The system made use of single board computer platforms that were small, low power, and low-cost. Users may use their mobile phones to trigger virtual buttons that allow them to monitor and operate building equipment from any location at any time and schedule them as their need. As a result, the automation system that has been developed provides an efficient, pleasant, and versatile user interface for managing building appliance from a distance. The design described here eliminates all of the constraints of previous system architectures and is capable of delivering high speeds, allowing users to manage electrical equipment from any location at any time and pre schedule them , and providing a user-friendly interface for users of all skill levels. It provides the ability to manage appliances using a mobile device's schedule at a specified time control easily.

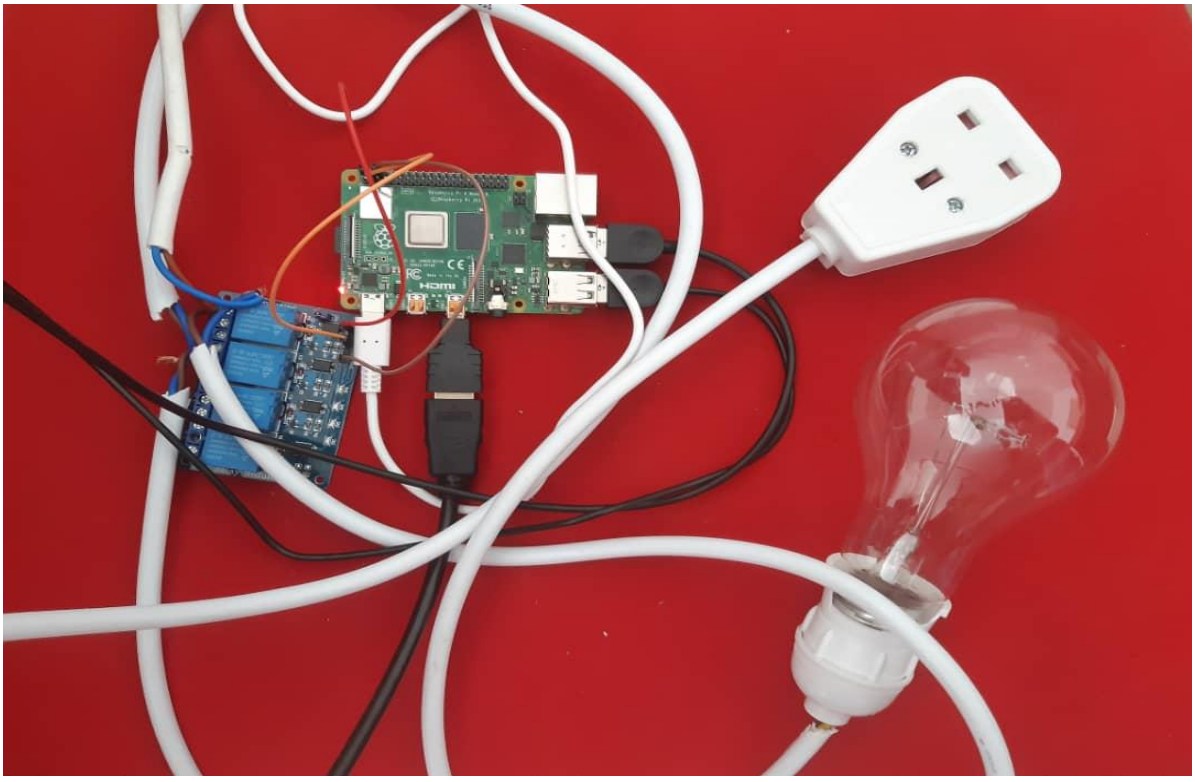

Figure 4.1 system prototype

It has been fully tested, and the findings have been presented and debated in the following steps: we deploy the system in three important areas in smart building first smart room/class(lights) second TV and air conditionar.

**Experiment 1** It is possible that the expense of just forgetting to switch off the lights and electric appliances in your classroom will quickly mount if you are not attentive. It is possible to significantly cut energy use by adjusting the temperature and lighting in a building according on the time of day or the number of occupants, for example.

A smart room is a space that makes use of electrical equipment that are considered"smart," which are driven by (IoT). Through the usage of Internet of Things (IoT) technology, formerly unconnected objects are now connected to the internet, allowing them to broadcast and receive data. You may remotely monitor and operate the room appliance via an app or the web as the figure 4.2 shows we switched on the light by using our mobile.

