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Assist. Prof. Dr. Saed ALQARALEH

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UMRAN HAJE

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Name of the student: Umaran Abdulla Haje HAJE

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Approval of the Graduate School of Natural and Applied Sciences

Prof. Dr. Mehmet KARPUZCU

Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Dr. Öğr. Üyesi Bülent HAZNEDAR

Head of Department

This is to certify that we have read this thesis and that in our consensus/majority opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

(Assist. Prof. Saed ALQARALEH)

Supervisor

Examining Committee Members	Signature
Prof. Dr. Ergün Erçelebi	…………………..
Assist. Prof. Dr. Mohammed MADI	…………………..
Assist. Prof. Dr. Saed ALQARALEH	…………………..

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Umran HAJE

ABSTRACT

AUTOMATED MULTI-FUNCTIONAL SMART HOME SYSTEM USING ARDUINO

Umran Abdulla Haje HAJE
M.Sc. in Electronics and Computer Engineering.
Supervisor: Assist. Prof. Dr. Saed ALQARALEH

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Monitoring the condition of domestic and its appliances has been always ranked among the main concerns of the daily lives of people. This concern is far more prominent for those who are outdoors during the day and have to keep watch on their children or elderly people. Maximizing home security is also proposed in many other. The smart home refers to a system that uses information technology and computers or smart phones to monitor domestic appliances. This technology can successfully resolve the concerns described above.

In this thesis, a method is proposed that implements a smart home in practice in several phases called Providing security (detecting theft and notifying mobile alerts), providing safety and comfort (setting the desired home temperature, adjusting ambient lighting) and controlling the domestic appliances through mobile phones and GSM.

The results obtained from the implementation of the proposed system show that the proposed system has been able to perform multiple tasks efficiently and can to be used by the public in many circumstances while, putting into effect factors such as security, safety and remote control of home appliances via smart devices.

Keywords: Smart Home, Internet of Things, Sensors, Home Automation, Remote Control, Arduino Microcontroller

ÖZET

ARDUINO'YU KULLANAN OTOMATİK ÇOK FONKSİYONEL AKILLI EV SİSTEMİ

Umran Abdulla Haje HAJE
Yüksek Lisans, Elektronik Bilgisayar Müh. Bölümü
Tez Yöneticisi: Assist. Prof. Dr. Saed ALQARALEH
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67 sayfa

Evin ve ev aletlerinin durumunu izlemek, her zaman insanların günlük yaşamının ana kaygıları arasındadır. Bu endişe, gün içinde dışarıda kalanlar ve çocuklarına ya da yaşlılarına sekmeleri tutmak zorunda olanlar için çok daha belirgindir. Bazı durumlarda ev güvenliğini en üst düzeye çıkarmak da önerilmektedir. Akıllı ev, ev aletlerini izlemek için bilgi teknolojisi ve bilgisayarları veya akıllı telefonları kullanan bir sistem anlamına gelir. Bu teknoloji, yukarıda açıklanan endişeleri başarılı bir şekilde çözebilir.

Bu tezde, güvenliğin sağlanması (hırsızlık tespiti ve mobil uyarıların bildirilmesi), güvenlik ve konfor (istenilen ev sıcaklığının ayarlanması, ortam aydınlatmasının ayarlanması) ve ev aletlerinin kontrol edilmesi gibi çeşitli aşamalarda pratikte akıllı bir ev uygulayan bir yöntem önerilmiştir. cep telefonları ve GSM ile.

Önerilen yöntemin uygulanmasından elde edilen sonuçlar, önerilen yöntemin bir akıllı ev sisteminin uygulanmasının maliyetini azaltabildiğini ve güvenlik, emniyet ve uzaktan kumanda gibi faktörleri gerçekleştirirken bunu kamuya kullanma becerisini sağladığını göstermektedir. akıllı cihazlarla ev aletleri.

Anahtar Kelimeler: Akıllı Ev, Nesnelerin İnterneti, Sensörler, Ev Otomasyonu, Uzaktan Kumanda, Arduino Mikrodenetleyici.

To My Parents

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CHAPTER 1

INTRODUCTION

The smart world starts from the smart home. In recent years, with the advent of electronic component manufacturers and their ability to produce small and low-cost components and sensors, in addition to the development of other technologies such as cloud computing, the Internet, the concept of a wireless sensor network (WSN) and a new concept, called the internet of Things (IoT), has been developed. These technologies allow us to control various domestic appliances and remotely send them relevant commands based on their status. In this technology, there is the ability to connect all devices and equipment through communication networks such as the Internet, Hence, it has attracted the keen attention of researchers and its applications are expanding rapidly. Smart City, intelligent transportation systems, remote medical care, intelligent remote monitoring systems and the smart home are the most important applications of IoT.

In a smart or digitized home, users can easily monitor and control their domestic appliances via different sensors. The necessary decisions are made based on the information received. In other words, the smart home allows users to automatically control and monitor home lighting, heating and cooling status, turn the stove on or off, and provide home security through security systems such as surveillance cameras or theft notification systems. Smart homes are also beneficial for managing energy consumption and significantly reduce expenses.

Being aware of the numerous applications of the Internet of things, especially smart homes, it seems that in the near future, smart home technology will become one of the most important aspects of people lives, as the number of its users is increasing every day. For this reason, recognizing the characteristics of smart homes and examining this phenomena’s various technical aspects can from the baseline of building the Internet of Things approaches. Therefore, this study aims to investigate various aspects of the smart home, its implementation and the application of this technology. Then, the knowledge obtained will be applied to implement a multiple functional smart home approach.

A smart home system must be able to provide users with easy accessibility, easy to use and low-cost implementation, while providing security and comfort. Considering these requirements, in this thesis, the smart home has been designed as a general system with four models called Security model, Safety model, Home Appliance Control using Bluetooth-based model, and Home Appliance Control using GSM-based model.

1.1. Problem statement and motivation

Monitoring the condition of home and their appliances has always been among the main concerns of the daily lives of people. This concern is far more prominent for those who are outdoors during the day and have to keep watch on their children or elderly people. Maximizing home security is also proposed in variant and other circumstances.

In addition to the above issues, the expansion of cities and urbanization, the long distances between home and workplaces usually make it impossible for people to make dinner, warm drinks and spend time together and this can have destructive effects on family members especially children who do not spend much time with their parents due to various circumstances. Also, when no one is at home, there is no desirable living condition. For example, when returning home, the home might be completely dark and considering the hot and cold seasons, the home temperature isn’t suitable and the food may not be prepared and there is the possibility of burglary due to the lack of security systems.

The above problems can be solved using a system called the smart home automation system. What does it mean precisely?

In the 1970s, the first steps were taken to automate homes. Over time, with the advent of new technologies, the idea has grown over the years and has greatly expanded. For a full installation, these systems use communication equipment such as wireless or cable communications. They also have the ability to utilize new technologies such as energy harvesting in order to create optimal communications and ease of use. In the 1990s, the idea of adding sensing technologies to such systems was introduced and the system was named "Smart Homes" [2]. In fact, the smart home refers to a system that uses information technology and computers or smart phones to monitor home appliances [18, 19 and 20].

This study aims to investigate various aspects of the smart home and its implementation and the application of this technology to provide security, i.e., detecting theft and alerting owners through mobile phones it will also examine issues of safety and comfort, i.e., adjusting the desired home temperature, lighting, and monitoring home appliances through mobile phones and GSM.

1.2. Scope of the research

This study focuses on designing and implementing a smart home system with four components called Security component, Safety component, Home Appliance Control using Bluetooth-based component, and Home Appliance Control using GSM-based component to provide a smart home system with capabilities such as easy accessibility, ease of use, low-cost implementation, while providing security and comfort efficiently.

1.3. Objectives of the research

This study aims to investigate different technical aspects of smart homes and implement ion of following four main models:

- Providing security, i.e. monitoring the home environment, detecting movement and alerting the target user or the homeowner about abnormal movements via mobile phones.
- Creating a safe and comfortable home environment including identifying indoor lighting and deciding whether to turn lights on or off based on the home lighting level. In addition, this model includes gas leakage detection, which notifies owners in case of gas presence in the home based on a threshold limit.
- Remote control of home appliances via Bluetooth
- Remote control using GSM (Global System for Mobile Communication).

1.4. Research contributions

The findings of the present study can be a very good resource for those researchers who are interested in discussing, investigating, implementing and evaluating the performance of smart homes. Also, in the near future, as smart homes turn into one of the main components and technologies of homes worldwide, the findings of this study can be a good resource to prepare low-cost and high-quality smart home approaches. Therefore, the practical and research contributions of this study can be summed up as follows:

- Provides an appropriate and optimal resource for those researchers who are interested in studying and implementing smart home systems.
- Implementing efficient multiple functional smart home approaches.

1.5. Organization of the study

The remainder of this study is structured as follows: the second chapter examines the technical aspects of smart homes and the relevant literature. In the third chapter, the methodology of the practical implementation of smart homes, i.e., security (including environmental monitoring, motion detection, notifying about burglary via mobile phone), comfort and safety (including lighting and temperature controlling and gas leakage detection), remotely control domestic appliances via telecommunication and communication systems such as mobile phones is proposed. In chapter four, according to the system proposed, the smart home system is implemented, and the results are examined. Finally, conclusions and further research are presented in chapter five.

CHAPTER 2

PRINCIPLES OF RESEARCH AND RELATED WORKS

Since smart home applications can be considered as a branch of the Internet of Things (IoT). in this chapter the concepts associated with the IoT will be examined, and then more detailed information about smart home technology in addition to the related literature will be reviewed. Also, in order to become familiar with the topic and to create the appropriate foundation for the next chapters, all the applied definitions, concepts, and methods will be elaborated.

