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DESIGNING AND IMPLEMENTATION OF SMART HOME MONITORING SYSTEM

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(M. Sc. In Communications Techniques Eng.)

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بسم الله الرحمن الرحيم

اللَّهُ لَا إِلٰه إِلَّا هُوَ الْحَيُّ الْقَيُّومُ ۚ لَا تَأْخُذُهُ سِنَةٌ وَلَا نَوْمٌ ۚ
لَّهُ مَا فِي السَّمَاوَاتِ وَمَا فِي الْأَرْضِ ۗ مَن ذَا الَّذِي
يَشْفَعُ عِندَهُ إِلَّا بِإِذْنِهِ ۚ يَعْلَمُ مَا بَيْنَ أَيْدِيهِمْ وَمَا خَلْفَهُمْ ۖ
وَلَا يُحِيطُونَ بِشَيْءٍ مِّنْ عِلْمِهِ إِلَّا بِمَا شَاءَ ۚ وَسِعَ
كُرْسِيُّهُ السَّمَاوَاتِ وَالْأَرْضَ ۖ وَلَا يَئُودُهُ حِفْظُهُمَا ۚ
وَهُوَ الْعَلِيُّ الْعَظِيمُ
صدق الله العلي العظيم

{سورة البقرة / الآية 255}

DESIGNING AND IMPLEMENTATION OF SMART HOME MONITORING SYSTEM

THESIS

SUBMITTED TO THE COMMUNICATION DEPARTMENT

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REQUIREMENTS FOR THE DEGREE OF MSc IN COMMUNICATIONS TECHNIQUES ENGINEERING.

By

MUSTAFA ASAAD OMRAN

Supervised by

Asst. Prof. Dr. Bashar Jabbar Hamza **Asst. Prof. Dr. Wasan Kadhim Saad**

2021

Dedication

To whom Allah has given him dignity and honor, who taught me how to give and expect nothing in return, to whom I carry his name with pride, your words still show me the way today, tomorrow and forever like the stars in the darkness of the night. My dear late father, may Allah have mercy on him and may Allah have mercy on him always.

And to my angel in life, to the meaning of love and mercy, to the eternal smile and the mystery of existence, my beloved mother.

For those with whom I spent the best days of my life and shared the best memories ever, those who feel the happiness for me and my success, my brothers and my friends.

To my companion, my soulmate, my partner and support in life, my dear wife.
And finally, to my dear children, Mayar and Ahmed.

I honorably dedicate my research to you, and I hope I can make a difference in my life in the way you are most proud of.

Supervisor Certification

We certify that this thesis entitled "**Designing and Implementation of Smart Home Monitoring System**" which is submitted by **Mustafa Asaad Omran** was prepared under our supervision at the Communication Techniques Engineering Department, Engineering Technical College-Najaf, AL-Furat Al-Awsat Technical University, as partial fulfillment of the requirements for the degree of Master of Technical in Communications Engineering.

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Committee Certification

We certify that we have read this thesis entitled "**Designing and Implementation of Smart Home Monitoring System**" which is being submitted by **Mustafa Asaad Omran** and as examining Committee, examined the student in its contents. In our opinion, the thesis is adequate to be awarded the degree of MSc.

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Linguistic Certification

This is to certify that this thesis entitled "**Designing and Implementation of Smart Home Monitoring System**" was reviewed linguistically. Its language was amended to meet the style of the English language.

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Date: /   / 2021

Abstract

The Internet's success, it's demonstrated capacity to meet the daily requirements of individuals from all areas of life, and its importance to society as a whole have all contributed to the advancement of the current Internet to a next level dubbed the Internet of Things (IoT). Internet of things is used in many fields such as smart home (SH), smart city (SC), smart agriculture (SA), smart industry (SI), smart healthcare (SHC), smart vehicles (SV) and smart energy (SE), etc. Home automation system (HAS) has attracted great interest as communication technology advances. The SH is an IoT app that utilizes the Internet to surveillance and control devices through the use of a smart home automation system (SHAS). Current home automation systems (HASs) are limited to a lack of safety, energy-saving, unfriendly user interfaces, a limited wire communication range and difficulty of maintenance. In this thesis, safe, easy-to-use and energy-saving IoT-based system is proposed, which is a mobile automation system that uses Wi-Fi as a wireless communication medium, and enables home appliances to be monitored by a homeowner in local and remote locations via mobile phone / personal computer (PC). The SH prototype was designed using Autodesk Fusion 360 software. After the design, this model was manufactured by Father Board & Three Dimensional (3D) Printer for the system to be placed inside it to use in real homes. Raspberry Pi 3 Model B+ and Arduino Mega 2560 were used for configuring the server automation framework. Moreover, various sensors that are connected to the Arduino Mega controller have been used to monitor current, voltage, power, energy, frequency, humidity, temperature, motion, flame, smoke, gas, doors, windows and other household conditions, and also to successfully control household appliances (lights, fans, reverse fan, water pump, buzzer.) either automatically (or via relays for lights only). The proposed automation system can

surveillance and control home conditions via an easy-to-use application (Blynk app) for both Android or IOS systems, or PC.

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All the people above, without whom I would not be the person I am today, these people who have provided me with the strength and motivation to manage to complete this thesis.

Declaration

I hereby declare that the thesis is my original work except for quotations and citations which have been duly acknowledged.

/ / 2022 Mustafa Asaad Omran

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List of Abbreviations

Abbreviation	Description
3D	Three Dimensional
6LoWPAN	IPv6 over Low-Power Wireless Personal Area Networks
AC	Alternating Current
AP	Access Point
BAN	Body Area Network
BLE	Bluetooth Low Energy
CPU	Central Processing Unit
CSI	Common System Interface
DC	Direct Current
DR	Demand Response
DSI	Display Serial Interface
EEPROM	Electrically Erasable Programmable Read-Only Memory
E-health	Electronic Health
EHR	Electronic Health Record
EVB	Evaluation Board
FHSS	Frequency Hopping Spread Spectrum
GPIO	General-Purpose Input/Output
GSM	Global System for Mobile Communications
HAN	Home Area Network
HAS	Home Automation System
HAT	Hardware Attached on Top
HDMI	High-Definition Multimedia Interface
HEMS	Home Energy Management System

HTML	Hypertext Markup Language
ICSP	In-Circuit Serial Programming
IDE	Integrated Development Environment
IEEE	Institute of Electrical and Electronics Engineers
IOS	IPhone Operating System
IoT	Internet of Things
IP	Internet Protocol
IPV6	Internet Protocol Version 6
IR	Infrared Radiation
LAN	Local Area Network
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LPDDR2	Low-Power Double Data Rate2
M2M	Machine to Machine
MIPI	Mobile Industry Processor Interface
MPEG-4	Motion Picture Experts Group-4
MQTT	Message Queuing Telemetry Transport
Node MCU	Node Micro Controller Unit
PAN	Personal Area Network
PC	Personal Computer
PoE	Power over Ethernet
PWM	Pulse Width Modulation
RF	Radio Frequency
RFID	Radio-frequency Identification
RST	Reset

SA	Smart Agriculture
SC	Smart City
SDRAM	Synchronous Dynamic Random-Access Memory
SE	Smart Energy
SG	Smart Grid
SH	Smart Home
SHAS	Smart Home Automation System
SHC	Smart Healthcare
SI	Smart Industry
SMS	Short Message Service
SoC	System on a Chip
SRAM	Static Random Access Memory
SV	Smart Vehicles
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
VNC	Virtual Network Computing
Wi-Fi	Wireless Fidelity
WLAN	Wireless Local Area Network
WPA2	Wi-Fi Protected Access 2

CHAPTER ONE

INTRODUCTION

1.1 Background

The Internet of Things (IoT) will be gradually present in our everyday life. Objects are gradually being turned into smart objects: smartphones, smart TVs, etc. Such heterogeneous objects have greater computing power, are capable of collecting data, interacting and accessing the Internet. Mobile cloud computing takes advantage of the specific advantages of heterogeneous IoT apps, sharing their computing power and storage of collected data in order to cooperate in individual processing activities and build an ambient intelligence. Types of literature-related applications include collaborative image processing, crowdsourcing and computation, the exchange of sensors, social networking or background recognition. Sensors embedded in smart objects can generate vast quantities of data, which can be processed remotely in the cloud. The basic model is intended as a client-server in order to communicate with one another, i.e. any IoT system acts as a data server, transmitting the data to a specific system, which can act as a client-server, as well. In many respects, the smart home (SH) or smart home is being defined as the home with an automated system made of sensors and device controllers that provides a convenient, smart and safe system that improves the standard of living and easily controls the home devices, particularly for seniors and people with disabilities. Nonetheless, the smart home automation system (SHAS) will deliver a Bluetooth and Wi-Fi interface between smartphones, personal computers and home appliances [1].

The home automation system (HAS) is widely available on the market and be able to be divided hooked on two principal categories: devices operated both locally and remotely [2]. In category 1, users can monitor their domestic appliances for home automation using an internal control device with a static or wireless communication system (Wi-Fi, Bluetooth, Zigbee and GSM). In the second group, users may use smartphones or personal computers to remotely monitor their homes via the Internet [3]. However, home automation systems (HASs) should have a user-friendly interface that can quickly and effectively set up, track and manage home appliances. Therefore, the automation should be quick enough to communicate with an appropriate data rate and contact range robust in order to achieve the actual Wireless systems control [4]. Ultimately, the control system should be cost-efficient, so that public users can own and justify their home automation applications.

The IoT smart homes (SHs) services expand day after day and digital devices can easily connect with the Internet Protocol (IP) addresses. All smart devices are connected to the Internet in a smart home setting. As the number of devices in the SH environment increases, the chances of malicious attacks also increase. The risks of malicious attacks are typically when doing security for the SH [5].

An smart home is composed of four parts: a service portal, smart appliances, home gateway, and a domestic network. Figure (1.1) shows a general example of the smart home. all smart home devices are linked with each other and doing smart information exchange via a local network. Therefore, a home portal tracks the information flow between smart devices linked to public networks. The platform for service utilizes a service provider's infrastructure to offer multiple home network services.

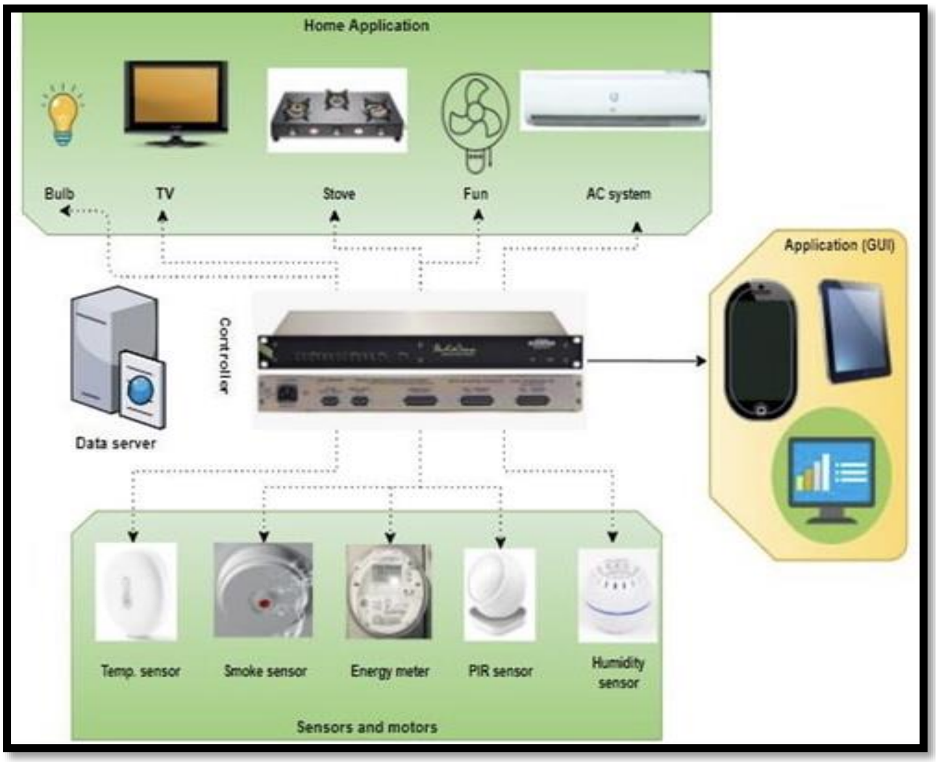


Figure 1.1. An example of the SH architecture

1.2 Motivations and Problem Statement

The advantages of SH automation systems include energy conservation, healthcare, comfort, saving money, and safety. As shown in Figure (1.2). A study was conducted to identify problems in home automation systems. One of the major problems with many HAS streams is their difficulty in maintaining them for most users. In addition, some current systems provide a home view from an inconvenient mobile app (either Android or IOS system), along with users who have to visit the web every moment they want to check their homes. Therefore, HAS does not have easy-to-use interfaces to monitor and track the device. Plus some smart home systems don't take safety or energy savings into account, which can be vulnerable to intruders not saving money for electric bills. Also, there are limitations to the wired communication technologies used in smart home automation systems.

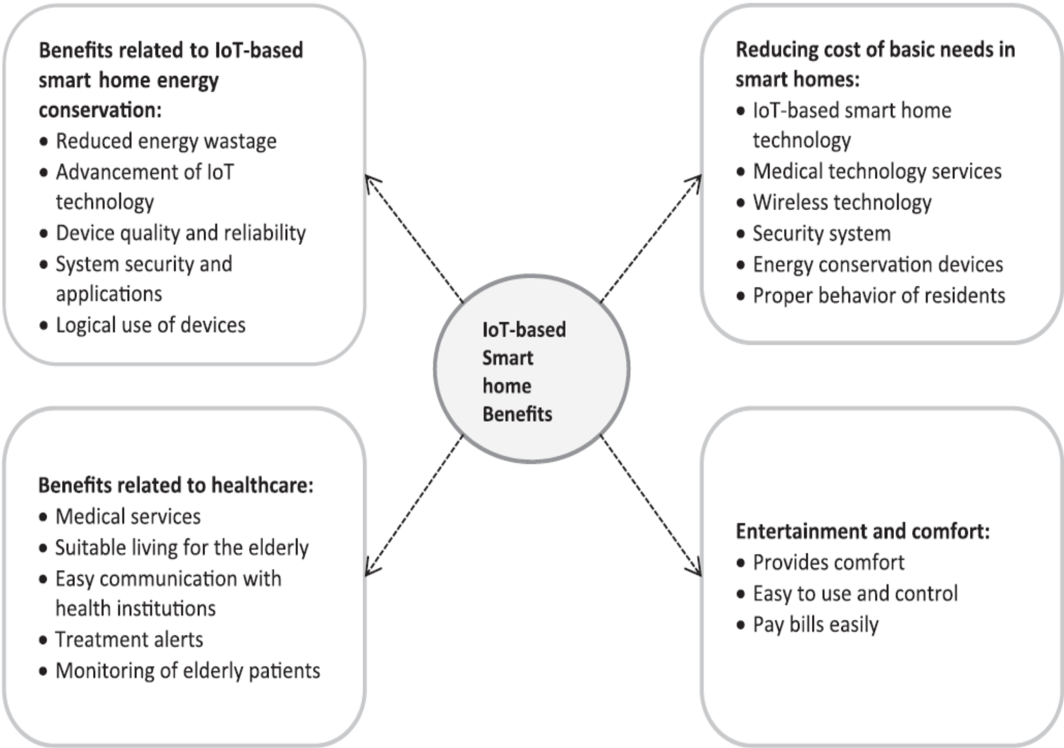


Figure 1.2. Classifications of advantages of IoT-based smart home apps [6]

Home automation systems should provide an easy-to-use interface to efficiently monitor and control home appliances. To address these issues and reduce the limitations of home automation systems, the current study presents an effective Wi-Fi-based automation system (both locally and remotely) to extend connectivity and allow users to easily and efficiently control their homes via a user-friendly application using smartphones and/or computers. The proposed system takes into account safety and energy saving.

1.3 Thesis Objectives

The current study aims to:

1. Implement efficient data collection parts on the real hardware platform to be evaluated in a smart home scenario, which is suitable for research requirements through evaluating these parts.
2. Design and fabrication of the smart home prototype to monitor and control home appliances via the real hardware platform.

1.4 Scope of Work

The scope of work is associated with this thesis is depicted in Figure (1.3). Where the blue color indicates the path we have taken. Work was done on the SH of the IoT. After collecting the components of the proposed system and the smart home prototype, the prototype was designed using Autodesk Fusion 360 application, This prototype was manufactured using Father Board and 3D Printer materials. For the system, it was worked on Arduino Mega 2560 and Raspberry Pi 3 Model B+ as microcontrollers, the Wi-Fi as a communication medium for the system.