Figure 4.2 controling the lights

The available power of a class or room is must be saved and utilized efficiently. A significant quantity of electricity is lost at educational institutions, which include lecture halls, classrooms, and practical laboratories, because of human mistakes and carelessness. It is possible to save a significant amount of energy by avoiding energy waste during unoccupied .figure 4.3 shows the energy saved when using the proposed system the blue line is zero and the cost is saved even if we forget to turn off the light because we can remotely switch off meanwhile the brown line shows the bill is increasing hourly if we forget to turn off the light because when the system is manual there is no way you can switch off remotely. Moreover, this solves the result of

inefficiency in the manual switching method, as well as the inability of the electrical equipment to be operated without the involvement of humans.

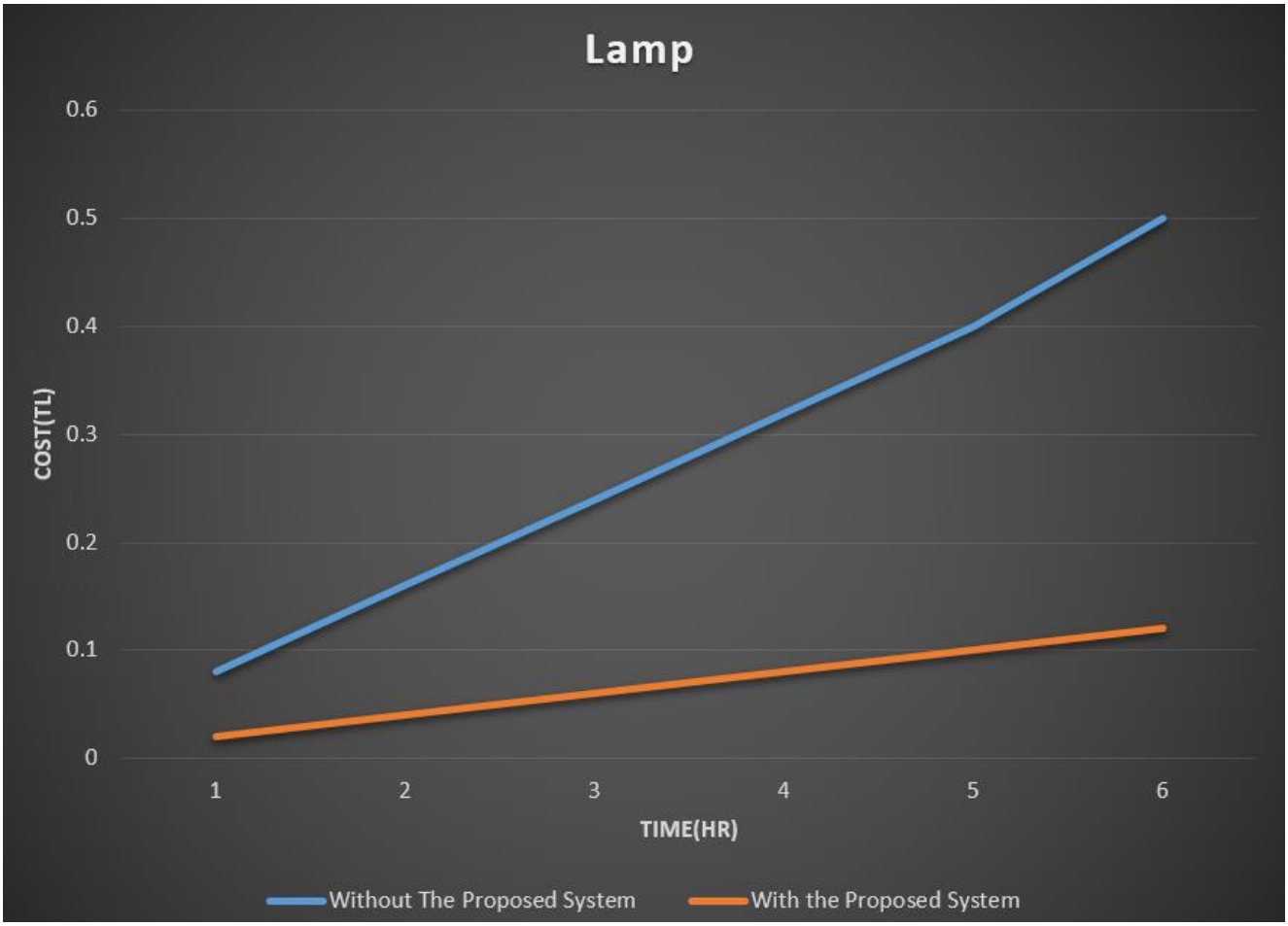


Figure 4.3 lamp electricity wastage

A fully automated system rather than a human switching method is therefore nearly required for the university system or big building . Our proposed system as figure 4.2 indicates has the capability of controlling the light bulbs and AC .So It can be used to decrease power waste, and it would be a solution to reduce excessive electricity consumption as figure 4.3 indicates.