Since the present thesis aims to implement the smart home, after introducing the above concepts, the present study is oriented toward the implementation and application of different sensors in the smart home. However, before this, it is necessary to investigate different aspects of the Internet of Things (IoT) and its challenges, advantages, disadvantages and the services provided.

2.1. History of the Internet of Things

The Internet of Things in the industry is a hot topic, and a concept that was only recently introduced. In the late nineties (1999), Quinn Ashton built the underlying foundation of the Internet of Things (IoT) at MIT University AutoID Lab. Ashton was one of the pioneers who understood this concept, as at that time he was looking for ways that Procter & Gamble Co. (P&G) could improve its business by communicating radio frequency identification (RFID) chips with the Internet. Considering the technical limitations of that time, RFID was probably the only option that Ashton could use to implement his idea. However, the concept and idea proposed by this researcher was very simple and yet very powerful, that is, if the entire world's objects and devices were able to use communication equipment, then they could communicate with each other and be controlled by computers. In 1999, in an article for the RFID Journal Ashton wrote:

“If we had computers that use data and information collected without our help to know everything about objects, then we will be able to trace and count everything, and reduce the waste of time and expenses. In this case, when things need to be replaced and repaired, we will be aware of them and will be aware of their freshness or weariness. With these definitions, we need computers with strong data gathering so that they can see, listen, and touch the world around them. RFID and wireless technology also enable computers to observe, recognize and understand the world without restrictions on the import of human data” [5].

At that time, this insight and thinking required major improvements in technology, and questions such as how to communicate between objects, the type of wireless communications that were embedded within the components, the changes required by the Internet to support billions of objects, and communicating among them were issues raised in 1999, and at that time the Internet of Things did not have the ability to resolve this issue. At present, with advancements in various technical areas, most of these barriers have been resolved. The size and the price of wireless radios have decreased dramatically. IP version 6 allows the connection of billions of objects to the Internet, and electronics manufacturers, put cellular and WIFI wireless connectivity devices on a wide range of devices, and this has led to the possibility of connecting billions of objects to the Internet. For example, Cisco’s Internet of Things Group (IOGT) has predicted that by 2020 more than 50 billion pieces will be connected.

Internet of Things (IoT) Definition

As mentioned in the previous section, the idea of the Internet of Things was first introduced by Quinn Ashton to develop the Proctor & Gamble marketplace and the IoT was introduced as identifiable interworking objects that could be connected through RFID. However, the precise definition the of IoT is still in its formative stages and is based on various designs [4].

Generally, the IoT is defined as a dynamic and public network infrastructure with self-configuration capabilities based on interoperable standards and protocols in IoT, physical and virtual objects have identities and attributes, and have the ability to use intelligent interfaces to connect to networks and to exchange information [6,7]. Basically, IoT can be considered as a large set of connected devices that are unique identifiable and detectable via field communication techniques (NFC) [4]. In simpler terms, it can be said that the IoT contains a set of different parts (such as a TV, stove, handset, smart wrists, etc.) that, through the management of computers, can be connected to the Internet via wireless communication technologies and interact with each other without human intervention.

2.1.1 Technologies related to the Internet of things

In order to implement the idea of the Internet of things, various technologies have been involved [1], such as, Wireless Sensor Networks (WSNs), Wireless Radio Frequency Identification (RFID) chips, Near Field Communications (NFC), Machine-to-Machine Communications (M2M), and Cloud Computing (CC).

Wireless Sensor Networks (WSNs)

Despite the extraordinary features and capabilities that RFID and NFC technologies offer, the lack of support for distant transferring ranges has caused limitations in communicating range, i.e., objects must be near each other to be able to communicate. Also, such technologies cannot be used anywhere.

The need for further development of the IoT and the communication between more objects, the control and monitoring of environments and places that do not have fixed network topologies, as well as the creation and development of wireless sensor networks, have also led to the development of this technology. In wireless sensor networks, a set of sensor nodes, each equipped with a processor, memory, transmitter and receiver antenna and power resource, can communicate with each other, through wireless communications and exchange data among each other or even send some data to the base station. In addition, establishing the relationship between vehicles on the road in order to relay details about the condition of the road, observing the distance between vehicles in bad weather conditions, and controlling the relationship between vehicles and roadside automatic payments systems, are nowadays essential services in the Internet of things. So, the use of WSN and Vehicle-to-Vehicle Communications (V2V) in the IoT has led to the fulfillment of the above requirements and provides features such as collision avoidance, infrastructure management, vehicle communication, supplying the Internet on the road.

Radio Frequency Identification (RFID) Chips

RFID technology includes one or more RFID tags and readers. Initially, the idea of the IoT was implemented on the basis of this technology and used radio frequency electromagnetic fields for transmitting information. The tags or labels that are attached to these components, store the data electronically, which can be read and used by RFIDs. This technology allows the monitoring of objects in real-time mode that do not have to be visible to the RFID tags. In this technology, the tag or RFID tag refers to very small microchips that are connected to an antenna in the form of a compact package. Such antenna tags receive signals from RFID and return them by adding additional information. The RFID tag has three different configurations, 1) The Active Passive Reader Tag (PRAT), 2) Active Tag Active Reader (ATAT) and 3) The Active Reader Active Tag (ARAT). ARAT has a passive reader and receives signals from the battery operating tag, and its transmission and communication range vary between 1 and 650 meters, depending on the type of architecture used [1]. Among the three above-mentioned configurations, the most common one is ARPTs as it doesn't require an embedded power supply, and uses the energy needed to send data from the query signal sent by the RFID reader [11].

This technology allows communication between objects, and in the early days could create the expectations of communication between two objects, but could not implement the whole idea of the IoT due to the constraints on which it was created. For this reason, , newer technologies have entered this field.

Near Field Communications (NFC)

NFC and RFID are very alike. This technology can create a customer-oriented model by integrating an RFID reader within mobile phones [1]. In fact, NFC is a low-power wireless link that can send a small amount of data between two devices that aren't far from each other. Unlike Bluetooth, this technology does not need to pair devices before sending information. Given the special features of NFC, this technology is recognized as one of the most important and critical technologies of the IoT.

Machine-to-machine communication (M2M)

This technology refers to communication between computers, embedded processors, smart sensors and mobile devices, and generally refers to communication between machines or objects that can communicate through infrastructures such as the Internet. This technology has many uses such as Health, Smart Robots, CTS, Building Systems, Smart Home and Smart Grids [1].

Cloud Computing (CC)

One of the technologies that has just been added to the IoT is cloud computing. The idea of the Internet of things is to have communication between multiple objects over the Internet and to exchange information without requesting human data. If all the objects able to communicate with each other and store their data a huge machines or databases on the Internet, and other objects are able to use this big data, the best option for implementing this procedure is cloud computing. In fact, the Internet of Things has been able to interact with cloud computing in its structure, creating a huge database of information without human intervention and input data, so that all information collected by objects stored on machines can be controlled by the cloud computing concept.

According to the above description, a summary of the technologies that have been used for the development of the Internet of Things have been briefly outlined in Figures 1 and 2.

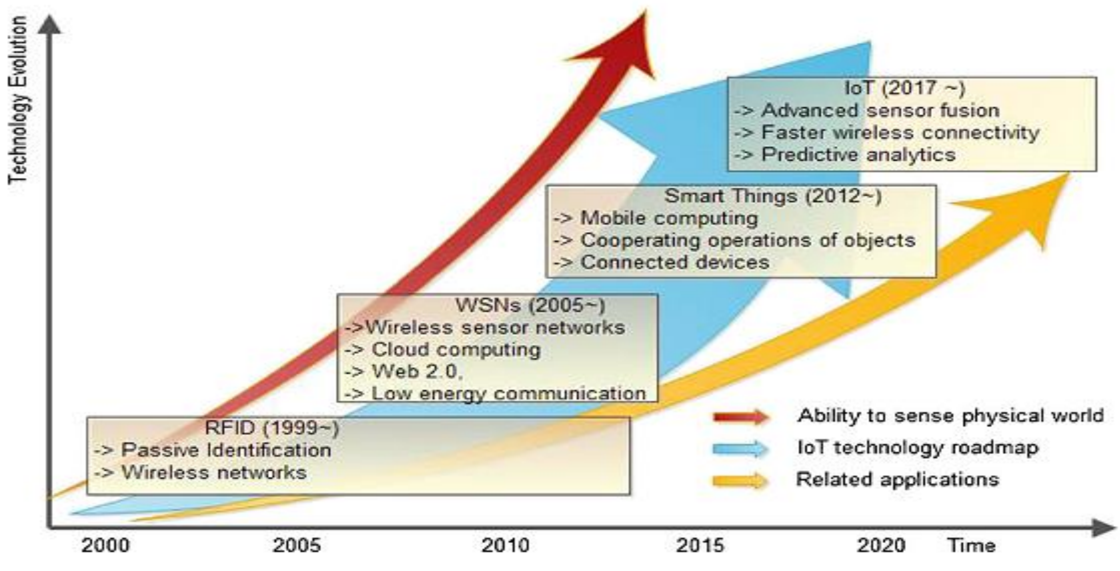


Figure 1. Development of the “Internet of Things” [4]

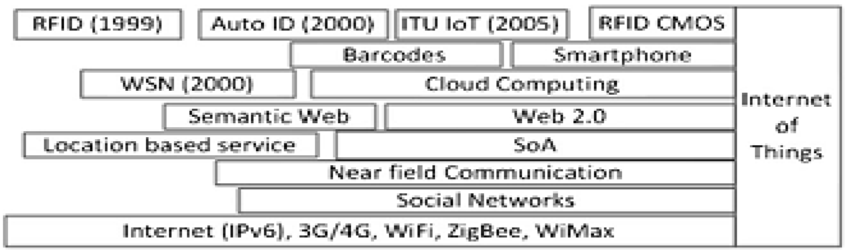


Figure 2. Technologies used in the Internet of Things [4].