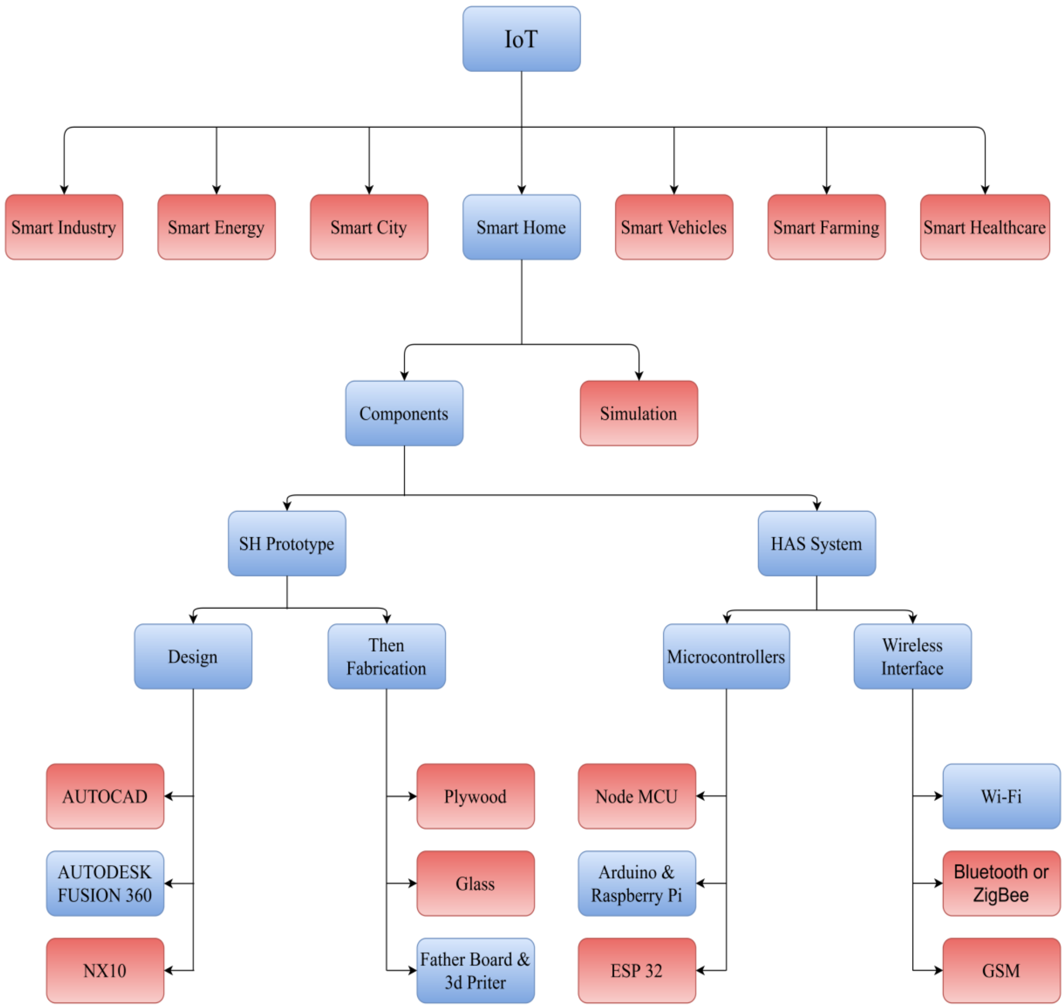


Figure 1.3. The scope of work

1.5 Brief Methodology

This part explains the conceptual framework and methods that are used in various stages to analyze different aspects of the research process, for the design and fabrication of the proposed system. In addition to explaining the structure and elements of the new framework of the suggested system in order to accomplish the goal of the study. Figure (1.4) reflects the flowchart of the analysis stages used in the current thesis.

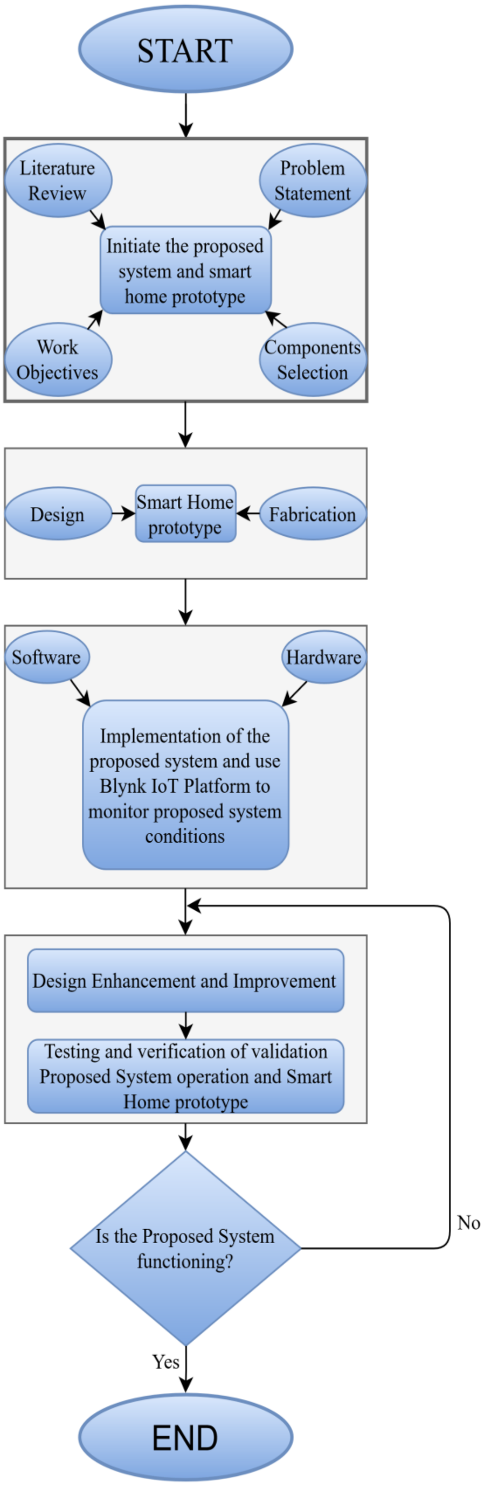


Figure 1.4. Flow diagram of the research tasks structure

1.6 Contributions of Work

This study adopts the following contributions:

1. Design of a portable, efficient, safe and saving-energy system to continuously monitor home conditions and comfortably control home appliances over the Internet.
2. Working on an easy-to-use platform (Blynk application) to provide the user with the convenience of monitoring and controlling home appliances.
3. The proposed system supports monitoring and control of home appliances remotely whether via mobile and/or PC.

1.7 Layout of Thesis

The thesis is organized as follows:

- **Chapter 2:** "Literature Review" This Chapter presents a general background on IoT in SH, introduces some basic knowledge about communication protocols and obstacles facing the SH network and challenges and recommendations for smart homes, and finally related work.

- **Chapter 3:** " Smart Home Architecture and Home Automation System Implementation" This Chapter tackles the methodology, software, hardware, and implementation of the practical system.

- **Chapter 4:** "Results and Discussion" Chapter provides this chapter results of the practical system and their discussion.

- **Chapter 5:** "Conclusions and Proposals for Future Work" this Chapter advances conclusions and future works.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Human activities today do not exist in a separate space from PC and smartphones; it is impossible to consider human achievements without paying attention to these two aspects of technology, it is as a result of the advancement of technology in general communication for human beings use has led to the growth of the Internet as a global communication channel. The need for Internet access is increasing, where we can have access to the Internet all the time.

Numerous studies are being conducted on the topic of creating smart environments based on IoT [7], for example in the more productive industries [8], the SH and SC [9,10], SE [11,12], vehicular communications [13], smart farming [14], smart interconnecting of university buildings, logistics, and health care [15,16]. A smart home is a new concept of a household. The SH provides comfort, security, and the potential for energy savings at any time [17,18], resulting in a higher quality of life for residents [19]. The smart home is here to assist the occupants of the home in managing all aspects of their comfort as residents from safety concerns to the issue of accessing devices that have been enhanced to be more interactive and can be controlled via a single device. Smart home is a subset of the Internet of Things innovation, in which all everyday items or devices [20] that are part of people's lives are spun because today's technology is predominantly all-chip.

Sensor technologies have advanced dramatically in the last few years. According to current developments in IoT technology, the tasks that involve monitoring and interacting with the environment have become simpler. and rapid development of embedded systems, which includes both hardware and software, has led to decreased implementation costs and increase flexibility. For example, an evaluation board (EVB), such as an Arduino, can be utilized to streamline and accelerate systems, while meeting the aforementioned needs [21].

Nowadays, the majority of homes have “smart” sensors or electronic appliance controllers because different devices incorporate sensor or controller technology into their electronic devices [22]. It is possible to monitor devices within the SH system with the use of an access point (AP) and to control house conditions and monitor house devices. For instance, the washing machine, light bulbs, door lock, the wash cycle, TV, and camera operating parameters can be controlled using a single integrated automation system. This type of system gains access to the Internet-enabled functionality when it becomes an automation system based on the Internet of Things. A home automation system has many advantages, such as reducing electricity bills and costs of energy. Home automation systems also have the additional benefits of increasing protection and ensuring that homeowners always know where to be and who is coming and going at all times (which results in less crime and stealing) [23]. For instance, motion detectors can warn the homeowners if they are not home, when they are away, and the appliances can send the signal to the fire department in the event of a fire. Internet of Things can be used to make current HASs better by entering a major control through the Internet.

Since these are smart home devices, they must choose what should be done and report environmental changes to the homeowners so that they can deal with them locally or remotely. Traditional IoT-based home systems, on the other hand, work passively in response to environmental data changes inside the house, requiring manually selecting appliances by the user. The device's status cannot be adjusted unless the user interacts with it. When rules have been established that govern a task but fail to take into account the characteristics of the user, for example, sensors with low usage can lead to unnecessary data loss and power consumption [24]. This Chapter will explain a general background on IoT in SH, as well as related work.

2.2 Smart Home

This part offers a summary of smart home technologies. It begins with the concepts of SHs, and what is the intelligence of SH, followed by the justification for using a smart home, the advantages and disadvantages of smart living, and a general overview of smart homes designs and their work and their relationship to the smart grid.

2.2.1. SH Description

The idea of smart homes first emerged as a wonderful home efficiency Vision of the "homes of tomorrow" in the 1930s [25]. Many promises of 'unprecedented comfort, Relief and complacency and advantages of modern household life have only been accomplished in the last few decades of the last century. At the same time, the focus on domestic efficiency has increased to energy efficiency. Darby [26] describes two key concepts for smart homes:

(i) home and user-focused, which defines smart houses as very automatic housing of integrated devices, with the emphasis on modern techniques, comfort and (domestic) quality.

(ii) Building and system-focused in building energy efficiency, auxiliary services and generation of distributed electricity, and how information and communication technology can be used to address them.

The author notes that both terms share the significance of communication. for the connection of devices and remote access/control and the provision of services. Figure (2.1) is an example to illustrate the smart home concept.

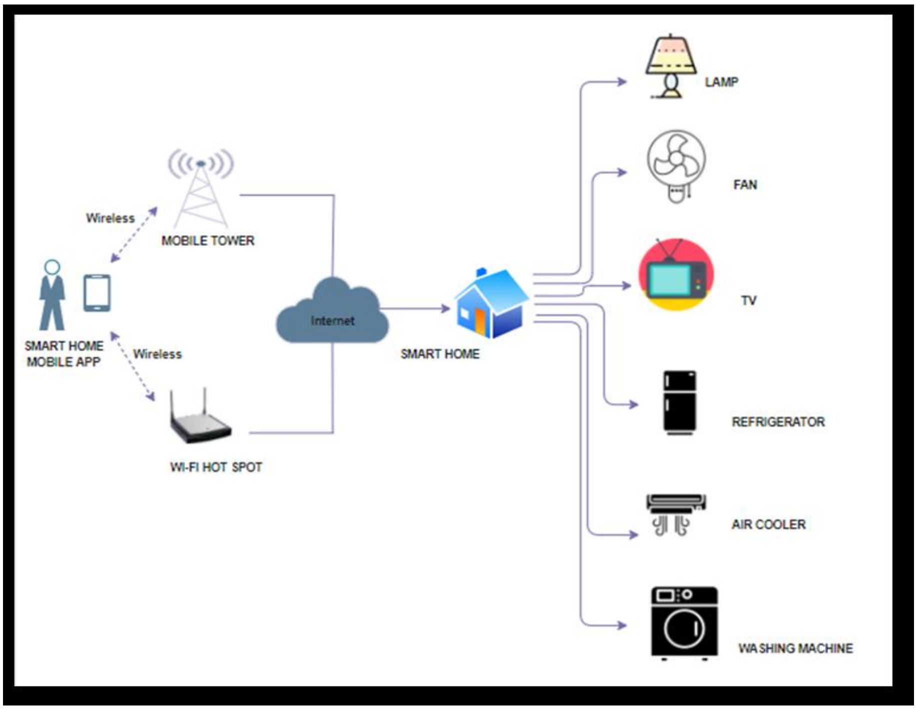


Figure 2.1. An example of the SH concept

2.2.2. What Does The Intelligence Mean?

When speaking of smart houses, one should too think of how to describe the word "smart". What distinguishes an smart home from a traditional home in which most of us live? Based on Edwards and Grinter [27], smart environments and omnipresent computing intelligence have four features:

a) The environment uses sensor information to assess the current situation (For eg, if you have triggered a motion sensor detector, it means somebody has to get near).
b) The thing can presume state while taking into account a variety of factors at once (e.g. the machine can determine that it is time for dinner if the table includes several persons).
c) By evaluating the situation, the environment will forecast a user's intentions (e.g. if motion detectors are installed in the future, it means that the consumer goes through the corridor and the user will want his or her path illuminated).
d) The environment can behave preventively based on purpose (e.g. the device can opt to switch the lights in advance so that the user may walk easily).

2.2.3 Why The SH?

The integrated illumination control system is one of the advantages of SH. The user no longer needs to turn electrical appliances on or off manually. There are two different choices, for instance, if the person enters the bedroom: either the lighting automatically on and off after the user exits the room or the user is able to control the software switch on his smartphone. The light luminosity also may be managed to reduce power consumption. Also, based on sensor readings, users can adjust room conditions (humidity, and temperature) such as regulating the fan speed from their mobile app or automatically changing the fan speed according to room temperature. This will help boost energy efficiency because, if the electrical appliances are turned off automatically or readily if they are not used, it decreases energy usage and power bill costs.

The user may also use a smartphone, tablet or computer to control electrical equipment and monitor the house conditions. For instance, if the user forgot about turning off the fan and has entered his office, he can turn off the fan by using his smart device. The user can also mount flood sensors, carbon monoxide, smoke, to warn users if their homes are inundated or whether air is unsafe, so they can only sit at home.

The user receives an alert on the phone for a safety system if an incident occurs. If there is an intruder, no need to worry about the owner because the homeowner can monitor the motion sensor from the smartphone and the alarm continues if any motion is detected. The security system is the main element of safeguarding the houses against intruders. By installing wired surveillance cameras to prevent a burglar from entering the house. All smart home components, such as air conditioning, ventilation, heating, central illumination, automated devices and a safety system, can offer comfort and protection in everyday life [28].

2.2.4 Benefits of Smart Living

Chronically ill individuals, disabled individuals, and elderly individuals who live alone benefit the most from SH applications. This smart technology has the potential to significantly improve the quality of information transmitted to physicians. By combining behavioral patterns and psychological sign readings with sirens and alarms, a specific action can be initiated.

Telecare appointments with health care providers and community health workers automate the gathering of clinical data and test results, allowing multidisciplinary care to be coordinated outside of the hospital. Chronic disease home telemonitoring is a promising patient-centered management strategy that offers accurate and reliable data, empowers patients, impacts their attitudes and actions, and may improve their medical condition. With remote care possibilities, patients become more self-aware, self-managers with task knowledge, experts, and informed when they receive telecare services. It has several advantages, including increased access to a variety of services and quality care locations. Telemedicine is generally well-received by patients. Numerous patients have expressed satisfaction with the advantages of telemedicine, which include shorter wait times for appointments, increased access to care, cost savings for the health care system, and the belief that distance exams are more comprehensive than traditional exams. The majority of patients would rather have a telephone consultation than travel to a doctor, as this saves them money and time [29].

2.2.5 Smart Living Disadvantages

Certain social, legal, and ethical constraints prevent widespread use of this technology, particularly electronic health record (EHR), due to sophisticated electronic models, health care service providers' lack of investment resources, and a lack of standards that allows clinical data sharing. Physicians face financial constraints and significant investment costs associated with integrating EHRs, decision support models, and e-prescribing. Additional expenditures are incurred for system maintenance, and money from patients is lost during the shift from paper records to electronic health records.

Other impediments are the time and effort required to learn how to use these technologies. According to one study, technology was the primary driver of the increase in health care expenses over the last 50 years, and the potential for future increases is unsatisfied. The elderly's impression of privacy is one of the factors that contribute to their acceptance of smart homes, which can improve their quality of life and raise their home's safety. When electronic health (E-health) tools reveal more information than the individual's preferences, privacy may be jeopardized. Distrust can result in information concealment, inaccurate disclosure to health care providers, or avoidance of health care models. Smart home technology may have a detrimental effect on human relationships, responses, and interactions. Individuals who use this type of technology may be concerned about technology taking the place of personal engagement with their health care professionals. Informal carers may fear that their workload may be increased. Users may be concerned that technology will hurt their lifestyle, financial situation, emotional and psychological well-being, and that of their family members. The introduction of E-health systems raises a number of issues: inadvertent disclosure of personal information, contacting the wrong persons, and inappropriate data utilization, to name a few. There is currently a lack of a comprehensive legal framework for telemedicine [30].

2.2.6 How Smart Home Works?

A smarter home system is composed of switches and sensors linked to a central device called the "gateway," which is controlled by a connected user interface or with mobile telephone programs or tablets. The equipment communicates via communications technologies Machine to Machine (M2M). M2M communication technology (sensors, measuring instruments) uses the event (temperature, metering, movement, lighting) transmitted via a network (wired, wireless, or mixed) to an application (computer or mobile) that converts the event In meaningful information captured.

Example: smart washing machines that alert their owners to the need for more detergents, and smart refrigerators that indicate recipes based on the nutrients they contain.

2.2.7 Smart Grid (SG) and Smart Home (SH)

Over the last decade, the global conscience towards energy consumption has been observed, especially concerning measures on energy conservation and the use of renewable energies. Implementation of the smart grid (SG) concept as a tool to update the power grid has made this possible [31]. The first official description of SG infrastructure gives ten features. Half of these features are specifically linked to smart homes:

1. Production and integration of demand response, energy-saving services and demand-side services.
2. The use of 'smart' technologies for calculating applications, grid and status communications and distribution automation (real-time, digital, interactive technology that optimizes the physical functioning of appliances and consumer devices).
3. The convergence of 'smart' equipment and commercial equipment.
4. Introduction and integration of integrated power storage and peak-shaving technology, like electric and hybrid connect and thermal storage for air conditioning.

5. Availability of knowledge and control choices in due course for customers.

Smart grid features therefore extend energy consumption beyond the transmission and home networks. The power system becomes more versatile and interactive in enabling energy and Information flows between home and grid in both directions and offers real-time feedback. A significant function of an smart grid is its demand response (DR) [32]. By organizing the operation of household goods with small priority (e.g. Washing or heating equipment), DR should make the most of the suitable and inexpensive sources of energy. Two types of energy planning exist:

i. Planning of energy services (which deals with the time when those sources of energy, i.e. When to be using the grid and the panel system installed house, are to be used).
ii. Planning of energy usage (which helps to maximize the schedule while different home devices are involved, because of limitations such as residual energy stored locally, or existing electricity costs in compliance with time-to-use price schemes).

As information can flow from the customer to the grid alongside energy, and the other way around, It opens some control options over smart homes. Smart meters can measure the energy consumed up at the stage of each appliance many times. This knowledge is obtained, stored and analyzed in the home energy management system (HEMS) [33]. HEMS is a household system that can plan the output of devices (e.g. based on the price on time) to minimize the cost of energy and optimize performance. However, all home appliances cannot be handled and some cannot be scheduled. Household devices can typically be split into two categories:

- Non-plannable equipment which unable to be arranged, because of the essence of the work to be performed (for example a lamp, a fridge, an electric kettle).
- Schedulable devices (e.g. launders, dryers, domestic hot water boilers, etc.) are further into interruptible devices: these are devices that can at some stage be disrupted by operation (e.g. a hot water boiler, electric charger).