**Experiment two** Turning off your television is the most straightforward method of conserving electricity. But some people forget to turn off the TV while leaving the home/building The proposed system, as illustrated by the line in the graph 4.4 saves energy and lowers costs while also providing the home owner with the ability to control their TV remotely. As shown in figure

4.4 the TV contributes to the energy bill and if we forget to switch it off the bill increases; however, by using the proposed system, as illustrated in the figure 4.4.The system saves energy and lowers costs while also providing the home owner with the ability to control their TV remotely. It is possible to not only save money on your energy bills, but you can also make a significant difference on the environment.

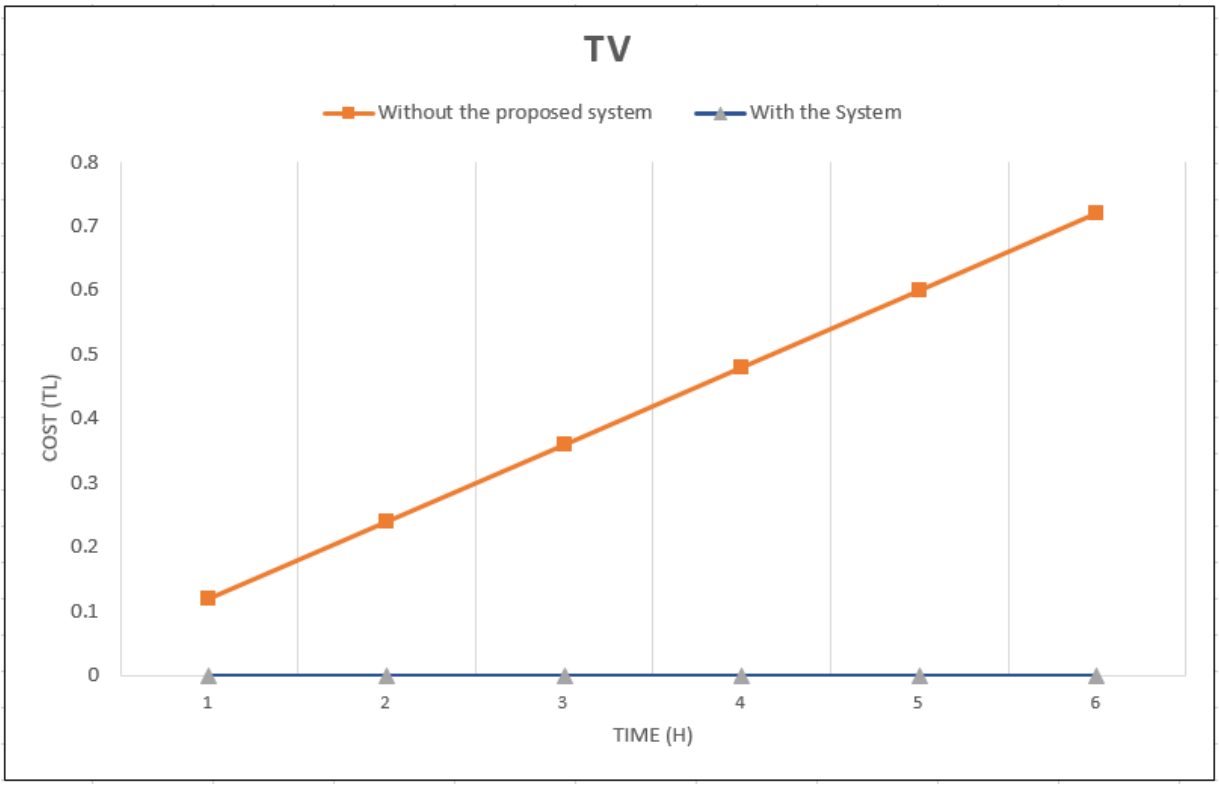


Figure 4.4 TV energy consumption

**Experiment three** Decreasing the use of an air conditioner will help lower costs, cooling is generally expensive and forgetting switching off the Ac will increase the bill as figure 4.5 shows .air conditioner power consumption trumps that of most appliances. Apart from looking to reduce carbon emissions, primary concern when it comes to energy usage is probably not the nominal wattage statistics. Rather, you're likely concerned about dollars and cents. It will be able to intelligently control the heating and remotely switch on and off. By using the phone. Furthermore, the system has the capability of pre-scheduling the heater and that saves the energy


Figure 4.5 Air conditioner energy consumptions

As soon as the installation process completes, the Online Dashboard will automatically appear and the dashboard shows the raspberry performance as figure 4.6 shows .Raspberry pi is the heart of the system and its performance effects the general system functionality