2.1.2. Internet of Things features

The internet of Things includes the following features:

- Providing a significant amount of data and information without human intervention: Given the fact that this information is collected through sensors installed on objects that can be connected to communication networks, the probability of mistakes occurring is very weak, and, therefore, this information can be considered as a stable and usable source and available to other objects on the network.
- Availability of sufficient information about the current status of the objects and their status. The Internet of Things gives users the ability to control and monitor some objects, and to constantly observe the status of the monitored environment. Obviously, this can enable a response quick to events that take place and prevent disaster from occurring in sensitive cases. For example, whenever patient's vital signs become abnormal, health controlling sensors can inform the control center immediately, and the necessary action can be quickly taken.
- The ability to quickly perform multiple jobs in different places, Objects on the Internet can communicate with each other whenever it is required to perform their duty.
- Producing cheaper and better-quality products, Internet objects can reduce the costs and increase the quality of agricultural, industrial, construction and other products by employing sensors with communication capabilities. In these applications, it is no longer necessary to test the moisture content and soil temperature, or control the temperature of the furnace in industrial

applications; instead the embedded sensors in these environments send the required information to designated devices. Using this information, it can provide ideal conditions for production and prevent waste of resources.

- Remote control of home appliances via smart phones. This could be one of the best features and benefits of the IoT. In the past, when we left our houses, we always had doubts about closing the doors and windows, shutting down the cooker, stove or television, etc. The Internet of Things allows users to remotely control their entire home appliances through their phones. For example, turning on the stove for half an hour before entering the house or turning on the cooler and bringing the house temperature to the optimum temperature.
- Save time and make things easy. If we are not sure about the status (on or 0ff) of a heater, even if we are at work, sometimes we have to go back home to check. This is true for other applications from home applications to agriculture, industry, and the military. The Internet of Things has ended this concern by linking various objects and sending status reports. This reduces increase saving in time and simplifies work and functions.

2.1.3. Internet of Things applications

The Internet of Things has a wide variety of uses, and its application is increasing every day. Some of its applications are mentioned below [1, 4, 3].

1) Smart Park

The use of intelligent sensors that can be used in car parks to identify vehicles entering and leaving is one of the IoT applications. This method reduces fuel consumption by providing complete information on the condition of the parking area and its vacant spaces and also reduce traffic jams in the environment and reduces the emission of carbon dioxide.

2) Automatic electronic maps

Providing these maps enables tourists to connect to the network using smart devices and find out their exact location, and the location of places of recreation, tourism and ancient, etc. There is also the possibility of directing users to such centers.

3) Collecting useful data without human intervention

Using the Internet of Things, data can be collected and transmitted in different areas without human intervention. This reduces data mistakes due to human error and can achieve the desired goals by providing sustainable information. For example, if the doctors are able to transfer their patient records to an emergency doctor, this action can speed up the recovery process or even save patient's lives.

4) Smart water source

Monitoring and controlling water and reporting on its contamination can lead to the production and delivery of healthy water for domestic and commercial applications. Also, the implementation of this system can also indicate the exact location of the water leakage, the fracture of transfer pipes and the entry of unauthorized persons to the place of feeding water. In addition, timely detection of fractures associated with transmission pipes can significantly reduce costs and optimize water consumption and prevent water from being wasted.

5) Health area

The IoT and basic equipment such as NFC have a great ability to monitor the health of patients. This application periodically reviews and reports patient information and it can be used to analyze patient data and enable necessary action to be taken faster.

6) Maintaining industrial and agricultural equipment

The ability to monitor and check special equipment used in various industries, such as controlling and monitoring the temperature and vibration of industrial engines, melting furnaces, and identifying incomplete operations in progress, and reporting these to the central station can significantly impede disasters such as fire and explosions. Timely detection of defects in industrial systems can result in timely repairs and cost savings.

7) Smart cars

With the IoT, we do not need to stop to pay road charges, or check the map for information about the location of fuel stations, or worry about driving in bad weather. Intelligent vehicles with smart equipment offer auto attendance, road status reports, precise location of fuel stations, and more.

8) Electrical industry and smart power transmission networks

Power grids provide the ability to transfer power efficiently, but in some cases, due to the occurrence of some defects, it causes problems and imposes severe human and material costs.

In the IoT, all equipment used in power grids possess sensors that periodically monitor and report their information. In this case, it is easier to detect faulty or damaged parts, so these can be replaced before affecting other parts of the entire network.

9) Smart offices and homes

In this application, domestic appliances are connected to smartphones using their communication equipment and send the status of these appliances to the remote device using the appliance's embedded sensors. They can also get some control commands from the remote device, such as smartphones. Since the main purpose of this thesis is the design and implementation of smart homes, this issue has been discussed more precisely.

2.1.4. Smart home

In the 1970s, the first steps were taken to automate homes. Over time, with the advent of new technologies, the idea has grown over the years and has greatly expanded and developed. For a full installation, these systems use their communication equipment such as wireless or cable communications. Also, these systems have the ability to utilize new technologies such as energy harvesting in order to create optimal communications and ease of use. Eventually, in the 1990s, the idea of adding sensing technologies to such systems was introduced and the system was named "Smart Homes" [2].

According to [12] the smart home is defined as follows: "A ubiquitous computing application that monitors indoor and outdoor environments of home or office and offers different services and remote controls to enhance welfare and security and reduce costs and prevent waste of time".

A smart home, however, should be able to fulfill the user's comfort and needs. Therefore, in defining the smart home, in addition to considering the aspects of intelligence, other aspects and human factors should be considered. So, in the implementation of smart homes two fundamental dimensions, namely the dimension of intelligent household appliances dimension and human factors are involved. In [8], based on these two dimensions, the smart home has been defined as follows.

- Understanding and identifying user needs (considering that users' needs vary depending on the content).
- Solving problem situations properly for each individual user.
- Meeting different needs in terms of ethical, legal, security and quality aspects of life.
- Learning and obtaining the necessary experience to combine reactions or habits depending on the capabilities and expectations of each individual and the field of their use in residential environment.

Figure3, shows the key aspects of Smart Home as defined in [8].

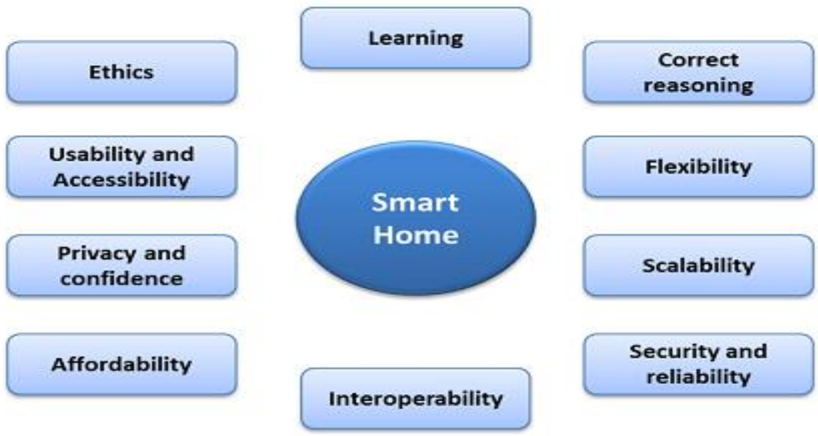


Figure 3. Key aspects of smart home [8]

Intelligent House Architecture

The architecture of a smart home must be able to respond to the user’s different needs. It should also be able to put together equipment that, while meeting the user's needs, will optimize energy consumption and achieve safety and security. In [13], two types of architecture for the design and implementation of smart home are provided, i.e., 1) the traditional architecture, where smart home appliances communicate through the Internet with a smart device such as mobile phones, computers and laptops, and exchange information via this kind of communication. 2) Up-to-date architecture, the Hierarchical Mobile IPv6 is used to communicate with domestic appliances. The advantage of this architecture over the traditional one is that the user can still control the device at the time of leaving the network and entering another network. Figures 4 and 5 show the traditional and Hierarchical Mobile IPv6 architectures respectively.

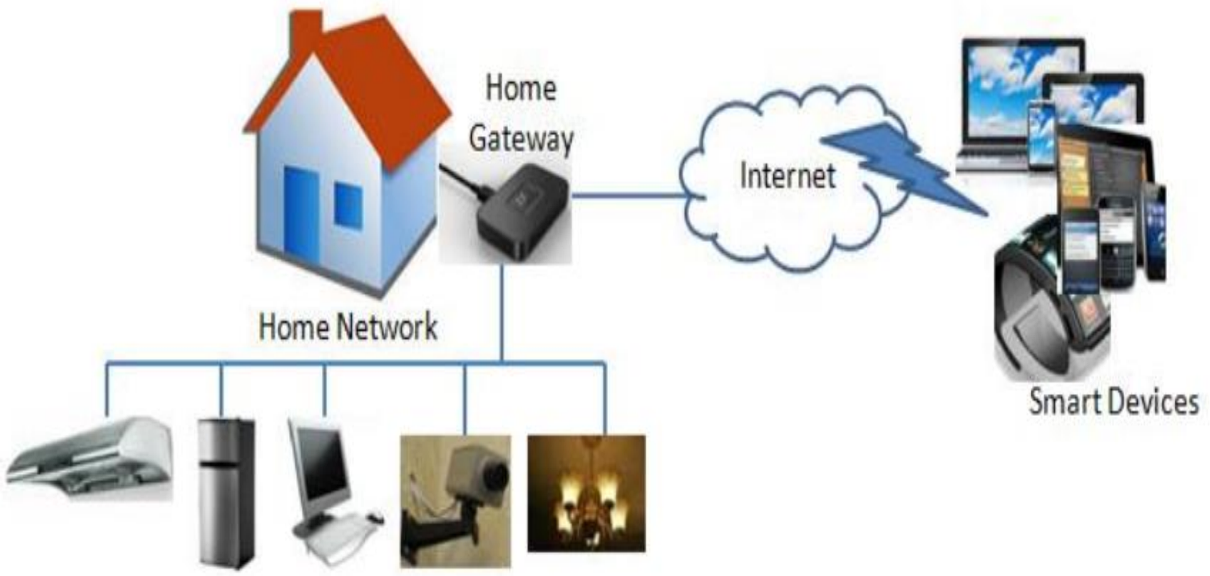


Figure 4. Architecture of a Traditional Smart Home System [13]