A few examples illustrate that smart grids depend on smart homes. In smart devices, the data are drawn from various sensors and smart meters, allowing smart homes to optimize the quantitative and qualitative need for grid power and reduce electricity costs (or even benefit from electricity produced and exported to the grid). However, this feature of smart homes is not covered in depth by this study. An interested reader may refer to a variety of other literary tools, for example [34–36].

2.3 Protocols of Connectivity and Communication

Devices must be linked to share information in an smart home environment. smart (as previously stated) occurs when the environment is aware of the system's current state. To accomplish this, a single sensor is insufficient to collect useful data; therefore, multiple sensors are needed to communicate and increase the usefulness of the data gathered. The communication protocols are used to decide how these devices and sensors can interact. These protocols determine how companies and collaborators exchange information with requirements, hardware, and licensing protocols. Communication protocols are typically classified into three main media groups:

1) Wired, 2) Wireless, and 3) Hybrid.

Some protocols provide longer distances, while others provide stronger protections, and others reduce energy consumption. The choice is often dependent on the size of the network. Personal area networks (PAN) and local area networks (LAN) are widely used within a smart home body area network (BAN). A comprehensive comparison of multiple home area network (HAN) communication technologies is given in [37]. The remainder of this section offers a summary and recommendations for selecting the most popular and evolving communication technologies (wired and wireless).

2.3.1 Wired Protocols for Communication

Wired communication involves information transmission via wired media. It's one of the earliest methods of data transmission from the electronic telegraph that was used to send messages. The following Paragraphs show the advantages of wired communication:

Safety: As a connection to a network involves a cable to physically link the device, it is almost impossible to spy or tamper from external communication networks.

User-friendly: a network connection is as simple as a cable connection to the device; the correct network doesn't need to be chosen from the list of entries of networks or passwords, as with wireless networks.

Distance: wired data transfer goes beyond the normal wireless protocols (Wi-Fi 802.11ac); issues like interference or obstacles would not impede the transmission of wire cables in the encircled media.

Data rate: Ethernet potential data rates over 100 Gbps, whereas Wi-Fi 802.11ac's maximum theoretical rate is 1.3 Gbps.

Wired communication systems, on the other hand, have a number of disadvantages:

Mobility: it is not possible to adjust the position of the device when the cables are installed without rewiring or extending the wire.

Power: wired networks normally require power; when power is cut off, the network cannot operate on a battery in a critical condition, as the wireless network may.

Expansion: expanding the wired network coverage is not simpler than installing a Fresh wireless modem, cabling and external hardware (hubs) might be required.

Complexity and Cost: professional works and preparation for the wired network; when a smart house is constructed, installing a wired network otherwise running cables through cables will later become a boring task, and can be a little unpleasant.

2.3.2 Wireless Protocols for Communication

Wireless communication does not require sending and receiving information via radio frequency (RF) signals using wires. Due to easy usage and reduced network configuration setup and implementation costs of new devices, wireless communication protocols are becoming common within smart home networks. The following paragraph shows the advantages of wireless communication:

Mobility: because the connection of a device to a network requires no physical connection, it is possible to move it without losing connectivity; it is also simple to move the device through another wireless network.

Expandability: it is easy to add additional devices to the network when the maximum approved system number is not surpassed; it is easy to scale up or down wireless networks if necessary at no or minimal cost.

Costs: it is very easy to create a wireless network, even without professional support.

Flexibility: creating a wireless network in a new location is as simple as the power supply connection of the system, this enables experimenting with new technologies or the placing of sensors.

Wireless communication has the following drawbacks:

Protection: although existing encryption mechanisms are solid, packets are intercepted able, and may be decrypted (although it may be extremely unlikely); most security problems occur in the absence of a proper configuration if the wireless network is not secured in any way.

Data rates: theoretic wireless networks do not have wired networks (e.g. ethernet); however, for most smart home applications, data rates are also adequate in practice.

Interference: interference-prone wireless networks may interrupt or affect network service efficiency.

Coverage: wireless networks ideally provide More coverage than wired networks in a specific domain, but barriers or poor positioning can limit coverage and lead to command/message loss.

In our proposed system, Wi-Fi was used as a communication medium, because Wi-Fi has a high data transfer rate, in addition to the wide range, ease of monitoring and controlling the system remotely unlike other technologies. The following paragraphs include summarized on wireless protocols most widely used in smart homes:

- **Wi-Fi:**

  Wi-Fi is available in an IEEE 802.11-based wireless networking protocol. Wi-Fi does not require a license and is one of the most commonly used wireless technologies today. It has a possible 45 m indoor coverage but can be extended to also include wireless Internet repeaters and redundant points of entry, making it ideal for wireless Internet. The platform provides encryption of Wi-Fi Protected Access 2 (WPA2) and operates at a frequency range of 2.4–5 GHz. The drawbacks of Wi-Fi provides high demand technology. for electricity and interference vulnerability. Indoor barriers can also affect network speed and reliability [38].

- **Bluetooth:**

  Bluetooth currently is IEEE 802.15.1's most popular wireless technology for PANs. It works on 2402–2480MHz or 2400–2483,5MHz with 79 channels in a single channel with 1MHz, although in some nations these channel limits are imposed. The technology is smart to stop busy channels and to change channels with frequency hopping spread spectrum (FHSS) [38]. Bluetooth is extremely common with wearable and Mobile appliances. Bluetooth Low Energy (BLE) is a Bluetooth separation intended for low-energy devices that are operating on a long-lasting battery of the cell. Bluetooth 5 also introduced a variety of BLE enhancements, focusing on evolving support for IoT devices, such as expanded channel range, improved range and increased data speeds.

- **ZigBee:**

ZigBee is an IEEE 802.15.4 based secure low-cost networking technology for devices with a small power supply (e.g. battery-powered ones). The technology is accessible and free to be used for all to use, vendors, building low-power devices are very popular. The standard data rates range from 20–250 kbps, with an impact region of up to 70 m [38, 39]. ZigBee advocates multi-hop transmission to extend the spectrum of actions, but often This can result in a "popcorn effect" as a result of the delay in action as the message is spread from system to system until reaching the final target. Hops are 5 by default, which means if you don't hit a response after 5 hops, the message will be rejected and the intended recipient never receives the message.

- **Z-Wave:**

Z-Wave is a second technology developed with a view to reliability for low-powered devices. In comparison to ZigBee, Z-Wave is a special technology that allows suppliers to buy a license to be accredited by the Z-Wave Alliance. The transmission speeds arrive at 100 kbps, with a range of up to 50 m. Z-Wave may form networks of mesh, This means that devices may connect without a gateway or controller. If a computer isn't close by, messages will jump up to four times between networks to get there [40].

- **6LoWPAN:**

6LoWPAN is also an open-source that can be used openly with low power PAN standards on Protocol to the Internet version 6 [41]. It is based on IEEE 802.15.4, which is the same as ZigBee. Depending upon the frequency, The technology gives 20-250 kbps data rates, ranging from 10 to 100 m. Since it is IPv6 oriented, both devices have a specific IP-version 6 address and are easy to get to from the Internet (In comparison to ZigBee and Z-Wave only accessible from the PAN).

The key features are summarized also in Table (2.1):

Table 2.1. Wireless protocols of communication

	Bluetooth	Bluetooth LE	Wi-Fi 802.11n	Z-Wave	ZigBee	6LoWPAN
Encryption	AES-128	AES-128	WPA2	AES-128	AES-128	AES-128
Data rate	0.7-2.1 Mbps	2 Mbps	450 Mbps	10-100 kbps	20/40 kbps, 250 kbps	10-40 kbps, 250 kbps
Frequency	2.402-2.483 GHz	2.402-2.483 GHz	2.4-5 GHz	868/915 MHz	868/915 MHz, 2.4 GHz	868/915 MHz, 2.4 GH
Network Topology	Star	Star	Star, tree, p2p, mesh	Star	Star	Star, mesh, p2p
Network size	8	N/A	Thousands (mesh)	232	65.536	250
Range	10-15 m	10-15 m	10-100 m	30-50 m	10-100 m	10-100 m

2.4 Obstacles to Communication in SH Network

This part describes the problems or obstacles of communication in the SH network, which are summarized in the points listed below:

A. Maintainability Obstacles

Maintainability is a critical need for a network since it indicates the network's reliability and durability. Everywhere, even the home environment, changes occur due to failed nodes, depleted batteries, and new duties. Thus, subsystems in a smart home network must be monitored for their strength and status to adjust operational parameters or choose between alternative services, such as offering lower-quality services to conserve energy. The SH network must be built with the aim of simple maintenance that can rapidly and cost-effectively repair the various appliances and communication components.

B. Interoperability Obstacles

Interoperability is critical because consumers require simple-to-connect and simple-to-use gadgets that work seamlessly together. In the SH network, devices and systems may originate from different manufacturers with varying network interfaces, yet they must nevertheless communicate in order to perform tasks in unison. Interoperability is described as the capacity of systems, apps, and services to communicate and interact predictably and reliably. Two or more systems can exchange information and make use of that information. The extraordinary interoperability initiative run by the Wi-Fi alliance is largely responsible for Wi-Fi's enormous success. In comparison to its initial version, which failed to achieve interoperability, ZigBee 3.0 will allow a greater range of devices to smoothly interoperate regardless of their functional domains. A combined solution enabling ZigBee products to use the 6LoWPAN protocol and a certification scheme to ensure interoperability is the consequence of the two organizations' April 2015 announcement of cooperation. Additionally, it is the latest step toward integrating a highly fragmented ecosystem that includes a plethora of standards initiatives centered on the IoT. With tens of thousands of certified devices that have demonstrated interoperability, the Wi-Fi alliance has one of the most trusted certificate regimes in the world. The Bluetooth special interest group's rigorous certification procedures encompass the whole protocol stack and application profile, enabling Bluetooth to achieve excellent market interoperability. ZigBee and 6LoWPAN both share fundamental physical requirements, allowing for some degree of compatibility between the two standards, while Z-Wave technology available on the market enables app-level interoperability.

C. Signaling Obstacles

In a linked Internet of Things network of appliances, bidirectional signaling reliability is critical for collecting and routing data between appliances, and it is here that the Internet of Things data streams come into play. All gadgets in an smart home network may communicate with a server in order to gather data, or the server may communicate with the devices directly, or those devices may communicate with one another. The critical issue is that data must be transported swiftly and reliably from point X to point Y. You must be certain that the stream of data will always reach its destination. Wi-Fi suffers a signal loss, however, ZigBee and Z-Wave have no signal loss due to their modest bandwidth, making these two technologies ideal for devices that simply require data connections. Z-Wave employs the 908.4 MHz (US) low-frequency radio band, thus its appliances will not interfere with a Wi-Fi network. The protocol 6LoWPAN communicates via radio in the 2.4 GHz band, which may interfere with Wi-Fi transmissions.

D. Power Consumption Obstacles

Devices connected to the Internet of Things in the smart home can calculate the optimal time to function, resulting in increased energy efficiency. Thousands of connected Internet of things devices transmit signals and data around the hour, consuming significant amounts of power and central processing unit (CPU). To be effective, an IoT network must have minimal battery drain and low power usage in this type of connectivity.

Standard Wi-Fi consumes a lot of power. Although BLE consumes less power, it has limitations in terms of signal range and appliance count. ZigBee networks typically consume 25% less power than Wi-Fi networks, and Z-wave networks consume less power than Wi-Fi but have a slower data transfer rate in comparison to Wi-Fi. 6LoWPAN is battery-powered and consumes relatively little energy to run. Devices communicate effectively to give an excellent user experience while still running for years on the tiniest of batteries.

E. Bandwidth Obstacles

Another challenge with IoT connectivity is bandwidth consumption. Managing bandwidth in a house network is also becoming increasingly important. As the number of personal and house gadgets increases, massive amounts of data are generated, and as a result, bandwidth requirements are becoming more prevalent in modern houses. Video streaming, in particular, has grown to be the application that consumes the most bandwidth. It generates a massive server issue, necessitating the use of a large-scale server to handle all of this data. As a result, a lightweight network moves data seamlessly between appliances and servers. Wi-Fi is a high-bandwidth network, while Bluetooth LE offers a larger data bandwidth than Z-wave and ZigBee (lower than that of Wi-Fi).

2.5 Challenges of The SH

There are various advantages of the smart way of smart home applications oriented to the Internet of Things, however, these systems are not suitable solutions for connecting telecommunication networks. The survey showed that researchers are concerned about the nuances of smart operation in IoT-based SH applications and their use. Users face obstacles to the difficulty in maintaining of the SH, unfriendly user interfaces, and most users do not take into account safety and security, restrictions on wired and wireless technologies, In addition to the challenges of energy management, data transfer, and healthcare. Figure (2.2) summarizes the main challenges that users face based on the smart home application method [6].

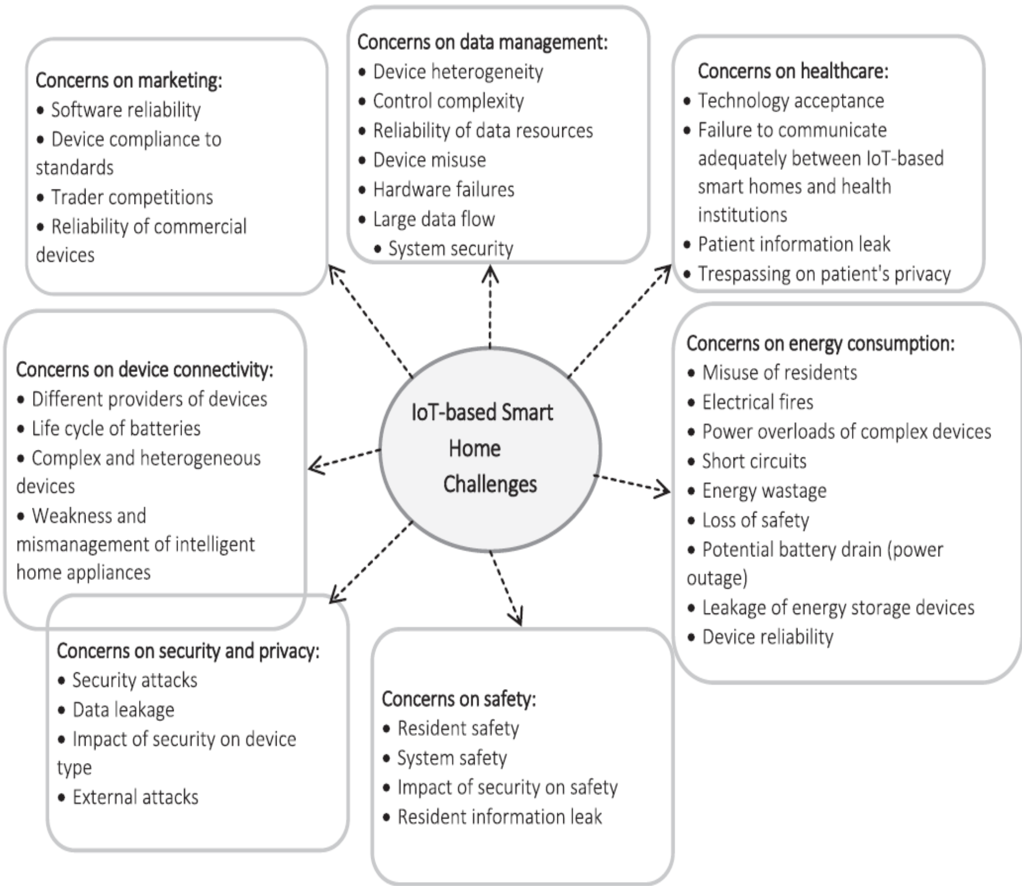


Figure 2.2. Challenges groups based on IoT smart home app methodologies [6]

2.6 Recommendations Related of The SH

This section summarizes the literature recommendations most relevant to mitigating challenges and promoting the safe and successful use of smart home technologies such as IoT-based devices and sensors. There are recommendations for the user in terms of behavior, energy consumption and device breakdowns, and safety and security recommendations to protect against external attacks and the entry of hackers [42-44] in Figure (2.3) explains the recommendations that the user should observe in SH systems.

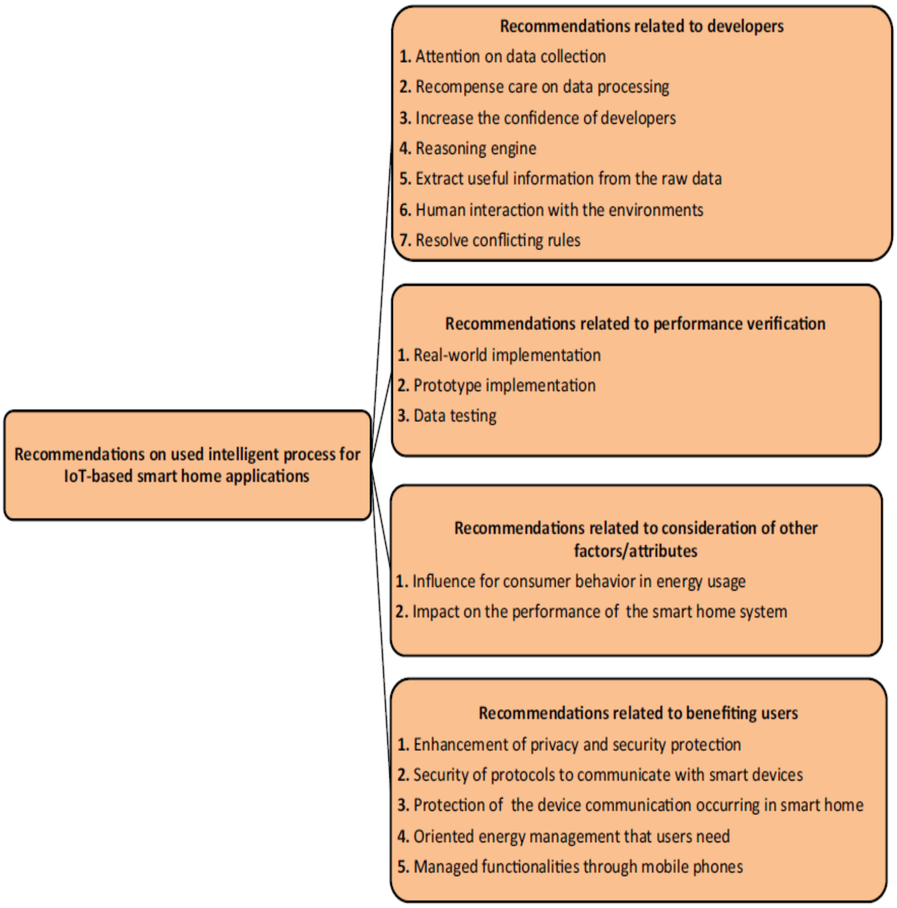


Figure 2.3. Recommendations groups for IoT applications in smart homes [42]

2.7 Related Works

In the future, the Internet of Things is expected to take on an unusual shape. This part deals with previous studies related to the Internet of Things about a range of SH-based research and was summarized in a Table (2.2). Studies on SHs on the prevalence of home equipment in IoT are also discussed, the proposed system is also listed in the comparison to emphasize its major contributions in relation to the existing systems.