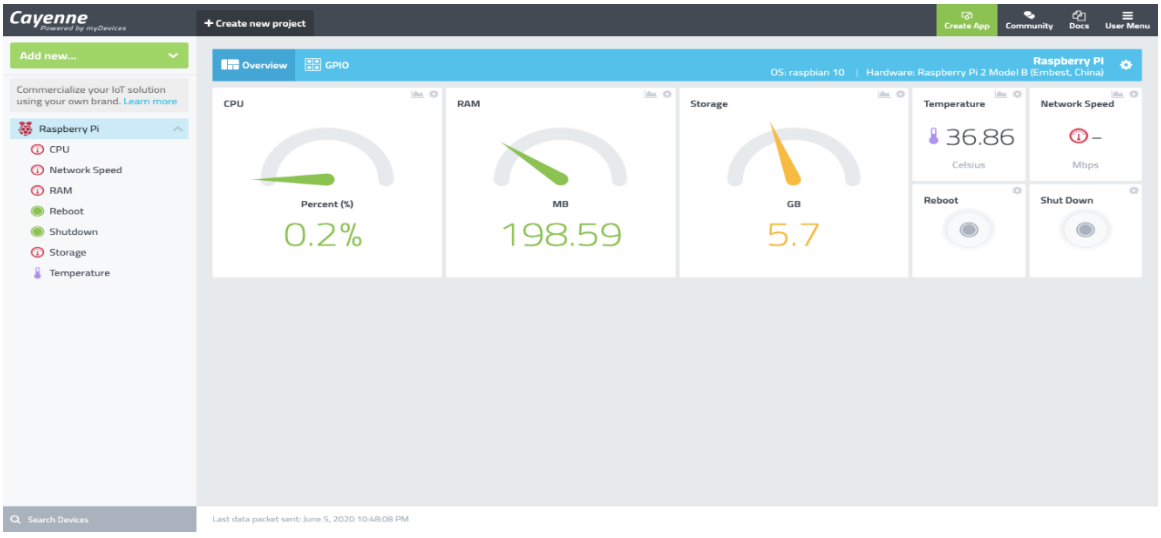


Figure 4.6 Raspberry pi performanc

# CHAPTER FIVE

# CONCLUSION AND RECOMMENDATION

## 5.1 Conclusion

The proposed solution uses raspberry pi & Relay in the hardware part; the relay acts as a switch to turn on/off the various electrical devices, while the current to the relay is provided by the raspberry pi. The indication to the relay for switching the load on or off is sent by the Cayenne app, the Cayenne app takes the login id & password from the user to login, , it basically acts as a trigger for the system.

Additionally, this method is adaptable to a number of environments, including offices, institutions, and banks, residential flats, houses, streets, poultry farms, greenhouses, and other similar building . In a word, this method can be applied to a variety of building and sectors in order to optimize their operation and make them smart

It is also an aid in saving money, as our project is cost effective than the ones currently available in market and not only money it also helps save electricity, as we know how forgetful humans are, we often forget to turn of lights/fans, here this project can help us to do that just by using our smart phones and remotes. This Project not only makes our day to day work & life easier but also is a huge help for the physically disabled people or the aged people, who are dependent on someone for even such small & minute tasks.

In other words the control of building appliances via web and app is presented in this article, which aims to overcome the shortcomings of conventional smart home automation. Previous smart homes management systems include GSM-based, Bluetooth-based, and infrared-based systems, these will use more electricity and demand more expense .The proposed system decreases the consumption of electricity usage ,the method enables people to live comfortably while effectively addressing their energy. . It facilitates the task of disabled and old persons, as well as assisting in the control of appliances. . Monitoring appliances with IoT

is feasible from anywhere in the globe, as it has no geographical limitations, making it very scalable.

Nowadays ,smart home is becoming increasingly popular with builders, scientists, and of course, customers. Smart home devices are now frequently found in several houses all over the world, in a variety of different nations. These solutions not only provide a high degree of control over household appliances, but they also attempt to decrease power wastage as much as possible. Building automation is becoming increasingly popular in all developed countries, and the word refers to the use of automation and information technology for the administration of buildings including such institutions, hospitals, and other such facilities, among other things.

## 5.2 RECOMMENDATION

To enhance intelligence of the smart building and make the system self-programmer able we recommend upgrading the system by using Artificial intelligence and machine learning.. Adoption of machine learning into iot systems is intended to make the house increasingly beneficial and accessible to users' demands and rituals by understanding their needs and routines and responding accordingly. The use of principles from various machine learning techniques, as well as computer vision, to create a smart learning automated system that regulates lighting, temperature, and other parameters.

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