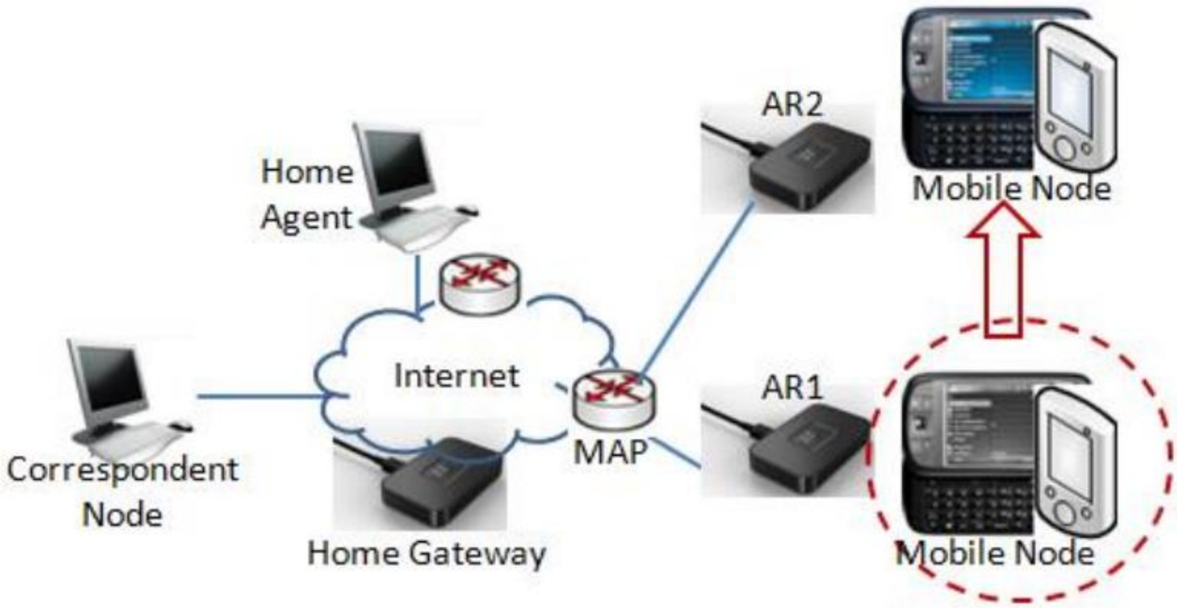


Figure 5. Hierarchical Mobile IPv6 Architecture [13]

In summary, the following applications can be considered for use in smart homes:

- Health Care
- Taking care of young and old people

- Providing security and preventing theft when no one at the home
- Ease of comfort including controlling the domestic appliances, monitoring the heating and cooling systems and adjusting the ambient temperature based on seasonal and climatic conditions
- Control and monitoring the home environments remotely
- Provide timely warnings in case of gas leakage, fire and so on.

2.2. Related work

In this section, we have summarized recent research, developments and solutions related to smart homes.

In [14], a new model which uses a Bluetooth network and home automation protocol (HAP) for implementing smart home was introduced. The proposed system includes remote communication, a host controller, and several client modules (domestic appliances). HAP facilitates communication between the host and client modules in a home automation system. In addition, HAP has been designed based on the architecture of the Bluetooth protocol, in which the proposed system has three layers called the Logical Link Control and Adaptation Protocol (L2CAP), Service Discovery Protocol (SDP) and RFCOMM (serial cable emulation protocol). L2CAP provides data services, SDP detects various services in the system, and the RFCOMM provides wireless communications and provides transport ability for home automation services. In the proposed system, the Bluetooth-based PC software module is considered as the host controller, and the ability to provide services such as registering new devices such as Plug and Play, repairing and troubleshooting problems, and controlling and monitoring the status of domestic appliances. In general, this method has been able to connect multiple controllers (DCs) of client modules to a host module (Bluetooth) and remotely control and monitor these devices cheaply. However, the use of Bluetooth to control appliances and the implement a smart home model can be a useful and effective option in places where distance is not a concern, but when the distance increases, due to the limited communication range of Bluetooth, it is not an appropriate option.

In [15], a secure PIC micro-controller based remote control system for smart home is proposed. This system can use public telephones or mobile phones, to allow users to control their domestic appliances anywhere in the world with no worry about security issues. In the proposed system of [15], with the aim of protecting the system, the remote-control device is electrically isolated from other parts of system and in order to enhance the overall systems security, researchers have also used the pin check algorithm. This method sends tone information through voice tone and provides remote communication with domestic appliances. This is also called Dual Tone Multi Frequency (DTMF), in which each key has a different frequency and when dialing, the frequency associated with the key pressed through the telephone line and the audio signal is sent. In fact, in this way, anyone who know the sim number connected to the microcontroller can control home appliances.

In general, when the sim number is dialed, the controller opens the line and waits for the pin to be entered. If the PIN does not arrive or the waiting time reaches 15 seconds, the controller will block it to prevent it from occupying the line. If the user inputs the PIN correctly after the line is released, the controller waits for the instructions to be received and executed. In this system, all commands are transmitted as DTFM signals; hence the system has a high level of security. However, in this method, the maximum number of controllable domestic appliances is equal to the number of key pads, which can be considered as a limitation of this method.

In [16], a method called Universal Mobile Application Development (UMAD) has been proposed. This method allows the implementation of home automation systems that can create XML-docs which can be deployed on the server. The server used in this way is platform-free and capable of adapting to any kind of mobile device with any OS. UMAD has used an operating system to implement a home automation system. In this implementation, all mobile devices, regardless of platform issues, have the ability to access and use the XML documents that are created and stored on the server. In this system, downloading XML files from the server and parsing them requires coding on any platform. Also, the design section is coded only once, which reduces the effort to re-encode the information, and, based on the platform-free of the method, uses a common file on various platforms. This method, despite having advantages in quick implementation of home automation system, has security problems because it can be easily accessed and used by other mobile devices.

In [17] and [18], the ZigBee network standard and Bluetooth network were used respectively to overcome the limitations of using wiring to communicate between devices. These methods provide the ability to interconnect devices with wireless connectivity, in order to 1) resolve the problems associated with wiring in supervised environments, 2) reduce costs. In [17], the authors have used the potential of ZigBee protocol IEEE 802.15.4.

wireless standard to build a home automation system called ZigBee Based Home Automation. The home automation system implemented in this method has three main components called Coordinator (ZC), that maintains the network and routing tables, Routers (ZR) and End devices (ZED). The proposed system for the home automation network includes controller PIC as the central processing unit, ZigBee receiver unit, sensor network unit (including light, temperature and smoke sensors) and display unit. All sensors transmit the information sensed through the ZigBee receiver unit to the controller, and the controller, based on received information performs the required action such as creating alert, temperature setting, or ambient light setting. The displays unit shows all activities performed on the entire system including ZigBee, sensors and controller activities on the LCD panel. This system is suitable for locations where the equipment distance is between 30 and 100 meters.

In [18 and 19], a home automation system based on Bluetooth network and mobile phone has been proposed. In this system, an Arduino BT board and home appliances connect through the relay to the input and output ports of the board. Using the microcontrollers high-level interactive C language, and over the Bluetooth connection, the Arduino BT board can be programmed wirelessly. In the proposed system, only authorized users can access home appliances by entering passwords. In addition to communications between mobile phones and the Arduino BT board, Python scripts have also been used to run the program on Symbian operating systems. A feedback circuit has been created to indicate the status of the device after receiving a command from the mobile phone. An algorithm has also been implemented in the proposed system that displays the available devices.

In [20], multiple models have been used to collect sensor information connected to the domestic appliances, and then the collected information is sent to the end user through a web-based GUI. In this method, the architecture of a home automation system is proposed in which various sensors connect to the Arduino by relay. Since the main purpose of this architecture is the communication between the user and domestic appliances, in the proposed architecture, the controller board is connected to the Internet using the router and authentication system for security issues. In this case, only when the Internet is available, the user will be able to use the smart device and monitor the status of the domestic appliances. In [20], a Graphic User Interface has been implemented in order to simplify the application's use and to enhance the system's security. In addition, authentication has been used so that only authorized users are able to access the system. The most important advantage of this method is that it uses the Internet of Things concept to implement the smart home. On the other hand, since the Internet is not always available to the public, and the entire community and people are not able to work with such modern environments, these models, despite the optimality of the used method, do not have ability to be used by all of people.

In [21], the Global System for Mobile Communications (GSM) has been used to design and implement a smart home system. The proposed system has the ability to control the temperature and ambient light levels of the home environment. To implement the proposed method, microcontroller ARM7 LPC2148, temperature sensors (Thermistor NTC) and LDR sensors have been used. Despite the fact that the proposed method has a proper and cost-effective implementation, other control components of home automation module system such as Bluetooth or mobile apps are not used to control home appliances. In addition, other essential parts such as security and identification of gas leakages have not been implemented in this method.

In [22], home automation implementation techniques are theoretically examined, using multiple factors such as ease of use, low cost, and high security, providing several approaches that are as follows:

- Arduino microcontroller as the heart of the system and controlling all received and sent orders

- Use of different sensors to monitor the condition of the environment and home equipment
- Use of communication infrastructure for remote control (GSM, android apps and SMS)

In [23], a Bluetooth Based Smart Automation System Using Android which includes two sections, safety and security has been developed. In the safety section, components for temperature control, lighting control and fire detection have been designed and implemented. In the security section, the Motion Detection Component and theft alert have not been designed and implemented. In addition, Bluetooth and Android applications have been used in [23]. Despite the low cost of using Bluetooth, it has a small communication range, so this system can only be controlled from short distances and can’t be used for remotely controlling devices that are situated in different places.