Konidala, et al. [45] used Radio-frequency Identification (RFID) tags in an smart refrigerator to differentiate between different components. This technique was utilized to improve house security, but it necessitated several factors inside the house. These components included RFID tags for house populations that are difficult to introduce because of human memory deficits. While many SHs use the Internet of Things, they are susceptible to different attacks. house appliances may thus be linked via a home gateway to the wired or wireless network, An attack at the home portal will automatically result in a fledged assault on the house network that could lead to an external connection. However, an entity may target a device that is connected to another via a local communication interface or a network, such as a field machine or a gateway, and may impersonate a system with a defective certificate.

Davidovic and Labus [46] proposed smart home-based sensor-based automation to automatically control home devices using remote controllers from Android-based smartphones. The authors used the communication protocol Raspberry Pi and the microcontroller Bluetooth. Wi-Fi was used to connect the Raspberry Pi controller to the same network access point (AP) via smart devices. The sensors' data has been transferred to a local server via a Raspberry Pi. The user is unable to connect to the server and cannot communicate directly with it to send commands to the Raspberry Pi controller using the smartphone while outside the Wi-Fi AP scope.

A home automation framework based on Message Queuing Telemetry Transport (MQTT) using ESP8266 was presented by Kodali and Soratkal [47]. ESP8266 was connected to actuators and sensors and MQTT has been used for tracking and control. Wi-Fi was used for prototype communications and ESP8266 was used for MQTT applications. The ESP8266 module was programmed by Arduino IDE (Integrated Development Environment) as MQTT. The effect of MQTT was Low power usage and bandwidth. The ESP8266 board was more cost-effective than other microcontrollers including Arduino UNO and ESP 32. Security and security concerns have been overlooked and the framework established has not been validated.

Gupta and Chhabra [48], developed and implemented an smart ethernet-based SH system to control energy usage in real-time, by using Intel Galileo Generation 2 board which is accessible via home monitoring systems in houses and communities. The system was operated by voice control, which enabled remote monitoring and surveillance of electronics equipment and key systems without or with Android. This study introduced an smart and smart IoT-based power management and protection system with autonomous, portable energy control, where users are able to monitor their own households' power and protection even when they are not present. The energy use was minimized and the usage of resources was maximized by monitoring and tracking electrical devices and home protection in real-time. Various sensors were used for real-time monitoring of the systems and for preserving home protection. The device has been remotely controlled and tracked via the Internet via an Android app. The findings of this research presented many advantages, such as keeping users in close contact with the houses by using voices or simply pressing their smartphones to regulate switching devices, providing electricity billing at home and tracking usage of resources to minimize electricity consumption. That experimental results have shown demonstrating that the system is energy efficient conservation and safety.

Ganesh [49] implemented smart home applications GSM IoT architecture and implemented the smart home design system of control on a GSM basis. This work proposed a framework that allows users can control and monitor smart systems remotely via the Internet, by converting web commands from users and user entries into SMS-GSM commands. The proposed architecture establishes a connection between the smart home and its users via the Internet and GSM, as well as a wireless connection between the web server and the smart home via GSM. These instructions will be sent to the module of the integrated devices. That can be linked to devices directly via the GSM network anywhere in the world. The module is also managed by the GSM network via an agent of IoT. All electronics, such as lights and household appliances, are tracked, evaluated and transmitted using a microcontroller. The prototype gathers and transmits data via SMS-GSM. Initial testing indicates that the prototype can track or control devices in the published environment and offers several advantages, including zero data loss, versatility, ease of operation, rapid distribution, energy efficiency, and low cost.

Bhat, et al. [50] introduced a system for energy management and device efficiency based on the IoT. The fundamental concept of the work would be to track house devices using smartphones using Wi-Fi to provide information on components composed of both hardware and software. The Internet of Things architecture in smart homes is the following: Firstly, all devices are linked with the smart central control system, that by each connected device is connected to a switch, allowing access from each device. The device can then be linked via a router to the Internet, allowing the user to connect as needed.

Jabbar, et al. [28] developed a smart home Wi-Fi system and put it into practice. Users can monitor and track the home using Wi-Fi through the existing Arduino Mega prototype integrated with the Virtuino Android-based app. Nevertheless, the prototype had a limited amount of connectivity and can only be carried out locally, and remote IoT-based control should be allowed. The prototype also did not automate doors and windows and didn't take into consideration the protection and safety of the smart home.

Badabaji and Nagaraju [51] showed a device that manages Internet of Things based equipment, monitors temperatures, fire and gas exhibits their values through a liquid crystal display (LCD) by various sensors. The system used while the user is away monitoring the temperature senses the leakage and fire of liquid petroleum gas and gives short home safety data when a fire or a gas leak is discovered. This means that the gas sensor detects and warns the user of a leak by submitting the siren and show of the SMS message on the LCD to the mobile telephone and people in their homes. Likewise, an automatic short text message is sent and a fire detection engine is powered. Since the proposed system uses different sensors, a range for temperatures, light and gasses is determined. As a result, a message is obtained through GSM when the value range is expanded when it is stored on displayed on the LCD panel of a future reference server. Additionally, the outcome of the webserver is stored and can be found worldwide. In short, the Internet of Things is utilized to improve safety requirements by resolving sensors communicate wirelessly and amplifiers using one chip via Wi-Fi.

Ozeer, et al. [52] stated that versatile methods for practical testing in the SH environment were planned and implemented Fog-IoT, in which this frame was performed and tested concerning environmental requirements. This review summarized the versatility of the architecture, enabling developers to provide IoT with a scalable services world. The whole application was prevented by this system in case of a malfunction, the spread of failures was restricted and appliance and infrastructure entities were recovered by reshaping and restoring a coherent application status.

Mahmud, et al. [53] proposed SHAS in addition to the measurement system using the Internet of Things. The system aims to control household devices The system aims to control household devices and also electrical appliances via the website. The website's user interface is extremely straightforward and accessible to anyone. With the help of this website, the user cannot only monitor and control electronic equipment but additionally the measuring system. The user can also monitor the measuring system and see if there is any conflict in the distribution system. The system lacks remotely control, in addition to not taking into account the issue of safety and energy saving.

Pujaria, et al. [54] used ESP32 and Wi-Fi as the transmission. System design specifications are chosen to be user-friendly, low cost and can be controlled remotely. This can be beneficial for everyone, especially the elderly and those with different abilities. The result shows that this system is operating well and achieving its goal. The system can be modified by adding support for iPhone and Windows users so that more users can access the application.

In our proposed system, the SH system was used, in which the homeowner can monitor and control home conditions through the Blynk application using a smartphone or PC. It was worked on Arduino Mega 2560 and Raspberry Pi 3 Model B + as microcontrollers, and Wi-Fi as a communication medium for monitoring and controlling locally and/or remotely. A wide range of sensors were used, the safety and energy savings of the system were taken into consideration.

Table 2.2. Summary of the smart home systems

SH System / Year	Microcontroller	Indoor control	Outdoor control	Energy Management	Monitoring	Safety	Smartphone	PC	Wireless Interface
Konidala, et al. [45] / 2011	PC Server						Yes		RFID
Davidovic and Labus [46] / 2015	Raspberry Pi	Yes			Yes		Yes		Bluetooth/ Wi-Fi
Kodali and Soratkal [47] / 2016	Node MCU	Yes					Yes	Yes	Wi-Fi
Gupta and Chhabra [48] / 2016	Galileo board	Yes	Yes	Yes	Yes		Yes	Yes	Ethernet
Ganesh [49] / 2017	8051µc	Yes	Yes					Yes	GSM
Bhat, et al. [50] / 2017	PC Server			Yes					Wi-Fi
Jabbar, et al.[28] / 2018	Arduino Mega	Yes			Yes		Yes		Wi-Fi
Badabaji and Nagaraju [51] / 2018	PC Server				Yes	Yes		Yes	GSM/Wi-Fi
Ozeer, et al. [52] / 2019	Raspberry Pi	Yes	Yes	Yes	Yes			Yes	Fog-IoT

Mahmud, et al. [53] / 2019	Arduino	Yes			Yes			Yes	Wi-Fi
Pujaria, et al. [54] / 2020	ESP 32	Yes	Yes		Yes		Yes		Wi-Fi
The Proposed System	Raspberry Pi 3 Model B+ / Arduino Mega 2560	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Wi-Fi

CHAPTER THREE

SMART HOME ARCHITECTURE AND HOME AUTOMATION SYSTEM IMPLEMENTATION

3.1 Introduction

The Internet of Things is the result of the merging of many engineering domains such as computers, communications, and electronics. This technology enables data collecting and recording from a variety of locations and under a variety of conditions a breeze. It also speeds up and improves the accuracy of the aggregated data flow analysis. Home monitoring and control have become a smart trend because of the rapid growth of the IoT and smart sensors.

This chapter will discuss the design, manufacture, and validation of a mobile automation system powered by the Internet of Things for homes. The system enables IoT automation for monitoring and control using Raspberry Pi 3 Model B+ and Arduino Mega 2560 as microcontroller and Internet gateway. The proposed system uses numerous sensors to keep track of numerous parameters related to the home, such as the PZEM-004T sensor, temperature and humidity sensor, magnetic door sensor, infrared radiation (IR) motion sensor, flame sensor, MQ-135 sensor and RFID sensor. Relays are also used to control household devices, such as turning on and off lights. The lights can also be turned on and off automatically using the IR sensors to save energy. As well as controlling the doors and windows by notifying RFID and buzzer sound when the IR sensors sense in the deny mode for RFID the movement of intruders by sending a message via Blynk app, turning on the fans when the temperature rises above the required limit, also discharging the gas leak when it is present through the reverse fans, and firefighting if it is present using the water pump, and the PZEM-004T sensor can also automatically turn off the electricity for the system when the sensor detects high loads. Moreover, a Blynk app was used to facilitate the monitoring and controlling of home-related parameters. A prototype for SH was created (design by Autodesk Fusion 360 and fabrication by Father Board & 3D Printer) to implement and validate the proposed system. A proposed system is intended to automate household devices and control locally/remotely via the smartphone or PC, increase safety and energy-saving, and improve quality of life and comfort.

3.2 SH Architecture

This section describes the framework and methods used at different stages of the research process to analyze different aspects for the design and manufacturing of the smart house during the research process. Additionally to clarifying the structure and elements of the proposed system's new framework in order to achieve the thesis's objective.

3.2.1 Methodology

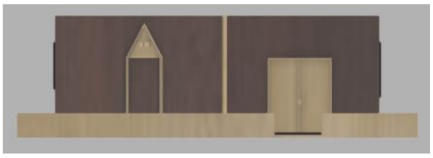
This section discusses the methodology used in this study, which entails a systematic organization of the various research phases, as well as the detailed design and implementation of a system that has been proposed and the smart home prototype. Additionally, the components selection and integration are discussed in detail to ascertain that the work objectives are met. The conceptual framework for this study is depicted in Figure (1.3). The research begins by identifying the issues that currently exist in SH systems. The next phase is dedicated to the material and component selection necessary to construct the smart home prototype and develop the proposed system. The SH is designed in Autodesk Fusion 360, and the prototype is constructed using a Father Board and 3D Printer. The automation system that has been proposed was designed and implemented. Wiring and connection of various components (bulbs, fan, reverse fan, water pump, buzzer, microcontrollers, RC522 (RFID), relays, step down power supply module, and sensors) in the proposed system's smart home prototype. After the microcontroller and its peripherals are connected, testing is conducted to ensure that the required tasks are accomplished. The design is then double-checked to ensure that no issues with the system's functionality exist. To validate the system's effectiveness, testing is performed again. When a problem is detected, we address the problems in order for the system to function satisfactorily.

3.2.2 Design and Fabrication of The Smart Home Prototype

The smart house is designed on Autodesk Fusion 360 software based on the specifications: Four main rooms are included in the prototype design, a garden, and two main doors and four windows. In the manufacturing process, the RFID sensor is located near the door, where the owner scans his or her access card to enter the home. And the magnetic door sensor on the windows to ensure safety. The rest of the system components are distributed in the rooms. In general, the smart home prototype is accomplished for utilizing the proposed system. Figure (3.1) depicts the smart home prototype's overall look and feel.

(a) Top display

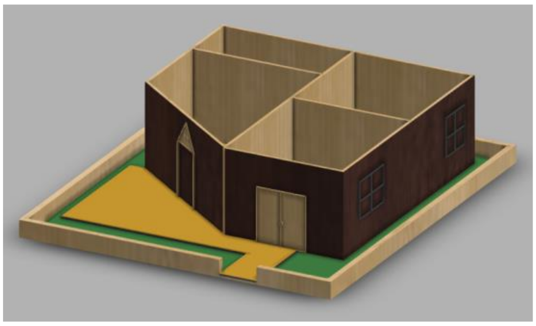
(b) Back display



(c) Front display

(d) Side display

(e) Side display 2



(f) Full home prototype

Figure 3.1. Designing of the smart home prototype by using Autodesk Fusion 360 software

The SH prototype is fabricated using Father Board & 3D Printer, as shown in Figure (3.2). Doors and windows by 3D printer, the rest of SH prototype by Father Board material. The prototype fabricated includes four master rooms and a garden. It has two main doors and four windows. The wiring of lights, sensors, microcontrollers, relays, and the rest of the devices are installed and arranged on the walls and the floor.

(a) Top display

(b) Front display

(c) Side display

(d) Back display

Figure 3.2. Fabrication of the smart home prototype by using Father Board & 3D Printer

3.3 The SHAS Development

This part shows all the tools and materials requisite for the proposed system to be tested to ensure that the required tasks are accomplished. Then the design is checked to ensure that there are no problems with the functions of the system. When a problem is detected, we address the problem to make sure the system is effective again. Then the system is fully implemented when the system is working satisfactorily. Otherwise, the system returns to the stage of troubleshooting.

3.3.1 Materials Selection

Software and hardware components are critical and integral to the design of the proposed system for it to operate successfully and smoothly. The following components were utilized in the construction of the proposed automation system:

Raspberry Pi 3 Model B+, Arduino Mega 2560, 9V DC power source, 4-channel relay module, as well as many other sensors for monitoring and controlling SH conditions such as PEZM-004T sensor, humidity and temperature sensor, magnetic door sensor, infrared motion sensor (IR sensor), flame sensor and MQ-135 sensor, mini fan, reverse fan, RFID, 12V DC water pump, buzzer, step down power supply module, Light Emitting Diodes (LEDs), breadboard to arrange the wires, Father Board and 3D Printer for the smart home prototype. The components of the software are listed as follows: Arduino IDE, Code with MU, Virtual Network Computing (VNC) Viewer, and Blynk app.

3.3.1.1 Microcontrollers

Two microcontrollers were used in our system. The first is Arduino Mega 2560, as shown in Figure (3.3). The Arduino Mega 2560 board is used as a key controller in this project, this board is based on the ATmega 2560 controller. Includes this board digital I/O ports 54, featuring 16 analog inputs, 14 Pulse Width Modulation (PWM) ports and 4 outputs for Universal Asynchronous Receiver/Transmitter (UART), 16 MHz crystal oscillator, Universal Serial Bus (USB) link, a power jack, In-Circuit Serial Programming (ICSP) module, and Reset (RST) switch. This board contains its microcontrollers and all their supporting components. This allows the board to be operated by a USB link or a battery, or power it by plugging it into an AC outlet. This plate can be covered from accidental electrical discharges by positioning the base plate. This board have a versatile working memory space and are capable of handling various types of sensors without delay. Compared to other Arduino style boards, this board are more durable. In this project, the function of this panel is to read the data from the sensors connected to it and send it serial to the Raspberry Pi. Table (3.1) shows the main features of the Arduino Mega 2560 [55].

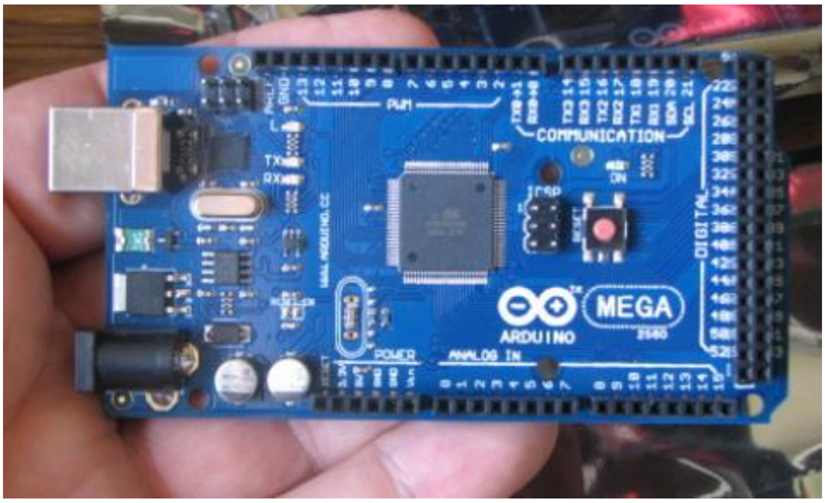


Figure 3.3. Arduino Mega 2560 microcontroller

Table 3.1. Summary of the main features of the Arduino Mega 2560 [55]

Microcontroller	ATmega2560
Input Voltage (recommended)	7-12V
Operating Voltage	5V
Input Voltage (limits)	6-20V
Analog Input Pins	16
Digital I/O Pins	54 (of which 14 provide PWM output)
DC Current for 3.3V Pin	50 mA
DC Current per I/O Pin	40 mA
Electrically Erasable Programmable Read-Only Memory (EEPROM)	4 KB
Static Random Access Memory (SRAM)	8 KB
Clock Speed	16 MHz
Flash Memory	256 KB of which 8 KB used by bootloader

The second microcontroller is the Raspberry Pi 3 Model B+, this microprocessor is the latest release in the Raspberry Pi 3 series, as shown in Figure (3.4). It is used as the secondary controller of this project and features a 64-bit quad-core processor operating at 1.4 GHz, Bluetooth 4.2 / Bluetooth Low Energy (BLE) and a dual-band 2.4 wireless local area network (WLAN), faster Ethernet, and Power over Ethernet (PoE) over a separate PoE Hardware Attached on Top (HAT) network. Dual-band WLAN with compliant compliance monitoring, enabling the board to be used in finished goods, at a lower cost and in less time. The Raspberry Pi 3 Model B+ retains the like physical scale as the Raspberry Pi 2 Model B and Raspberry Pi 3 Model B.

Its function processes the serial data sent from the Arduino and sends it to the Blynk app in this work. Table (3.2) shows the specifications of the Raspberry Pi 3 Model B+ [56].

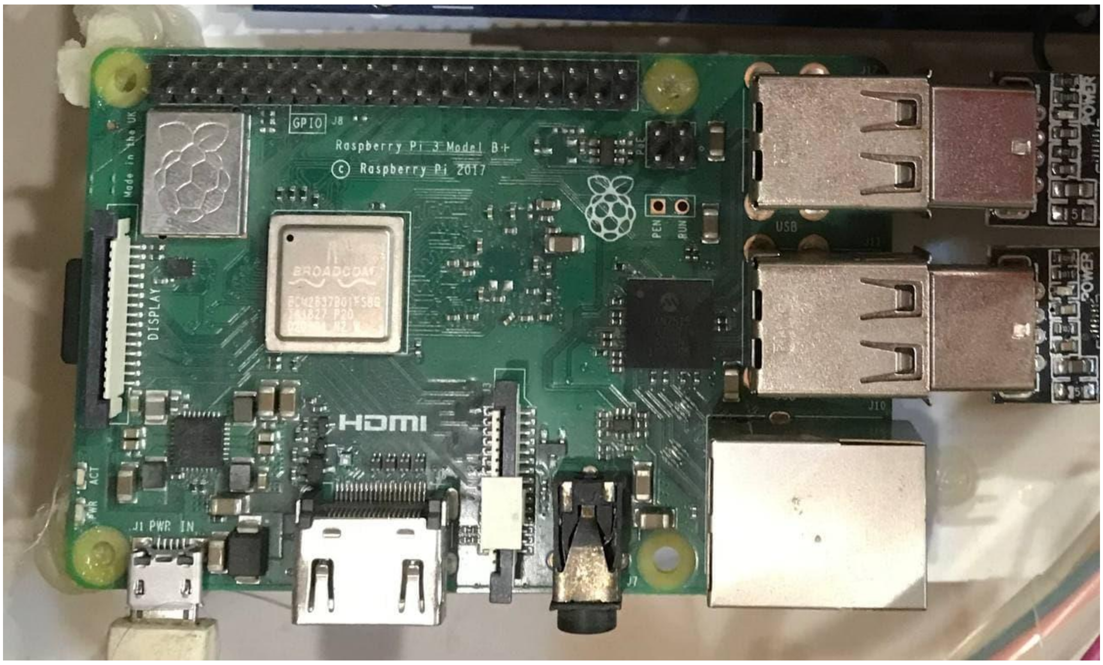


Figure 3.4. Raspberry Pi 3 Model B+ Microprocessor

Table 3.2. Summary of the specifications of the Raspberry Pi 3 Model B+ [56]

Processor	Broadcom BCM2837B0, Cortex-A53 64-bit System on a Chip (SoC) @ 1.4GHz
Connectivity	➢ 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac WLAN, Bluetooth 4.2, BLE ➢ Gigabit Ethernet over USB 2.0 (maximum throughput 300Mbps) ➢ 4 × USB 2.0 ports
Video & sound	➢ 1 × full-size High-Definition Multimedia Interface (HDMI) ➢ Mobile Industry Processor Interface (MIPI) Display Serial Interface (DSI) display port ➢ MIPI Common System Interface (CSI) camera port ➢ 4 pole stereo output and composite video port
Memory	1GB Low-Power Double Data Rate2 (LPDDR2) Synchronous Dynamic Random-Access Memory (SDRAM)

Access	Extended 40-pin general-purpose input/output (GPIO) header
Secure Digital (SD) card support	Micro SD format for loading operating system and data storage
Multimedia	H.264, Motion Picture Experts Group-4 (MPEG-4) decode (1080p30); H.264 encode (1080p30); OpenGL ES 1.1, 2.0 graphics
Input power	➢ 5V/2.5A DC via micro USB connector ➢ 5V DC via GPIO header ➢ Power over Ethernet (PoE)–enabled (requires separate PoE HAT)
Compliance	For a full list of local and regional product approvals, please visit www.raspberrypi.org/products/raspberry - pi-3-model-b+
Environment	Operating temperature, 0–50°C
Production lifetime	The Raspberry Pi 3 Model B+ will remain in production until at least January 2023.

3.3.1.2 Relays

The 4 Channel Relay Module is a versatile board that can be used to control high current, high voltage loads such as solenoid valves, motors, lamps, and alternating current loads. It is intended to be used in conjunction with microcontrollers such as Arduino, Raspberry Pi, ESP32 and others. As shown in Figure (3.5) [57].

In this study, a 4-channel relay module is used to control the lights. The relay is activated or deactivated in response to signals received from the Arduino Mega 2560, which processes user or sensors commands.

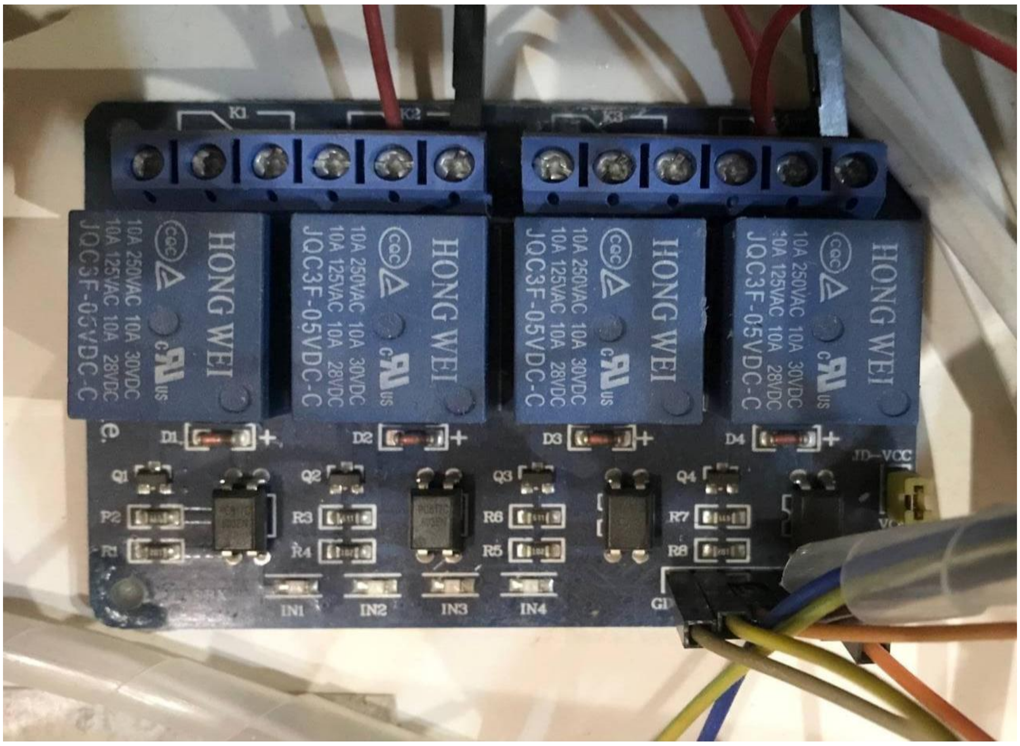


Figure 3.5. Pinout of a 4-Channel Relay Module

3.3.1.3 Sensors and Other Devices

Several sensors were used for various purposes in this study. The PZEM-004T sensor is used to monitor current (AC), voltage (AC), power (AC), energy (AC), frequency (AC), etc. The PZEM-004T sensor can automatically turn off the electricity when the sensor detects high loads that may cause damage to the SHAS. The PZEM-004T sensor is shown in Figure (3.6). DHT11 & DHT22 sensors are used to measure the humidity and temperature levels in the home, Figures (3.7, 3.8) show these sensors. These sensors have been used due to their numerous advantages, including excellent quality, low cost, long-distance signal transmission, strong anti-interference capability, rapid response, and long-term stability. When the temperature exceeds 25 degrees celsius, the sensors transmit a command to the Arduino Mega which in turn sends a command to the small fan to turn automatically it on in the SH prototype. Also when the humidity is higher than 30 C, the reverse fan will turn on to get rid of the excess moisture (DHT22 was used to measure outdoor temperature and humidity because of its high accuracy, while DHT11 was used to measure indoor temperature and humidity).

Figure 3.6. PZEM-004T sensor

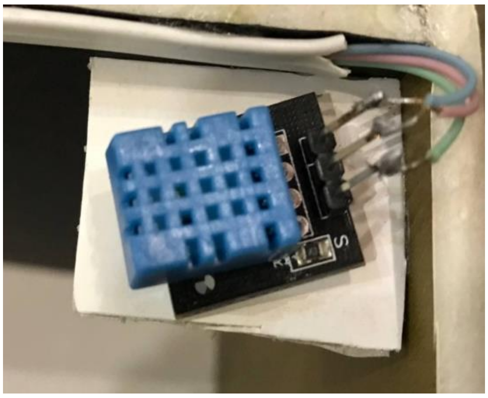


Figure 3.7. DHT11 sensor

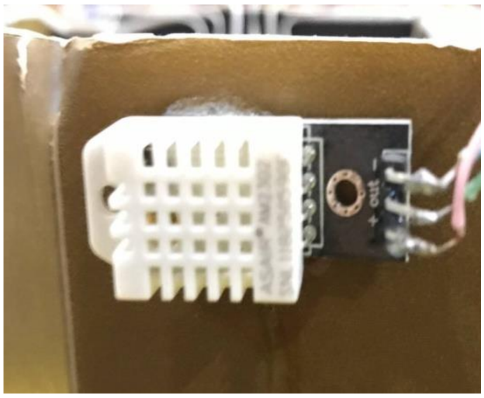


Figure 3.8. DHT22 sensor

Infrared sensors (four IR sensors) is used to detect the presence of humans in the house, Figure (3.9) shown this sensor. These sensors send the information to the Arduino Mega which response by taking the required action. Signals acquired from two IR sensors can be utilized through the movement of the inhabitants of the house, to turn on/off lights in the home, demonstrating that the suggested system saves energy. In addition, when someone is spotted for security reasons while the homeowner is away, the output of two IR sensors can trigger the buzzer and send notifications to the phone (the buzzer is triggered in RFID deny mode, where nothing happens in the access mode for RFID when entering homeowners). RFID sensor was used to unlock doors by clicking on their access card, This sensor is limited to users with pre-programmed access cards to open doors, and it sends their data to the server through Arduino Mega. RFID shown in Figure (3.10).

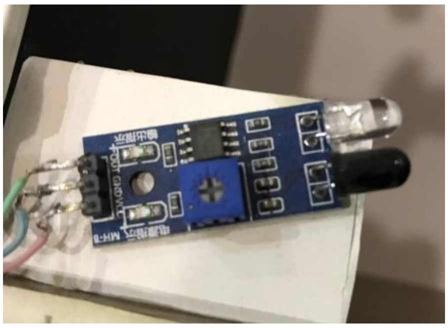


Figure 3.9. IR sensor

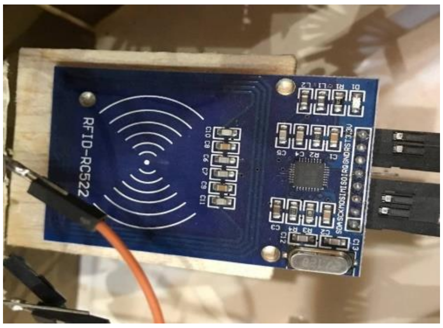


Figure 3.10. RFID sensor

The magnetic door and window sensor was used on the windows to increase the safety in the house, as shown in Figure (3.11) (when opening the window in the RFID deny mode, the magnetic door sensor sends signals to the Arduino mega, the bell is activated and notifications are sent to the phone, indicating the presence of an intruder in the house). Figure (3.12) shows the shape of the buzzer used in our system.

Figure 3.11. Magnetic door sensor

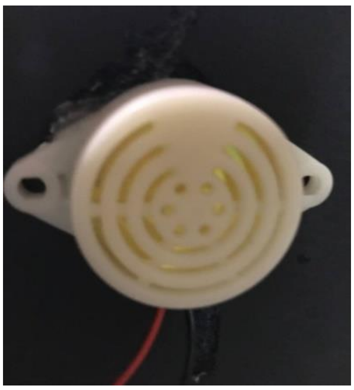


Figure 3.12. Buzzer alarm

This system employs the MQ-135 Gas Sensor to monitor for gas leaks in the house, MQ-135 shown in Figure (3.13). This sensor is capable of sensing a wide variety of different gases. An analog signal is forwarded to the Arduino Mega controller and when gas or smoke is detected, the user is notified. A reverse fan has been set up to automatically empty the house from gases or smoke when it exists. This gas sensor is used to safety the smart home from gases leaks and smoke. The flame sensor is used in our system to detect the presence of fires in the house. When the fire is sensed via the sensor, it sends an analog signal to the Arduino Mega and notifies the user of the presence of fire in the house. Figure (3.14) shows the shape of this sensor. A water pump is set up in the prototype of the smart house, to automatically turn on when the sensor detects a fire in the home. The water pump shown in Figure (3.15). Also, a 9V DC power supply is used to power our system. But here there is a problem because our system needs 6.5V DC, the 9V DC power supply will damage the system, so step down power supply module is used to regulate the power for the system to function normally.

Figure 3.13. MQ-135 Gas sensor

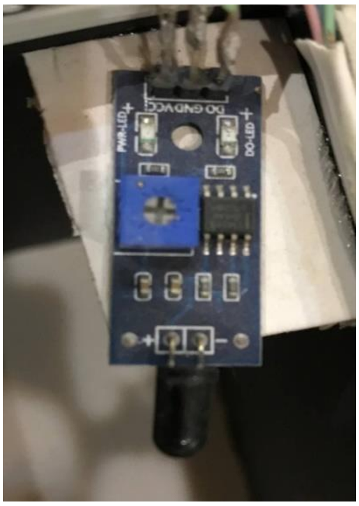


Figure 3.14. Flame sensor

Figure 3.15. Submersible water pump

3.3.1.4 Programs and Applications

A set of software was used in our proposed system, the Arduino IDE is a program that allows you for writing and uploading codes to the Arduino Mega board. The Arduino IDE is used in this project to debug and test the functioning of our suggested system and its accessories using the C programming language. Likewise for Code with Mu program is used to write codes and upload them to a Raspberry Pi in Python language. The VNC Viewer application was also used to simulate Code with Mu program across Windows. The Blynk app is the main platform we use in our system to monitor and control in all home conditions such as movement, temperature, humidity, flame, gas, doors, windows, current, voltage, power, energy, frequency, etc. All these materials have been used for smooth and successful SH automation.

3.3.2 HAS Implementation

This work consists in creating a smart home system, to constantly monitor the conditions of the house and deal with home appliances easily via the Internet, whether locally or remotely. This thesis focuses on using an Arduino mega controller with a Raspberry Pi 3 in HAS to monitor house conditions or control house devices. It is established a local Wi-Fi monitoring system as well as a distant monitoring system based on the IoT. A suitable based on Android or IOS application is used which is the Blynk app because it has a user-friendly interface, which can work effectively with Arduino Mega and Raspberry Pi either for monitoring or control via smartphone. Raspberry Pi controllers are programmed in Python and Arduino in C language to interact with the Blynk app. The sensors PZEM-004T, DHT, Magnetic door, RFID, Infrared (IR) Motion, Flame and MQ-135 Gas connect with the Arduino Mega microcontroller directly, and the Arduino Mega sends data coming from the sensors to the Raspberry Pi 3 in form serial. The Raspberry Pi receives the data in sequence from Arduino, then sends it to the Blynk app, this data is divided in the Blynk application and this data takes its own addresses. then the homeowner monitors the conditions of the house via the smartphone or PC, and to be controlled the home automatically or through relays as needed. Figure (3.16) shows a flowchart of the general operation for the system.

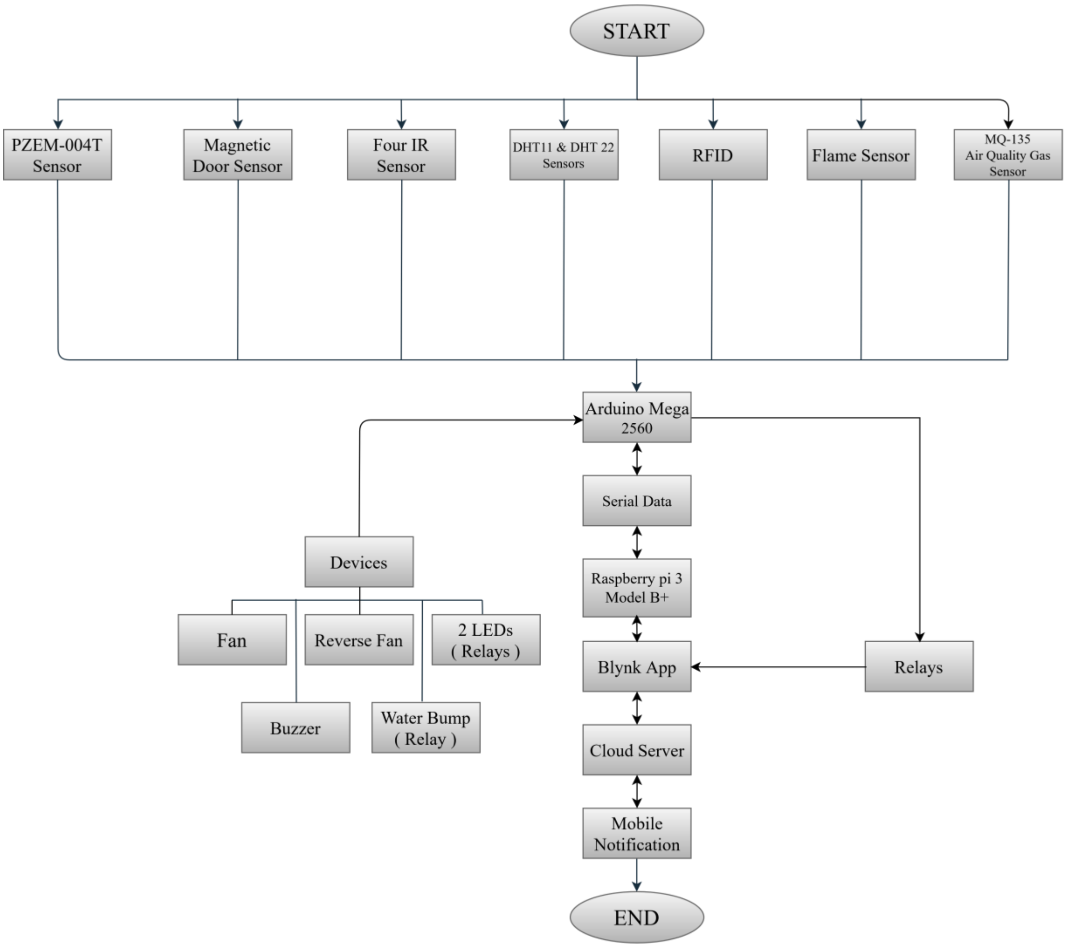


Figure 3.16. Flowchart of the general operation

For example, when the ambient temperature exceeds 25 degrees Celsius, the fan will operate automatically in the prototype, or the air conditioning system in the real application. When the humidity is higher than normal or when the MQ-135 senses gases or smoke, the reversing fan operates automatically to rid the house of moisture, gases or smoke. As for the flame sensor, when it senses the flame in the room, the water pump operates automatically, to increase the safety of the house from fires. When an intruder enters the house whether, through the door or the window, the IR sensors will sense the intruder's movement, which leads to the buzzer activating and sending notifications to the phone. The lights can also be turned on by relays or by IR sensors when moving in front of them, indicating that our system is energy efficient. Finally, the PZEM-004T sensor can automatically turn off the electricity when the sensor detects high loads that may cause damage to the SHAS.