In [24, 25], a GSM Based Home Automation System using android is proposed. Similar to [23], in [24], a technique for designing and implementing a smart home system has been proposed. However, in this approach, only components for controlling lighting and temperature have been implemented; some important components, such as fire detection and gas leak detection have been ignored. In addition, only GSM was used for the purpose communications.

In [25], GSM technology is used to control home appliances. However, the approach of [25] has limited available features, for instance, only gas leak detection and lighting control components have been designed and implemented, and other important components, such as home temperature control and fire detection, have not been taken into account.

A smart home system using Infrared ray, Global System for Mobile Communication (GSM) and android phone mobiles is proposed in [26]. In general, Bluetooth and GSM communication technologies were used to control home appliances. However, similar to the approach of [25], this approach has limited available features.

According to our knowledge, none of the available approaches has fully implemented a multi-functional smart home system.

2.3. Conclusion

In this chapter, the concepts, definitions, structure, advantages, and disadvantages of the Internet of Things and Smart Homes were discussed and then the challenges related to this new field were described. Afterwards, Smart Home architectures were discussed and their applications were described. Also, at the end of this chapter, work, and research related to the implementation of the smart home were explained. Looking at the content presented in this chapter, it can be concluded that many efforts have been made to implement the smart home, and different methods have been tested to implement smart homes and minimize costs while improving the performance. However, the lack of some infrastructures and the lack of access to the Internet everywhere can limit the spread of this technology, so in the next chapter, we will try to provide a multi-functional smart home system.

CHAPTER 3

PROPOSED SMART HOME AUTOMATION SYSTEM

The content included in this chapter aims to using the tools available to provide a smart way to design and implement a smart home that facilitates the use of a smart home and reduces costs.

As mentioned before, a smart home system must be able to provide users with easy accessibility, be easy to use and have low-cost implementation, while providing security and comfort. Considering these requirements, in the proposed system, the smart home is designed as a general system with four models called Security model, Safety model, Home appliance Control using Bluetooth-based model, and Home appliance Control using GSM-based model.

3.1. Security model

Considering that security is one of the main requirements that a smart home system needs to be able to implement, in the proposed system namely the Security model (SM), is developed. SM's main task is to monitor the home environment, identify motion and notify the owner of the home by calling about abnormal movements. Figure 6 shows a block diagram of this model.

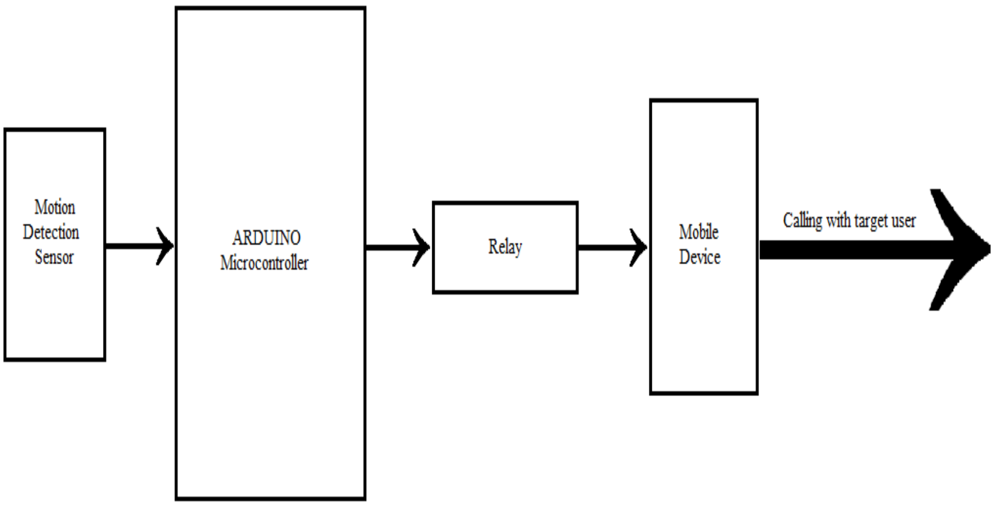


Figure 6. Block Diagram of the Proposed Security Model

In the proposed system, when the sensor detects motion in home, it sends pulses to the microcontroller, the microcontroller; after receiving the pulse, makes a call using a mobile phone to the target user or the homeowner and warns about possible theft.

The full function of the security model of the proposed system is as follows. The main purpose of the security model is to protect the monitored environment in the absence of its owners. In order to achieve this goal, motion detection sensors have been used. In this case, a Motion Detection Sensor will be initiated and connected to the Arduino Microcontroller. After the setup stage, the motion detection sensor starts monitoring the environment and sending the information collected to the microcontroller. Arduino's microcontroller analyzes the received data, and whenever it detects motion in the reported data, sends a call command to the mobile device to inform the home owner of the possibility of burglary. Otherwise, if, abnormal movement not detected, the system continues monitoring the environment. The flowchart of the proposed security model is shown in Figure 7.

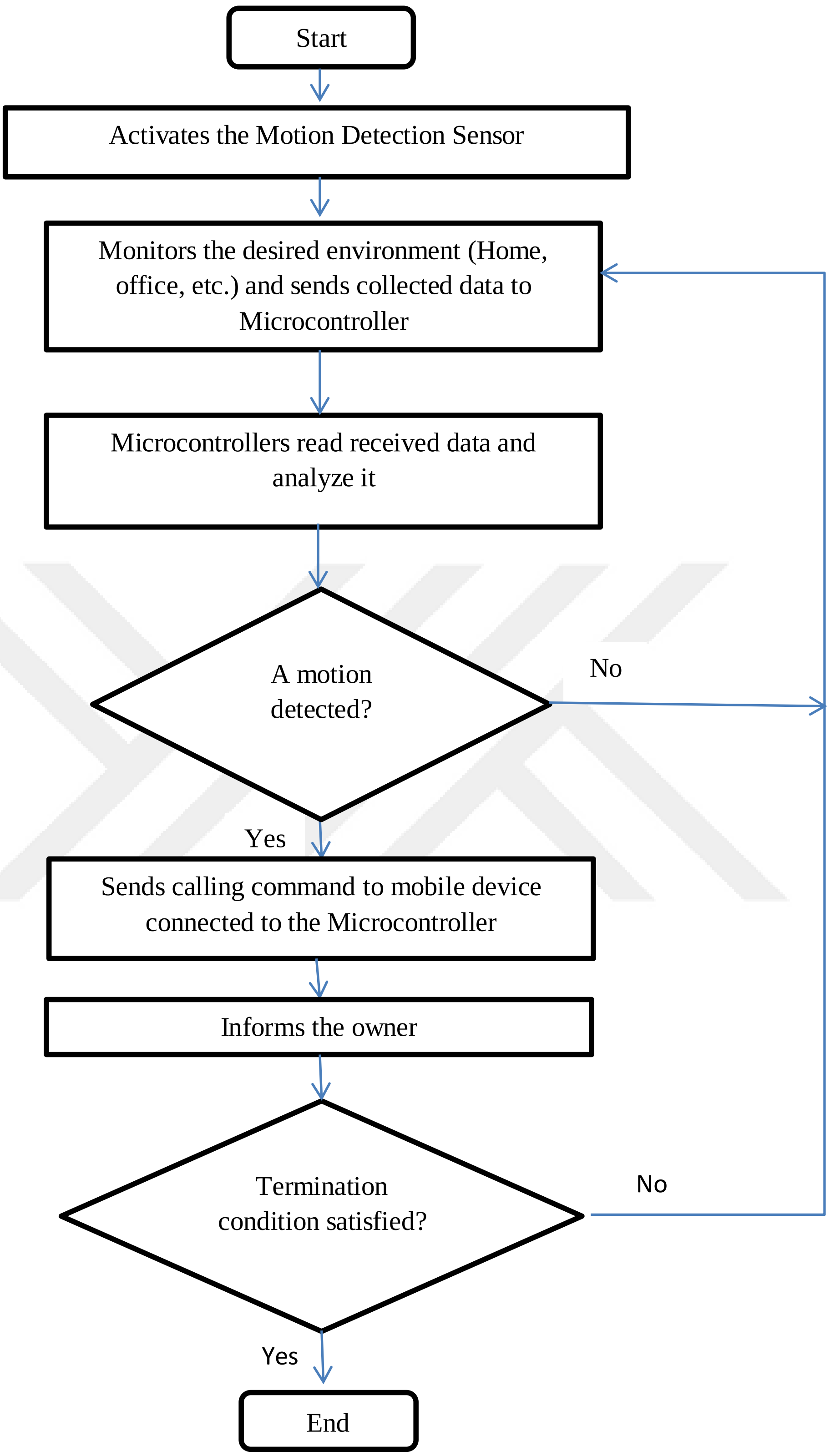


Figure 7. Flowchart of the proposed security model.

3.2. Safety Model

An intelligent home system, in addition to being able to deliver security, must also be able to fulfill users, needs for safety and comfort. The safety requirements considered in this thesis are respects such as setting the home temperature, monitoring and detecting leakage of gas and giving timely warnings to the residents, and adjusting home lighting based on the environment and various hours of the day and night.

Considering the requirements for the Safety model, Figure 8 illustrates the block diagram of this model.