The circuit of the proposed system is illustrated in Figure (3.17) drawn via Fritzing software. Figure (3.18) details the sample structure and how the proposed system will work.

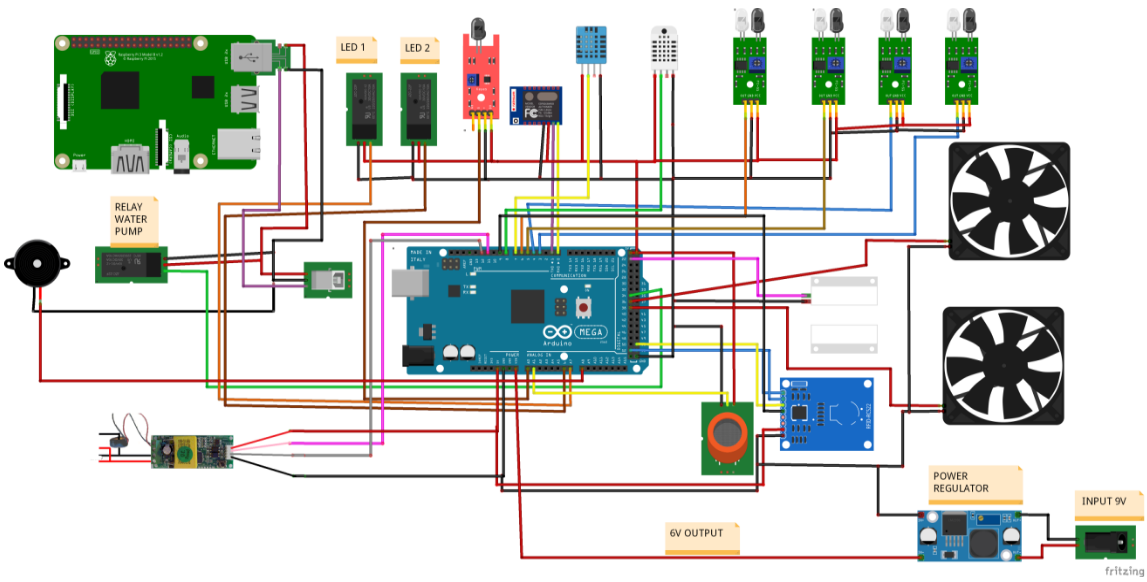


Figure 3.17. The practical circuit of the proposed SH system

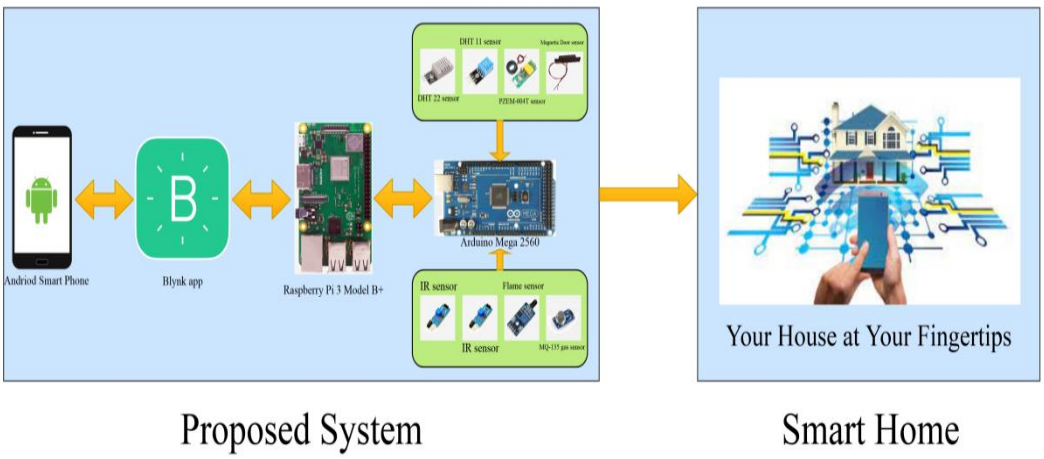


Figure 3.18. The shape illustrates the proposed system architecture

Figure (3.19) shows the steps of how to monitor and control home conditions using the Blynk smartphone app. We connect the Raspberry Pi 3 Model B+ to the home's Wi-Fi via the IP Address, then we connect the smartphone or PC to any internet network (whether the home network or another network), then we login to the VNC Viewer software (to run the python code for the Raspberry Pi on the Windows system through this software), we do a login to the Blynk application, and then monitor all the home conditions and other home appliances to provide for the needs of the smart home.

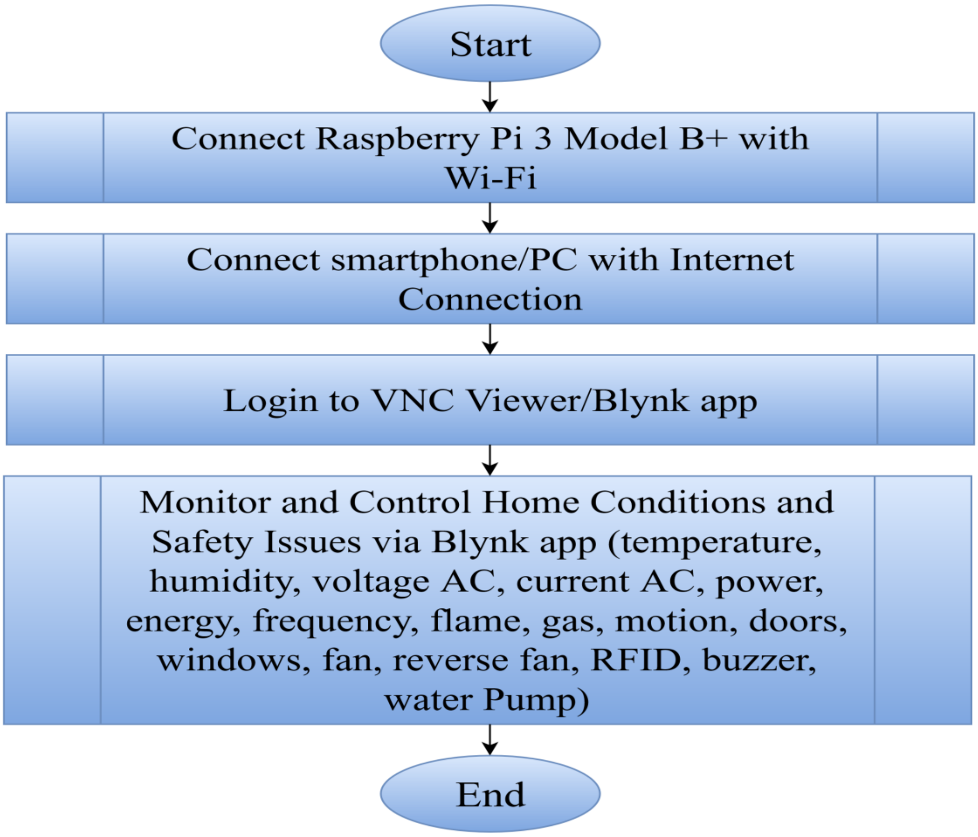


Figure 3.19. Flowchart of monitoring and controlling all home conditions

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

Nowadays, people live in an Internet-connected world with the majority of devices connected to exchange knowledge, consequently the world has come to be like a small town. The fast development of several Bluetooth, Wi-Fi, ZigBee, and GSM technologies has made it convenient and easy to connect various devices to the Internet. Home Automation Systems (HASs) has gained substantial attention to the development of telecommunications technology. An Internet of Things for the smart house is an option that enables users to access and manage their home devices anytime and anywhere from their PC or mobile devices. An SH contains automatic systems including motion detectors, heat/cool systems, perimeter alarms, sprinkler systems, air-flows, etc. Items like smart washing machines, smartphones, smart refrigerators, smart TVs, and smart sensors are now readily available within this modern generation. This Chapter will discuss the results of the smart home system, which is a mobile automation system based on the Internet of Things. Also, all home conditions can be monitored and controlled locally and/or remotely, via smart mobile and/or personal computer.

4.2 Sensors Results and Discussion

This part provides an example to ensure that the HAS is implemented and tested. Our preliminary research results will be used for this work for further guidance and improvement. This research succeeded in building a Wi-Fi-based HAS using an IOS or Android system smartphone. First, we need to connect our IOS or Andriod smartphone to the current Wi-Fi network. Next, we open the Blynk application in our smartphone and adjust its settings. We connect the Blynk app to a Wi-Fi network. We can now monitor all household conditions From anywhere and anytime, whether through a smartphone or a personal computer such as movement, temperature, humidity, flame, gas, current, voltage, power, energy, etc, and also successfully control household appliances (lights, fans, reverse fan, water pump, doors, etc.).as illustrated in Figure (3.19). To obtain more accurate results, a set of curves were drawn in a limited period of time for some sensors that contain a set of measurements (PZEM-004T, DHT), and the Matlab software was used to draw these curves.

4.2.1 The PZEM-004T Sensor Results

The PZEM-004T is a sensor that is used to monitor current (AC), voltage (AC), power (AC), energy (AC), frequency (AC), etc. A sample was taken (current, voltage and power) to test the results of this sensor in a limited period of time, as shown below:

A test was performed to measure current, voltage and power in a certain period of time (5 minutes). This test was divided into five cases: In the first case, no electrical device was turned on for one minute. In the second case, an electrical device was operated by drawing a limited current for a period of (1-2 minutes). In the third case, an electrical device was turned on by drawing a higher current for a period of (2-3 minutes). That is, the devices were turned on incrementally with respect to the draw current to the fifth state for a period of one minute for each case. The results of this test were taken from the Blynk application as shown in Figure (4.1), and the curves of these results were drawn using Matlab software. Table (4.1) shows the five cases of this test. Figure (4.2) shows the results of this test for current, voltage and power plotted by Matlab software for all cases.

Case 1

Case 2

Case 3

Case 4

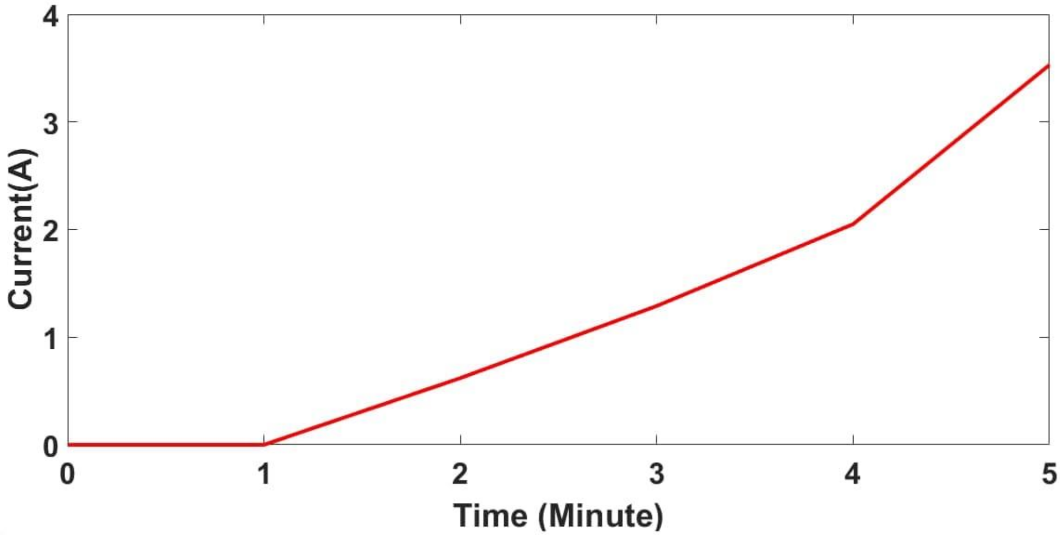
Case 5

Figure 4.1. Shows the results of current, voltage and power readings taken from the Blynk app

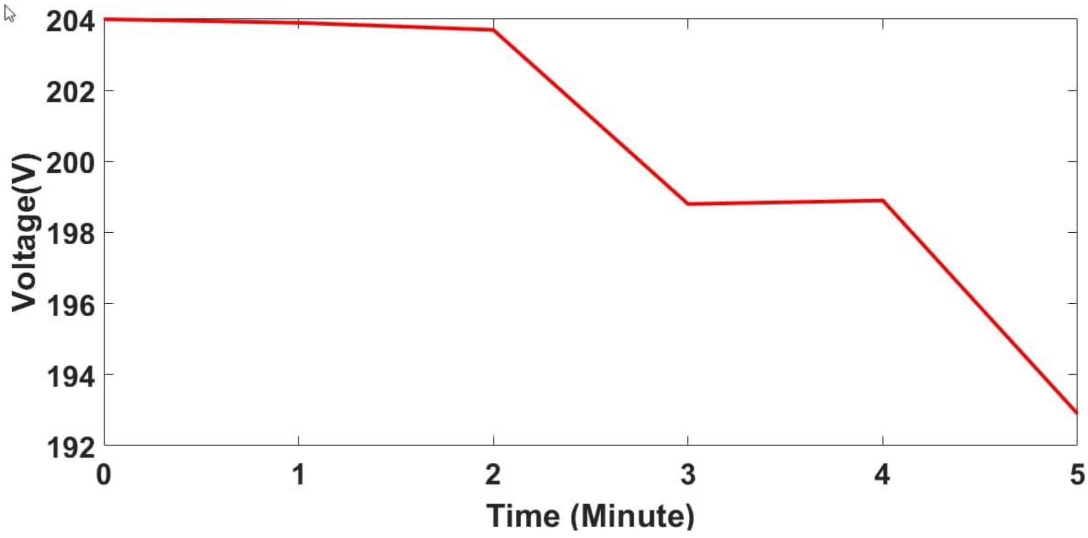
We notice in Figure (4.1) that the current increases gradually (according to the test that was conducted), while the alternating voltage is approximately constant (180-240). As for the power, it increases depending on the increase in current (the product of the current multiplied by the voltage).