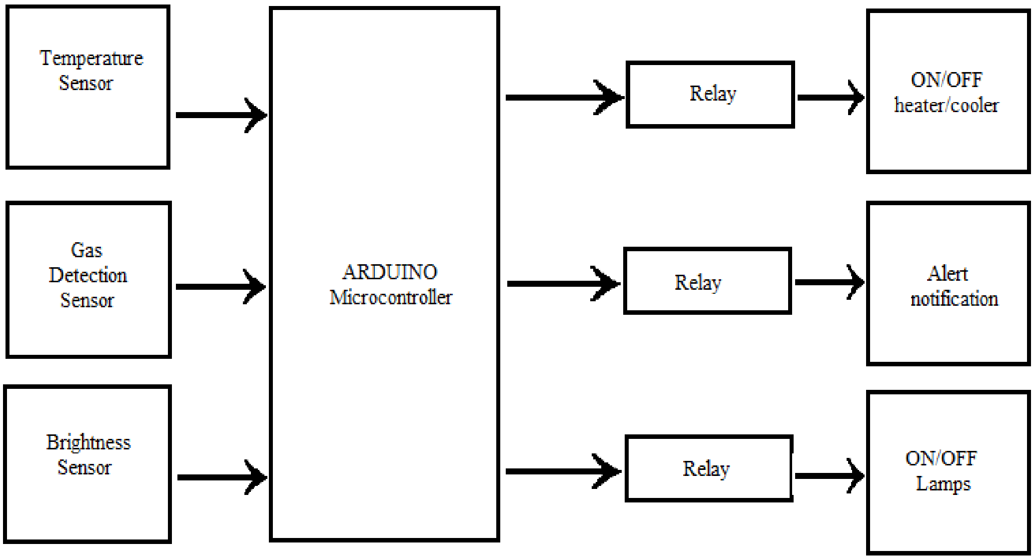


Figure 8. Block Diagram of the proposed Safety Model

As shown in Figure 8, the proposed Safety model includes the following three sub- models, 1) A model to control the temperature of the home environment, 2) A model to detect leakage of gas and produce a timely warning and 3) A model to control environment lighting.

3.2.1. Temperature monitoring

The main task of this sub- model is to monitor the temperature of the house and set it at a predefined temperature. Temperature sensors have been used to do this. After the initial setup, the temperature sensors send the gathered data to the microcontroller. Next, the Arduino microcontroller analyzes the data received according to the predefined schedule. The result of data analysis leads to one of the following three actions:

1. The temperature of the home environment is less than the optimal temperature. In this case, the heater is turned on to balance the temperature.
2. The temperature of the home environment is higher than the optimum temperature. In this case, the cooler switches on to balance the temperature.
3. The temperature of the home environment is equal to the optimum temperature. In this case, the micro-controller will take no action and continue to monitor the temperature until the termination condition is fulfilled.

The flowchart of the proposed temperature monitoring sub-model which is a part of the safety model is shown in Figure 9.

3.2.2. Gas leak Monitoring

The main goal of Gas Leak Monitoring section is to control and monitor the gas leak and to alert the residents of the home. Therefore, in the proposed system, gas leak detection sensors were used to implement this part.

After the initial setup, the gas leak detection sensors send the gathered data to the microcontroller. Next, the Arduino microcontroller analyzes the data received according to the predefined values. The result of data analysis leads to one of the following two outcomes:

1. Gas is not leaking. In this case, the microcontroller does not work and continues to monitor until the termination condition is fulfilled.
2. Gas is leaking. In this case, the microcontroller will turn on the alert system and inform the residents, while continuing to monitor until the termination condition is fulfilled.

Figure 10 shows the flowchart of the gas leak detection sub-model of safety model.

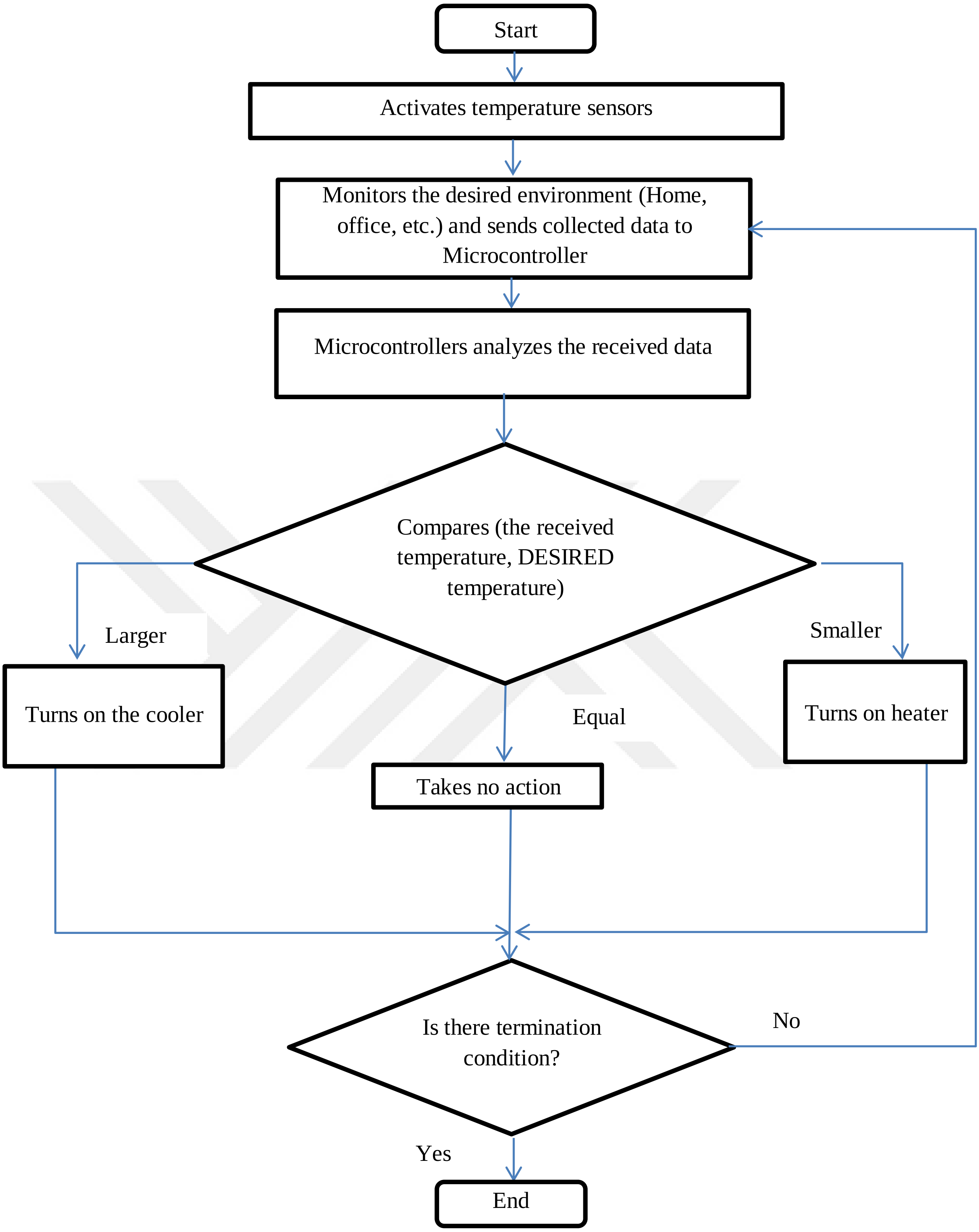


Figure 9. Flowchart of the temperature monitoring sub-model.

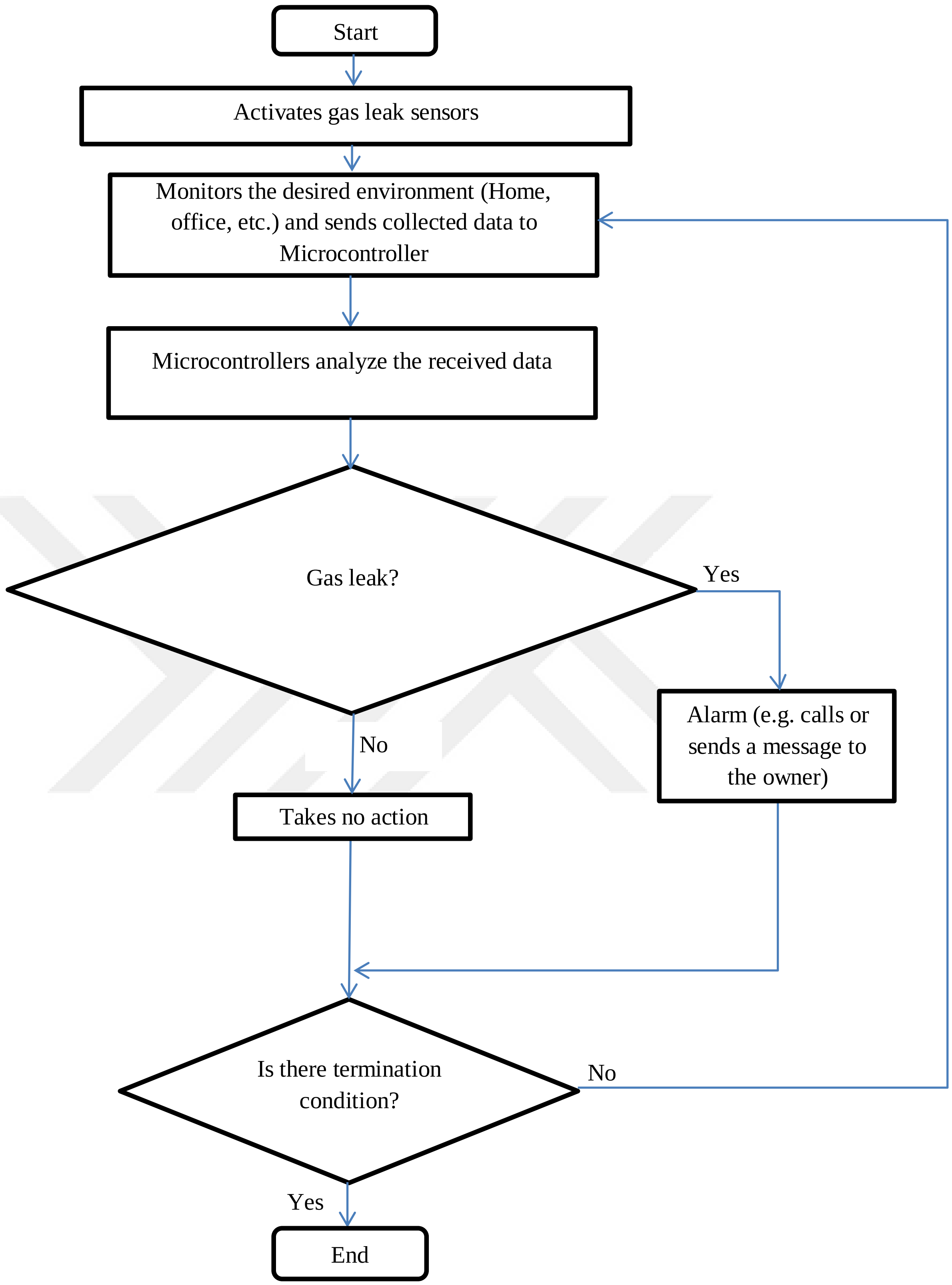


Figure 10. Flowchart of the gas leak detection subsystem.

3.2.3. Light Monitoring

This subsystem controls the lighting level of the house in terms of environmental conditions throughout the day. In implementing this subsystem, a threshold value is considered as the optimal brightness. The LDR (Light-Dependent Resistor) after gathering the necessary information, sends it to the microcontroller. The microcontroller then analyzes the information received and the results can fall within one of the three options:

1. The ambient light is less than the threshold value. In this case, the micro controller lights up the lamps.
2. The ambient light is greater than the threshold value. In this case, if the lamps are turned on, it will turn off.
3. The ambient light is equal to the threshold value. In this case, the microcontroller does not work.

However, the microcontroller will continue monitoring until the termination condition is reached. The flowchart of this subsystem is shown in Figure 11.

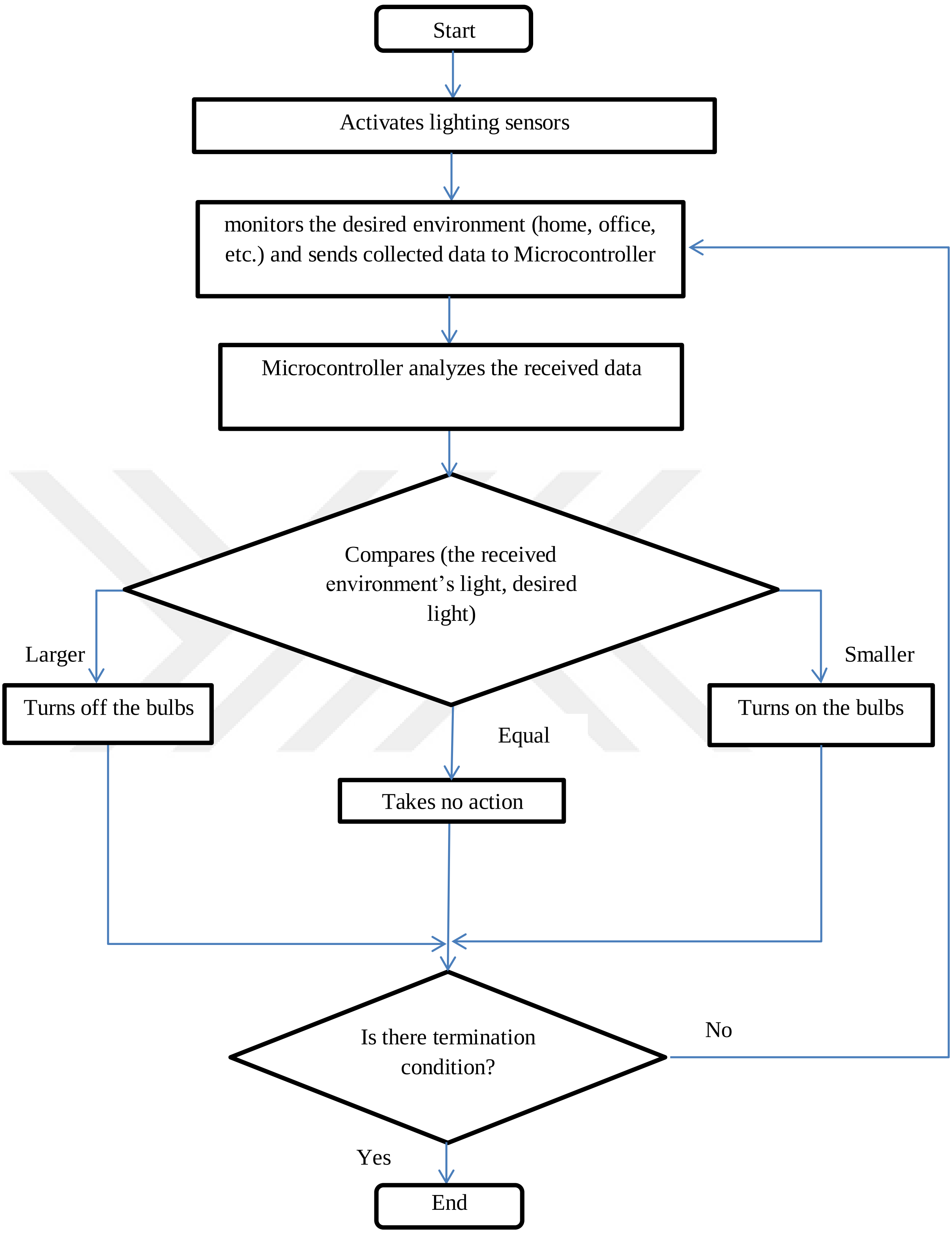


Figure 11. Flowchart of the light monitoring subsystem.

3.3. Home Appliance Control via Bluetooth

The proposed system allows for the control of domestic appliances through Bluetooth, and the block diagram is shown in Figure 12.

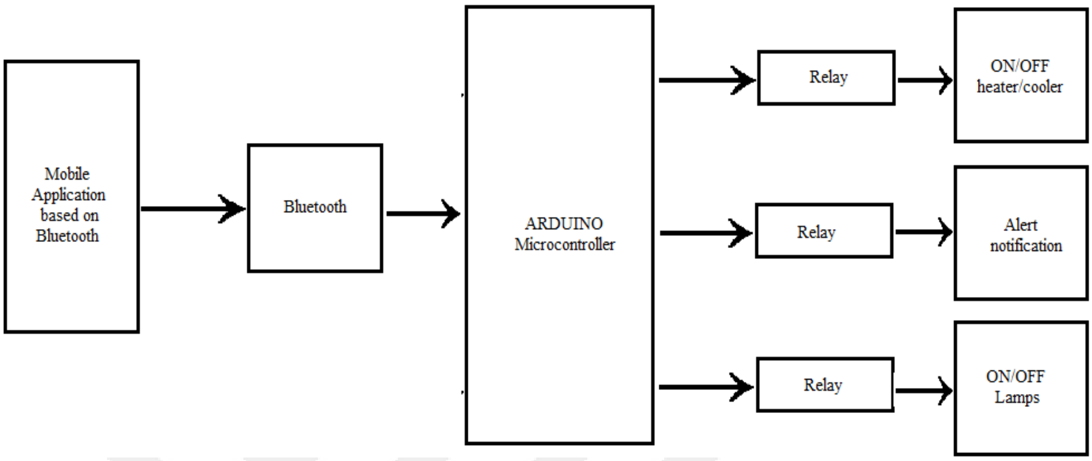


Figure 12. Block Diagram for controlling the home appliances via Bluetooth

As shown in Figure 12, the proposed system allows domestic appliances to be controlled via Bluetooth wireless technology through an Android app. In addition, the Android app has been used to implement domestic Appliance Control via Bluetooth (see section 4.1. for more details about App Inventor). The purpose of the implementation of this app is to communicate between the mobile phone and the Arduino microcontroller via Bluetooth, send the command to the microcontroller and receive environmental information such as the temperature or the amount of gas leakage in the environment. In the internal structure of the app, two modules, namely gas leak detection and temperature control, have been implemented.

In fact, in this model, commands are sent to the microcontroller by the user and via the Bluetooth connection. In implementing this model, a Bluetooth-based application has been used to control domestic appliances so that the user first communicates with the microcontroller using the mobile phone and Bluetooth network, Then, using the written program, the user sends the necessary commands to control or monitor the device to the microcontroller. After receiving the commands, the microcontroller will first check their validity. If the received command is valid, it executes it and waits to receive subsequent commands.

Commands sent by the user can be either monitoring commands or control commands. In monitoring instructions, the user receives the state of the home devices from the microcontroller, and in case of control commands, the microcontroller switches off or on the device according to the commands received Figure 13 shows the flowchart of the proposed model.