Table 4.1. Demonstrates the five cases of the current, voltage and power test for the PZEM-004T sensor

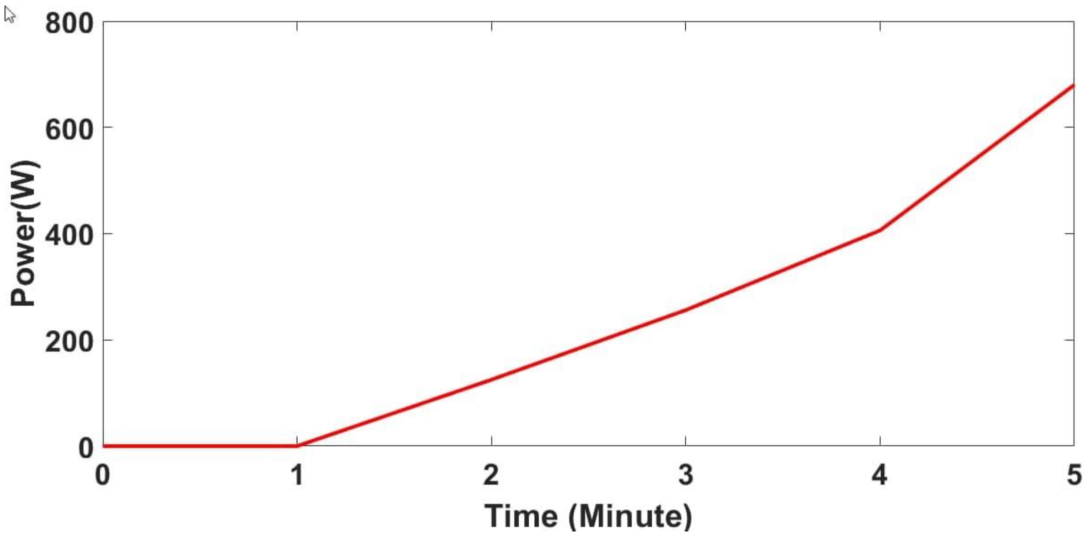
Case / Time (Minutes)	Current (A)	Voltage (V)	Power (W)
Case 1 / (0-1 Minutes)	0 A	203.9 V	0 W
Case 2 / (1-2 Minutes)	0.62 A	203.7 V	125 W
Case 3 / (2-3 Minutes)	1.29 A	198.8 V	256 W
Case 4 / (3-4 Minutes)	2.05 A	198.9 V	406 W
Case 5 / (4-5 Minutes)	3.53 A	192.9 V	680 W



(a)



(b)

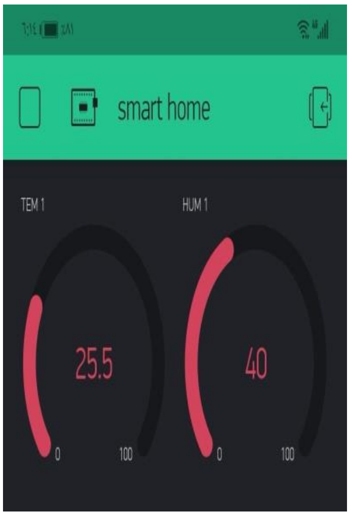


(c)

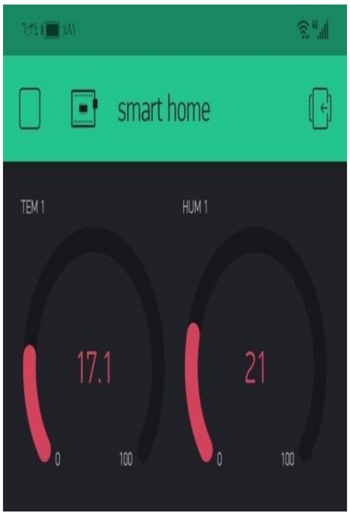
Figure 4.2. Shows the curves drawn by Matlab software for time with (a) current, (b) voltage, (c) power

4.2.2 The DHT Sensors Results

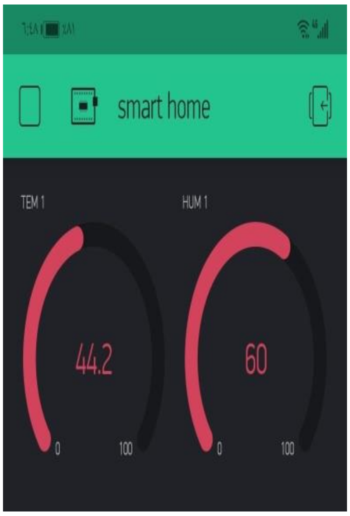
A sample was taken to test the DHT22 sensor (because it is more accurate than the DHT11 sensor) to measure temperature and humidity in a limited period of time (5 minutes). This test was also divided into five cases: In the first case, temperatures and humidity were measured in a room under normal conditions for one minute. In the second case, temperatures and humidity were measured in a room under changing conditions (cold air and low humidity) for (1-2) minutes. In the third case, the temperature and humidity were also measured under variable conditions (hot air and high humidity) with a period of time (2-3 minutes). For the fourth case, the conditions were (cold air and high humidity) for (3-4 minutes). Finally, in the fifth case, the test was carried out under conditions (hot air and low humidity) for (4-5 minutes). The results of this test were taken from the Blynk application as shown in Figure (4.3), and the curves of these results were drawn using Matlab software. Table (4.2) shows the five cases of the DHT22 sensor test. Figure (4.4) shows the results of this test of the DHT22 sensor for temperature and humidity plotted by Matlab software for all cases.



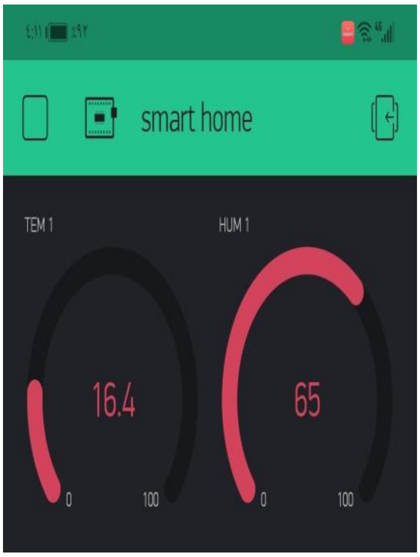
Case 1



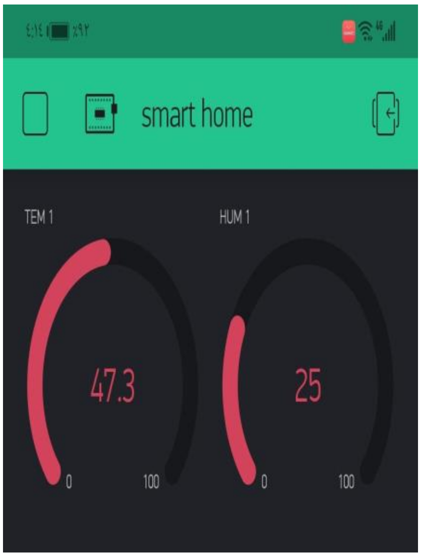
Case 2



Case 3



Case 4

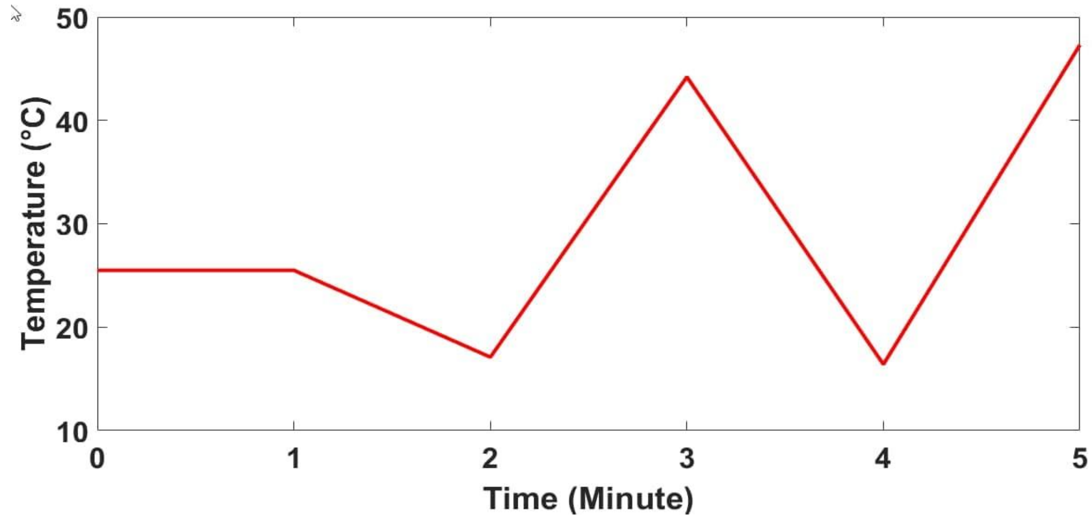


Case 5

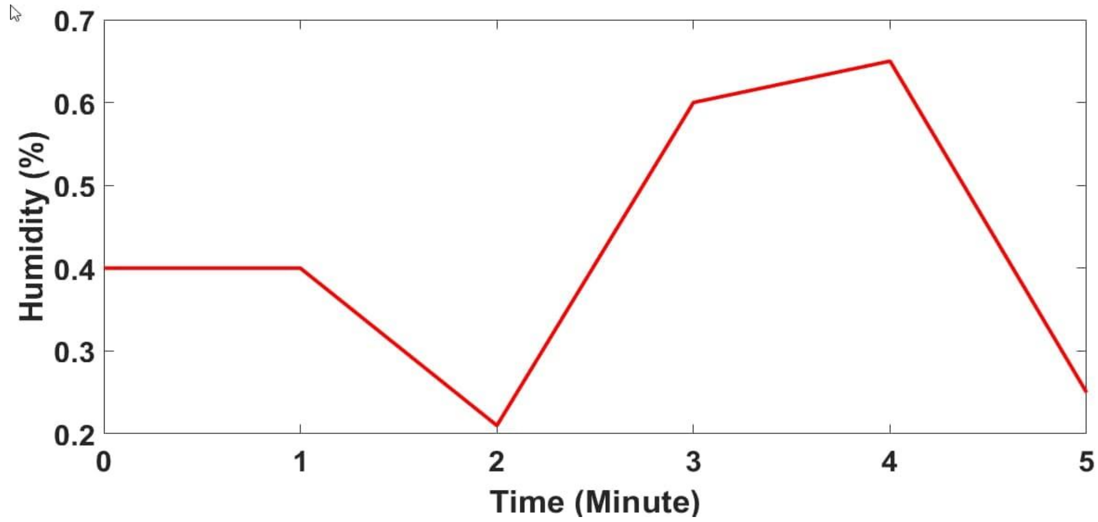
Figure 4.3. Shows the results of DHT22 readings taken from the Blynk application

Table 4.2. Demonstrates the five cases of the temperature and humidity test for the DHT22 sensor

Case / Time (Minutes)	Temperature (°C)	Humidity (%)
Case 1 / (0-1 Minutes)	25.5°C	40%
Case 2 / (1-2 Minutes)	17.1°C	21%
Case 3 / (2-3 Minutes)	44.2°C	60%
Case 4 / (3-4 Minutes)	16.4°C	65%
Case 3 / (4-5 Minutes)	47.3°C	25%



(a)



(b)

Figure 4.4. Displays the curves drawn by Matlab software for time with (a) temperature, (b) humidity

4.2.3 Sensors Readings (IR, Magnetic Door and Window and RFID)

Infrared sensors (four IR sensors) are used to detect movement in the house (These sensors are pre-programmed in the event that the sensor reading is 1, there is movement in the house, and if the sensor reading is 0, there is no movement in the house). The signals obtained from two infrared sensors (IR1 & IR2) can be used to turn the lights on or off automatically in the home, which means our system saves energy. In addition, when someone is detected for security purposes while the homeowner is away, the output of two infrared sensors (IR3 & IR4) can activate the buzzer and send notifications to the phone (the buzzer is triggered and the notification is sent to the phone in RFID reject mode, where no Something happens in RFID access mode when homeowners enter). Table (4.3) shows the cases of these sensors in our smart system.

Table 4.3. Displays the states of the IR sensors

Sensor Status	Lights on	Send Notifications / Buzzer Activation
Readings IR1 & IR2 are 0	No	No
Readings IR1 & IR2 are 1	Yes	No
Readings IR3 & IR4 are 0	No	No
Readings IR3 & IR4 are 1	No	Yes
Readings IR1 & IR2 & IR3 & IR4 are 0	No	No
Readings IR1 & IR2 & IR3 & IR4 are 1	Yes	Yes

The RFID sensor and the magnetic door and window sensor have been used to increase security in the home to prevent intruders from entering. Where the RFID sensor was used to open doors by clicking on the users' access card, RFID only allows users with pre-programmed access cards to open the doors. The magnetic door and window sensor on the windows was used to increase the security of the smart home (this sensor has been pre-programmed in case of If the reading is 1 evidence of the presence of an intruder in the home, The buzzer is activated and notifications are sent to the phone, but if the reading is 0, this is evidence of the presence of the owners of the house only). Figure (4.5) shows how to send the notifications for the smartphone via the Blynk app.

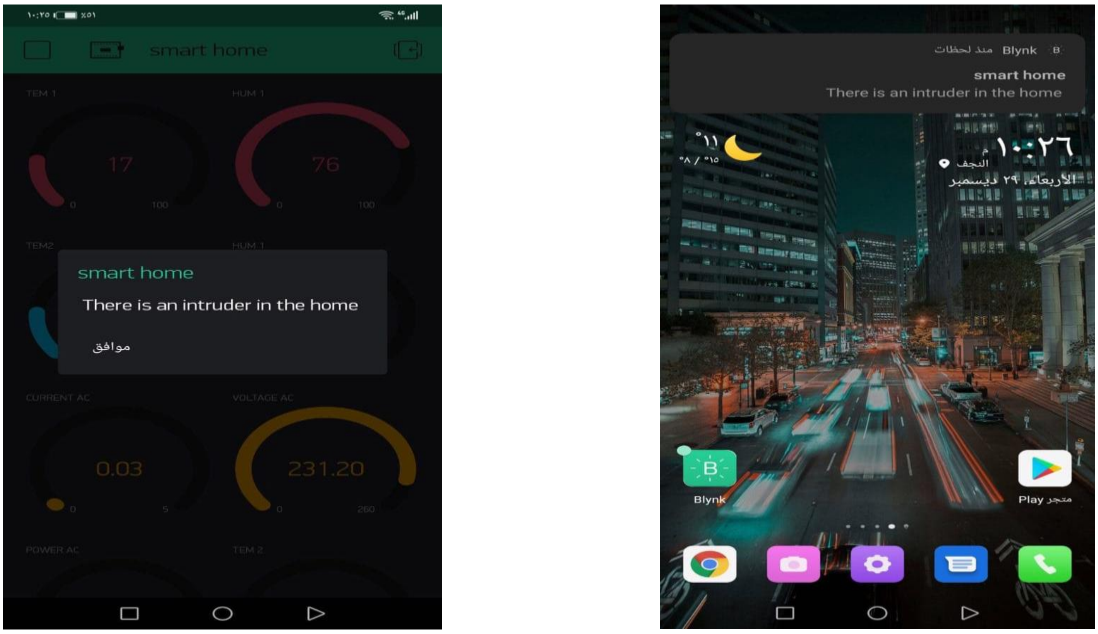


Figure 4.5. Displays how to send notifications via the Blynk app when there is an intruder in the home

4.2.4 Analog Sensors Readings (MQ-153 Gas and Flame)

Two analog sensors were used in our system. The first is the MQ-135 Gas sensor which is used to monitor gas or smoke leaks in the home. The second is the flame sensor that senses the presence of fires in the house. These two sensors are very important to prevent harm to homeowners. Where a reversing fan has been set up to automatically empty the house of gases or smoke if present, and a water pump has been made in the smart home prototype, to turn on automatically when the flame sensor detects fire in the house (these sensors are pre-programmed, so if the reading is 1 is proof of the presence of fire, gas or smoke in the house, but if the reading is 0, this reading indicates that there is no fire, gas or smoke in the house. As shown in Figure (4.6)). Table (4.4) shows the status of these sensors.

(a) (b)

Figure 4.6. Shows (a) the absence of gas, smoke or fire. (b) The presence of gas, smoke or fire.

Table 4.4. Displays the states of the MQ-135 Gas sensor and Flame sensor

Sensor Status	Gas or Smoke	Fire
Reading MQ-135 Gas is 0	No	No
Reading MQ-135 Gas is 1	Yes	No
Reading Flame is 0	No	No
Reading Flame is 1	No	Yes
Readings MQ-135 Gas & Flame are 0	No	No
Readings MQ-135 Gas & Flame are 1	Yes	Yes

4.2.5 Lights Control via The Relays

In addition to the automatic lighting control feature (as described above), full lighting control was set up via relays, both locally and/or remotely. This feature is very important for homeowners to control SH in the office or on the job site for example. Table (4.5) shows the status of the relays for controlling the lights. Figure (4.7) shows how the lights are turned on in the prototype smart home via relays.

Table 4.5. Shows the states of relays to on/off the lights

Relay Status	LEDs
Relays status are 0	off
Relays status are 1	on

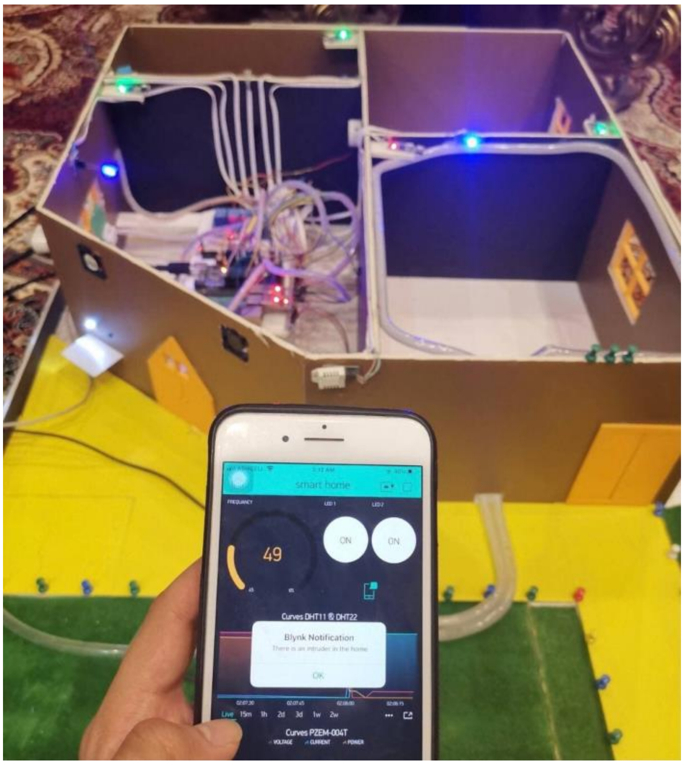


Figure 4.7. Displays how the lights are turned on in the prototype smart home via relays.

CHAPTER FIVE

CONCLUSIONS AND PROPOSALS FOR FUTURE WORK

5.1 Conclusions

1. This research project proposed to design and fabrication The SH prototype and implement SHAS using Raspberry Pi 3 Model B+ and Arduino Mega 2560 based on IoT.
2. The SHAS can be implemented in a real home to monitor all home conditions of current, voltage, power, energy, temperature, humidity, movement, flames, smoke, gases, doors and windows via Wi-Fi using the Blynk app.
3. This system supports local control and/or remote control, whether using a smart mobile (Andriod or IOS) or via a PC.
4. The system used is safe, as sensors were used to protect the house from intruders entering, whether for doors or windows (RFID sensor, magnetic door and window sensor), in addition to sending notifications to the phone via the Blynk application and the sound of the bell to alert the owner of the house when the intruders entered.
5. The system that was designed is energy-saving, as the lights were made to work automatically with the motion sensors. When there is movement in the house, the lights work, which is an indication of energy saving.

5.2 Proposals for Future Work

In our next study:

1. We will use encryption and decryption to protect the system from external hacker attacks to increase security for SH.
2. We will optimize all circuits using printed circuit boards to conserve space and minimize the risk of contact loss or short circuits.
3. We will also add more sensors to provide more needs for the smart home, for instance, Adding sensors for the garden to make it smart.

After completing all these works, we can now move to the smart city.

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APPENDICES

Appendix A

The code of Arduino Mega 2560 that was programmed by using C language via the Arduino IDE software.

```
#include <SoftwareSerial.h>
softwareserial rece (12, 13);

#define BLYNK_PRINT Serial

#include <ESP8266_Lib.h>

#include <BlynkSimpleShieldEsp8266.h>

// You should get Auth Token in the Blynk App.

// Go to the Project Settings (nut icon) .

char auth [] = "G0MgqO3hxUqN6X7BeyWp1hi3WevPIVzJ";

// Your WiFi credentials.

// Set password to "" for open networks.

//char ssid [] = "IoT";

//char pass [] = "24682468";

//char ssid [] = "IoT3";

//char pass [] = "0246802468";

//char ssid [] = "IoT2";
```

```
//char pass [] = "0246802468";

char ssid [] = "IoT4";

char pass [] = "24682468";

#define ESP8266_BAUD 115200

ESP8266 wifi (&Serial);

#include <PZEM004Tv30.h>

#include <Wire.h>

PZEM004Tv30 pzem (10, 11); //rx tx

#include "DHT.h"

#define DHTPIN 3

#define DHTPIN1 7

#include <SPI.h>

/* Include the RFID library */

#include <RFID.h>

/* Define the DIO used for the SDA (SS) and RST (reset) pins. */

#define SDA_DIO 9

#define RESET_DIO 8

/* Create an instance of the RFID library */

RFID RC522 (SDA_DIO, RESET_DIO);
```

```
#define DHTTYPE1 DHT11   // DHT 11

#define DHTTYPE DHT22

DHT dht (DHTPIN, DHTTYPE);  //dht 1

DHT dht1 (DHTPIN1, DHTTYPE1); // dht2

String s = "";

String x, y, xx, yy;

int p;

float voltage;

float current;

float power;

float energy;

float frequency;

float pf;

int iR1,iR2,iR3,iR4,wind1;

int relay1, relay2;

void setup () {

Serial.begin (9600);

SPI.begin ();      // Initiate  SPI bus

/* Initialise the RFID reader */
```

```
RC522.init ();
Serial.begin (ESP8266_BAUD);
delay (10);
Blynk.begin (auth, wifi, ssid, pass);
rece.begin (9600);
Serial3.begin (9600);
pinMode (A3, OUTPUT);
pinMode (A4, OUTPUT);
pinMode (A5, OUTPUT);
pinMode (A6, OUTPUT);
digitalWrite (A3, 1);
digitalWrite (A4, 1);
digitalWrite (A5, 1);
digitalWrite (A6, 1);
pinMode (A8, OUTPUT);
pinMode (41, OUTPUT);
pinMode (40, OUTPUT);
pinMode (34, OUTPUT); //fan1
pinMode (36, OUTPUT); //fan2
```

```
pinMode (38, OUTPUT); //pump

digitalWrite (38, 1);

pinMode (A0, INPUT); //gas sensor

pinMode (A1, INPUT); //flame sensor

pinMode (6, INPUT); //ir sensor

pinMode (5, INPUT); //ir2 sensor

pinMode (22, INPUT_PULLUP); //window sensor

dht.begin ();

dht1.begin ();

}

BLYNK_WRITE(V6)

{

relay1 = param.asInt (); // assigning incoming value from pin V1 to a variable

// process received value

}

BLYNK_WRITE (V7)

{

relay2 = param.asInt (); // assigning incoming value from pin V1 to a variable

// process received value
```

```
}
void loop () {
Read ();
Blynk.run ();
//  Serial.print (relay1);
//  Serial.print ("  ");
//  Serial.println (relay2);
iR1 = digitalRead (2);
wind1 = digitalRead (22);
iR2 = digitalRead (20);
iR3 = digitalRead (21);
iR4 = digitalRead (6);
Serial.println (wind1);
if (relay1 == 1 || iR1 == 1)
{   digitalWrite(A5, 0);
delay (1500);
}
else
digitalWrite (A5, 1);
```

```
if (relay2 == 1 || iR2 == 1)

{   digitalWrite(A6, 0);

delay (1500);

}

else

digitalWrite (A6, 1);

// Look for new cards

if (RC522.isCard())

{

/* If so then get its serial number */

RC522.readCardSerial ();

//    Serial.println ("Card detected:");

//    for (int i=0;i<;i++)

//    {

//    Serial.print (RC522.serNum[0]);

long int x = (RC522.serNum[0], DEC);

Serial.print ("x=");

Serial.println (x);

if (RC522.serNum[0] == 10) //access
```

```
{
digitalWrite (41, 1);
digitalWrite (40, 0);
}
if (RC522.serNum[0] == 42) //den
{
digitalWrite (40, 1);
digitalWrite (41, 0);
if (iR3 == 1 || iR4 == 1||wind1==1)
{
Blynk.notify (" There is an intruder in the home ");
digitalWrite (A8, 1); //buzzer
delay (50);
digitalWrite (A8, 0);
delay (190);
}
else
digitalWrite (A8, 0);
}
```

```
//    Serial.print (RC522.serNum[i],HEX); //to print card detail in Hexa Decimal
format
//    Serial.println ();
//    Serial.println ();
}
int val = analogRead (A0);
//   Serial.print (val);
//    Serial.print ("\t");
int gas = map (val, 1000, 100, 0, 1);
gas = constrain (gas, 0, 1);
int val1 = analogRead (A1);
int flame = map (val1, 1023, 190, 0, 1);
flame = constrain (flame, 0, 1);
//  Serial.print (val1);
//  Serial.print ("\t");
int ir1 = digitalRead (5);
int ir2 = digitalRead (6);
int door1 = digitalRead (22);
int door2 = digitalRead (23);
```

```
//
//
float h = dht.readHumidity ();
// Read temperature as Celsius (the default)
float t = dht.readTemperature ();
//
float h1 = dht1.readHumidity ();
// Read temperature as Celsius (the default)
float t1 = dht1.readTemperature ();
Serial.print ("\tTemp1 :");
Serial.print (gas);
Serial.print ("\tTemp2 :");
Serial.print (t1);
Serial.print ("\tHum1 :");
Serial.print (h);
Serial.print ("\tHum2 :");
Serial.println (h1);
Blynk.virtualWrite (V11,gas);
Blynk.virtualWrite (V2,t);
```

```
Blynk.virtualWrite (V3,t1);

Blynk.virtualWrite (V4,h);

Blynk.virtualWrite (V5,h1);

if (t > 25) //control temp out

digitalWrite (36, 1);

else

digitalWrite (36, 0);

if (h1 > 300||gas>=1)

digitalWrite(34, 1); //on

else

digitalWrite(34, 0); //off

if (flame >=1)

digitalWrite (38, 0); //on

else

digitalWrite (38, 1); //off

Serial3.print (t);

Serial3.print (",");

Serial3.print (h);

p=voltage*current;
```

```
//sentdata to raspberry  by serial

Serial3.print(",");

Serial3.print(ir1);

Serial3.print(",");

Serial3.print(ir2);

Serial3.print(",");

Serial3.print(t1);

Serial3.print(",");

Serial3.print(h1);

Serial3.print(",");

Serial3.print(door1);

Serial3.print(",");

Serial3.print(door2);

Serial3.print(",");

Serial3.print(voltage);

Serial3.print(",");

Serial3.print(current);

Serial3.print(",");

Serial3.print(p);
```

```
Serial3.print(",");
Serial3.print(energy);
Serial3.print(",");
Serial3.print(frequency);
Serial3.print(",");
Serial3.print(pf);
Serial3.print(",");
Serial3.print(flame);
Serial3.print(",");
Serial3.println(gas);
  /*
Serial.print("Temp1 :");
Serial.print(t);
Serial.print("\tTemp2 :");
Serial.print(tsfxv 1);
Serial.print("\tHum1 :");
Serial.print(h);
Serial.print("\tHum2 :");
Serial.print(h1);
```

```
Serial.print("\tGas :");

Serial.print(gas);

Serial.print("\tFlame :");

Serial.print(flame);

Serial.print("\tIR1 :");

Serial.print(ir1);

Serial.print("\tIR2 :");

Serial.print(ir2);

Serial.print("\tdoor1 :");

Serial.print(door1);

Serial.print("\tdoor2 :");

Serial.print(door2);

Serial.print("\tdoor3 :");

Serial.print(door3);

Serial.print("\tdoor4 :");

Serial.print(door4);

Serial.print("\tvoltage :");

Serial.print(voltage);

Serial.print("\tcurrent :");
```

```
Serial.print(current);
Serial.print("\tpower :");
Serial.print(power);
Serial.print("\tenergy :");
Serial.print(energy);
Serial.print("\tfrequency :");
Serial.print(frequency);
Serial.print("\tpf :");
Serial.println(pf);
*/
delay (100);
}
void receserial ()
{
}
void Read ()
{
voltage = pzem.voltage ();
if (voltage != NAN) {
```

```
//	Serial.print ("Voltage: ");
//	Serial.print (voltage);
//	Serial.println ("V");
} else {
//	Serial.println ("Error reading voltage");
}
current = pzem.current ();
if (current != NAN) {
//	Serial.print ("Current: ");
//	Serial.print (current);
//	Serial.println ("A");
delay (10);
} else {
//	Serial.println ("Error reading current");
}
power = pzem.power ();
if (current != NAN) {
//	Serial.print ("Power: ");
//	Serial.print (power);
```

```
//      Serial.println ("W");
delay (10);
} else {
//      Serial.println ("Error reading power");
}
energy = pzem.energy ();
if (current != NAN) {
//      Serial.print ("Energy: ");
//      Serial.print (energy,3);
//      Serial.println ("kWh");
//          Serial.println ("W");
  } else {
//      Serial.println ("Error reading energy");
}
frequency = pzem.frequency ();
if (current != NAN) {
//      Serial.print ("Frequency: ");
//      Serial.print (frequency, 1);
//      Serial.println ("Hz");
```

```
delay (10);
} else {
//      Serial.println ("Error reading frequency");
}
pf = pzem.pf ();
if (current != NAN) {
//  Serial.print ("PF: "); Serial.println (pf);
} else {
//   Serial.println ("Error reading power factor");
}
}
String getValue (String data, char separator, int index)
{
int found = 0;
int strindex [] = {0, -1};
int maxindex = data.length () - 1;
for (int i = 0; i <= maxindex && found <= index; i++)
{
if (data.charAt(i) == separator || i == maxindex)
```

```
{ found++;

strindex [0] = strindex[1] + 1;

strindex [1] = (1 == maxindex) ? i + 1 : i;

}

}

return found > index ?

data.substring(strindex[0], strindex[1]) : "";

}
```

Appendix B

The code of Raspberry Pi 3 Model B+ that was programmed by using Python language via the Code with MU software.

```
import serial
import string
import time
import blynklib
import os
import time
from time import sleep
from datetime import datetime
file = open("/home/pi/Desktop/datalogger.txt", "a")
i=0
if os.stat("/home/pi/Desktop/datalogger.txt").st_size == 0:
    file.write("Time,voltage,current,power,temp out,temp in,hum,\n")
x=0
y=0
z=0
c=0
volt=0
current=0
if __name__ == '__main__':
    ser1 = serial.Serial('/dev/ttyUSB1', 9600, timeout=1)
    #ser1.flush()
#BLYNK_AUTH = 'KJwXCtJzgyVm7G8V_IoTEVEjuigcqf4o'
```

```
BLYNK_AUTH = '_kfTEv4j8F9cUnOb_1eZj1J4bInYX0Hc'

# initialize blynk

blynk = blynklib.Blynk(BLYNK_AUTH)

ser = serial.Serial('/dev/ttyUSB0', 9600)

@blynk.handle_event('write V3')

def write_virtual_pin_handler(pin, value):

    global y

#   print(WRITE_EVENT_PRINT_MSG.format(pin, value))

    print("x value: " + str(value[0]))

    y=str(value[0])

#   register handler for virtual pin V4 write event

@blynk.handle_event('write V4')

def write_virtual_pin_handler(pin, value):

    global x

#   print(WRITE_EVENT_PRINT_MSG.format(pin, value))

    print("y value: " + str(value[0]))

    x=str(value[0])

@blynk.handle_event('write V5')

def write_virtual_pin_handler(pin, value):

    global z

#   print(WRITE_EVENT_PRINT_MSG.format(pin, value))

    print("y value: " + str(value[0]))

    z=str(value[0])

@blynk.handle_event('write V6')

def write_virtual_pin_handler(pin, value):
```

```
    global c
#   print(WRITE_EVENT_PRINT_MSG.format(pin, value))
    print("y value: " + str(value[0]))
    c=str(value[0])
p=0
while True:
    blynk.run()
    data=str(x),":",str(y),":",str(z),":",str(c),":",'x'
    ser1.write(str(data).encode('utf-8'))
    if ser.in_waiting > 0:
        rawserial = ser.readline()
        cookedserial = rawserial.decode('utf-8').strip('\r\n')
        datasplit = cookedserial.split(',')
        temperature = datasplit[0]
        humidity = datasplit[1]
        ir=datasplit[2]
        ir2=datasplit[3]
        temp2=datasplit[4]
        hum2=datasplit[5]
        door1=datasplit[6]
        door2=datasplit[7]
        volt=datasplit[8]
        current=datasplit[9]
        Power=datasplit[10]
        energy=datasplit[11]
```

```
frequency=datasplit[12]
pf=datasplit[13]
flame=datasplit[14]
gas=datasplit[15]
# p=str(volt)*str(current)
blynk.virtual_write(1,temperature)
blynk.virtual_write(2,humidity)
blynk.virtual_write(3,temp2)
blynk.virtual_write(4,hum2)
blynk.virtual_write(5,volt)
blynk.virtual_write(6,current)
blynk.virtual_write(7,Power)
blynk.virtual_write(8,energy)
blynk.virtual_write(9,frequency)
blynk.virtual_write(10,flame)
blynk.virtual_write(11,gas)
blynk.virtual_write(12,ir)
blynk.virtual_write(13,ir2)
now = datetime.now()
file.write(str(now)+","+str(volt)+","+str(current)+","+str(Power)+","+str(temperature
)+","+str(temp2)+","+"\n")
file.flush()
#time.sleep(1)
#file.close()
```

```
print(temperature,"   ",humidity,"   ",ir,"   ",ir2,"   ",temp2,"   ",hum2,"   ",door1,"   ",door2," ",volt," ",current," ",p," ",energy," ",frequency," ",pf," ",flame," ",gas)
#print(humidity
print("\n")
time.sleep(1)
```

BIODATA OF STUDENT

The author was born on January 6, 1994, in Najaf, Iraq. Starting 1999 until 2011, he attended elementary, middle, and high school in the Holy City of Najaf. He received his Bachelor's degree in Communications Engineering from the Technical College, Najaf, Iraq, in 2015. On September 15, 2019; he started studying for his Master's degree in Communications Engineering from the Technical College, Najaf, Iraq. His main research interests are wired and wireless networks, especially the CISCO aspect, engineering mathematics, digital signal processing and the Internet of Things.

LIST OF PUBLICATIONS

➢ Conferences

1. Omran, M. A., Saad, W. K., Hamza, B. J., & Al-Baghdadi, A. F. (2021, August). Designing and Manufacturing of Home Automation Monitoring System Using Internet of Things Technology. In *Journal of Physics: Conference Series* (Vol. 1973, No. 1, p. 012081). IOP Publishing.

Certificate of participation in the 3rd International Conference of Engineering Sciences and Advances Technologies IICESAT 2021

➢ Journals

1. Mustafa Asaad Omran, Wasan Kadhim Saad, Bashar Jabbar Hamza, and Ahmed Fahem Al-baghdadi. (2021). A survey of various intelligent home

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2. Omran, M. A., Hamza, B. J., & Saad, W. K. (2021). The design and fulfillment of a Smart Home (SH) material powered by the IoT using the Blynk app. *Materials Today: Proceedings*.

الخلاصة

ساهم نجاح الإنترنت ، وقدرته الواضحة على تلبية المتطلبات اليومية للأفراد من جميع نواحي الحياة ، وضرورته على المجتمع ككل في تطور الإنترنت الحالي إلى المستوى التالي الذي يطلق عليه اسم إنترنت الأشياء (IoT) . يتم استخدام إنترنت الأشياء في العديد من المجالات مثل المنزل الذكي (SH) والمدينة الذكية (SC) والزراعة الذكية (SA) والصناعة الذكية (SI) والرعاية الصحية الذكية (SHC) والمركبات الذكية (SV) والطاقة الذكية (SE) ، إلخ. اجتذب نظام أتمتة المنزل (HAS) اهتمامًا كبيرًا مع تقدم تكنولوجيا الاتصالات. المنزل الذكي هو تطبيق إنترنت الأشياء الذي يستخدم الإنترنت للمراقبة والتحكم في الأجهزة من خلال استخدام نظام أتمتة المنزل الذكي (SHAS). أنظمة التشغيل الآلي للمنزل (HASs) محدودة بسبب الافتقار إلى الأمان وتوفير الطاقة وواجهات المستخدم غير الودية ونطاق اتصالات الأسلاك المحدود وصعوبة الصيانة. في هذه الرسالة ، تم اقتراح نظام قائم على إنترنت الأشياء ميسور التكلفة وآمن وسهل الاستخدام وموفر للطاقة ، وهو نظام أتمتة متنقل يستخدم Wi-Fi كوسيط اتصال لاسلكي ، مما يتيح مراقبة الأجهزة المنزلية عن طريق صاحب المنزل في المواقع المحلية والبعيدة عبر الهاتف المحمول / الكمبيوتر الشخصي (PC). تم تصميم النموذج الأولي للمنزل الذكي باستخدام برنامج Autodesk Fusion 360. بعد التصميم ، تم تصنيع هذا النموذج بواسطة Father Board وطابعة ثلاثية الأبعاد (3D) من أجل وضع النظام بداخله ليكون جاهزًا للسوق للاستخدام في المنازل الحقيقية. تم

استخدام Raspberry Pi 3 Model B + و Arduino Mega 2560 لتكوين إطار عمل أتمتة الخادم. علاوة على ذلك ، تم استخدام العديد من المستشعرات المتصلة بوحدة التحكم Arduino Mega لمراقبة التيار والجهد والقدرة والطاقة والتردد والرطوبة ودرجة الحرارة والحركة واللهب والدخان والغاز والأبواب والنوافذ والظروف المنزلية الأخرى ، وكذلك التحكم بنجاح في الأجهزة المنزلية (الأضواء ، والمراوح ، والمروحة العكسية ، ومضخة المياه.) إما تلقائيًا (أو عبر مرحلات للأضواء فقط). يمكن لنظام الأتمتة المقترح مراقبة ظروف المنزل والتحكم فيها عبر تطبيق سهل الاستخدام (تطبيق Blynk) لأنظمة Android أو IOS أو الكمبيوتر الشخصي.

تصميم وتنفيذ نظام مراقبة المنزل الذكي

الرسالة

مقدمة الى قسم هندسة تقنيات الاتصالات كجزء من متطلبات نيل درجة

الماجستير

تقدم بها

مصطفى أسعد عمران

إشراف

الأستاذ المساعد الدكتور

بشار جبار حمزة

الأستاذ المساعد الدكتورة

وسن كاظم سعد

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الكلية التقنية الهندسية- نجف

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مصطفى أسعد عمران

(ماجستير في هندسة تقنيات الاتصالات)

2021