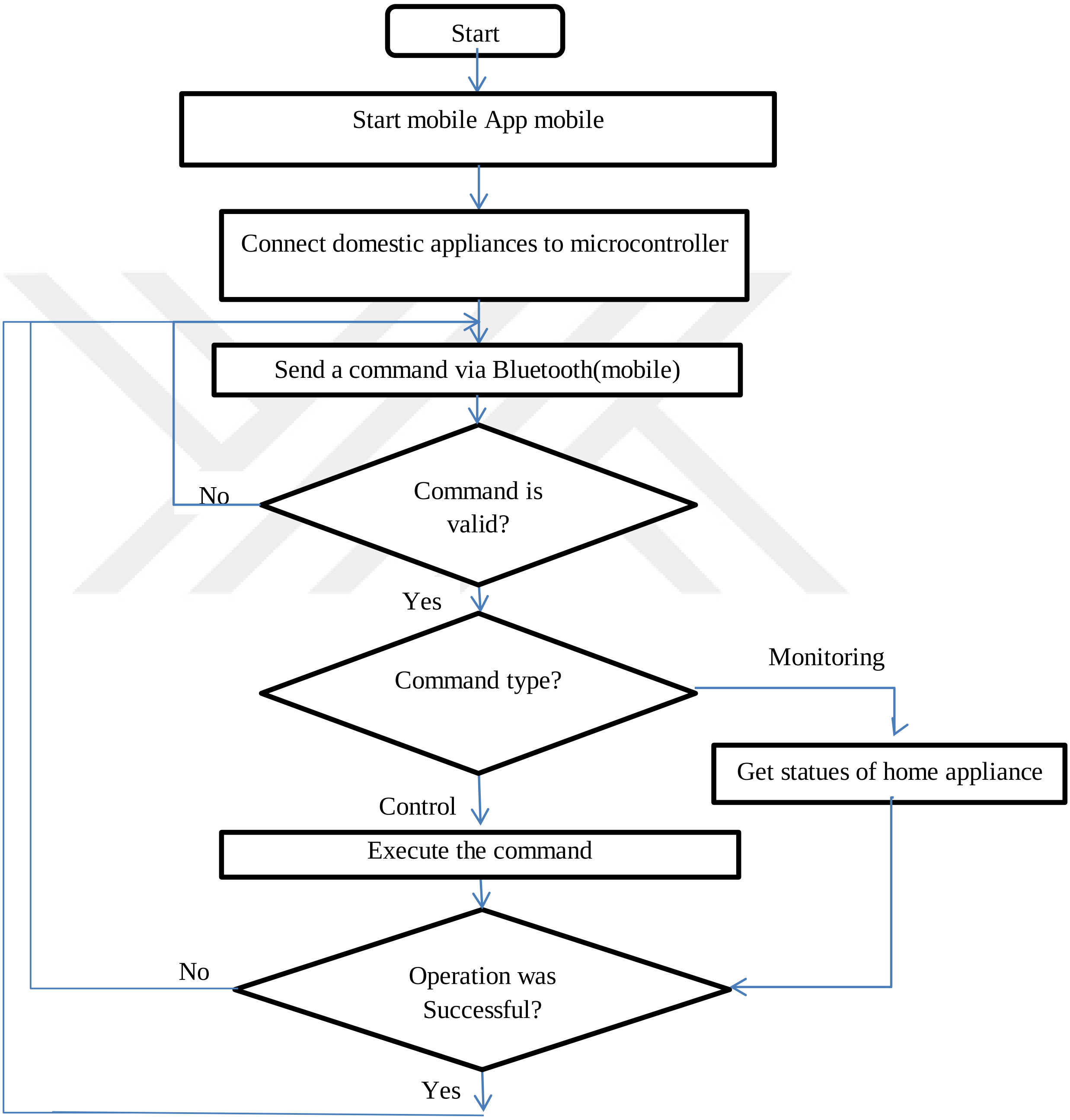


Figure 13. Flowchart of Controlling the Home Appliances via Bluetooth Model

Despite the fact that the use of Bluetooth can provide homeowners satisfaction in terms of remote control of domestic appliances, due to the fact that Bluetooth has a short radio range, it can’t be used when the distance between the user and the home exceeds the Bluetooth radio range. Therefore, in order to cover this defect, in the proposed system, remote control capability via other technology such as GSM is also considered.

3.4. Remote control of domestic appliances

In order to solve the above-mentioned problem, the proposed system allows the remote control of domestic appliances through GSM modules, so that a person can send commands to control the domestic appliances by sending a message or by receiving an SMS to be informed about the status of the home and its equipment. A block diagram of this system is shown in Figure 14 and Figure 15 shows its flowchart.

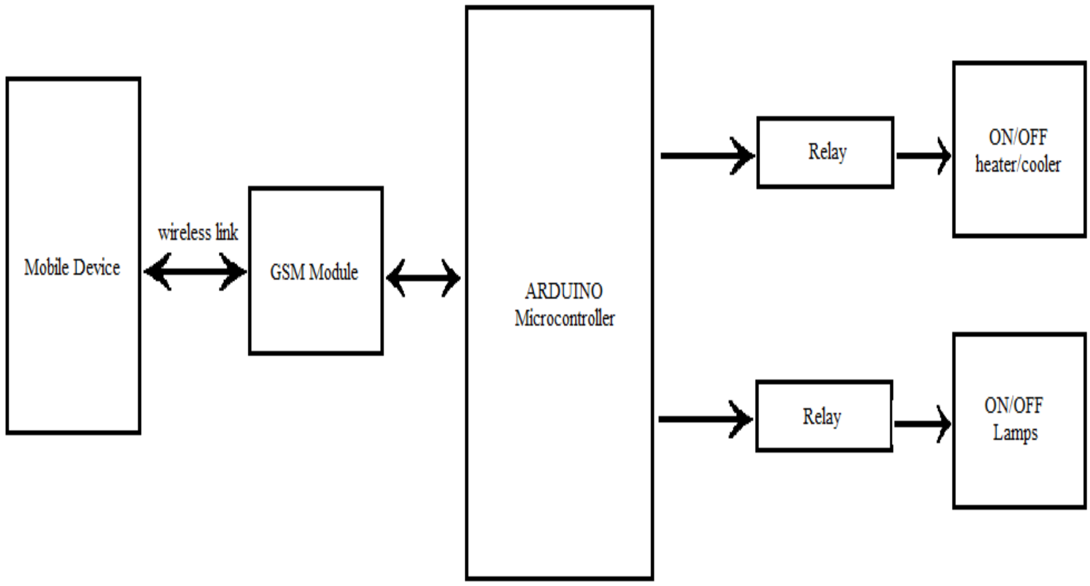


Figure 14. Block diagram of domestic appliance remote control via GSM

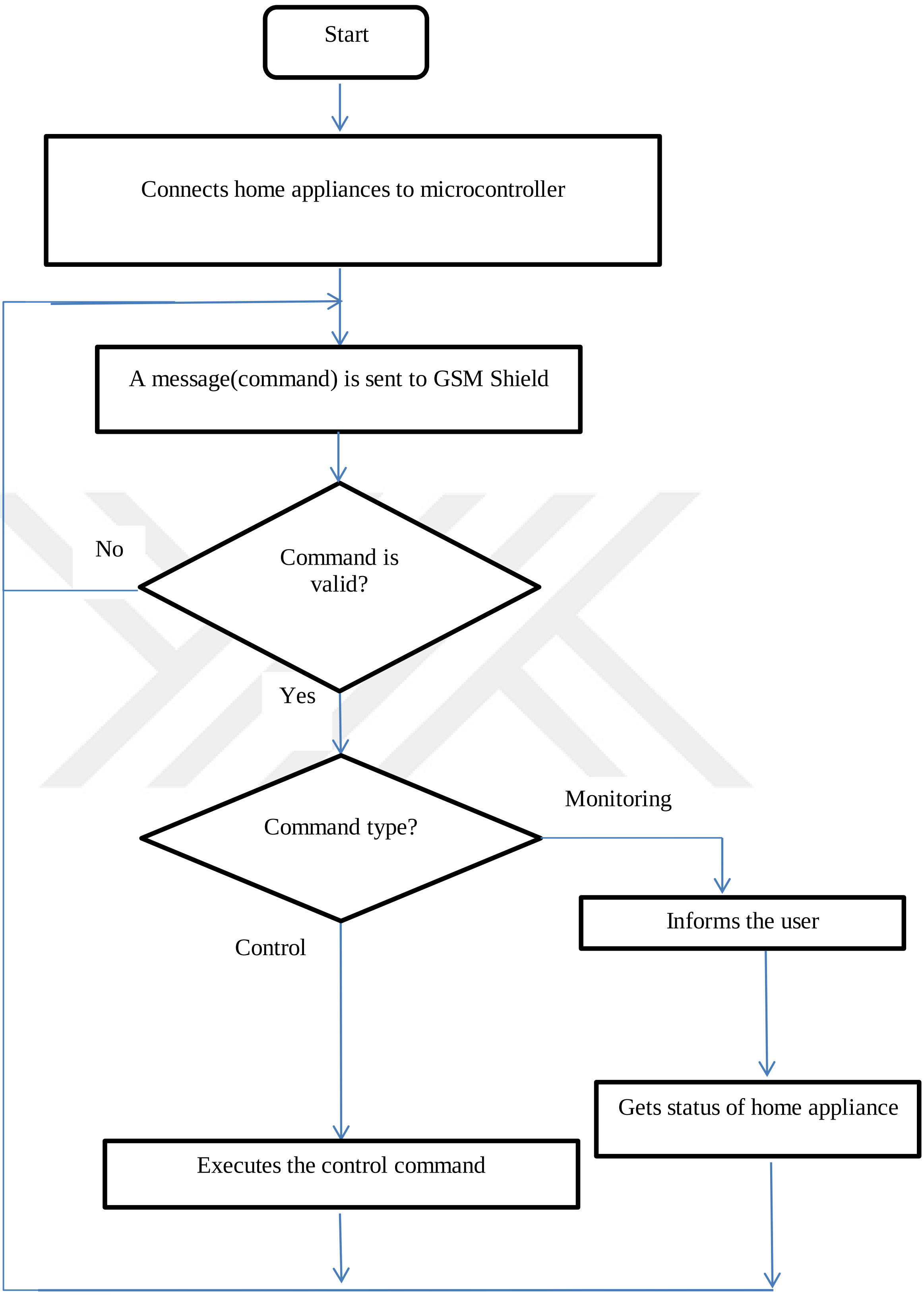


Figure 15. Flowchart of the Home Appliance Control via GSM Shield

Figure 16 shows the block diagram of the proposed system all models.

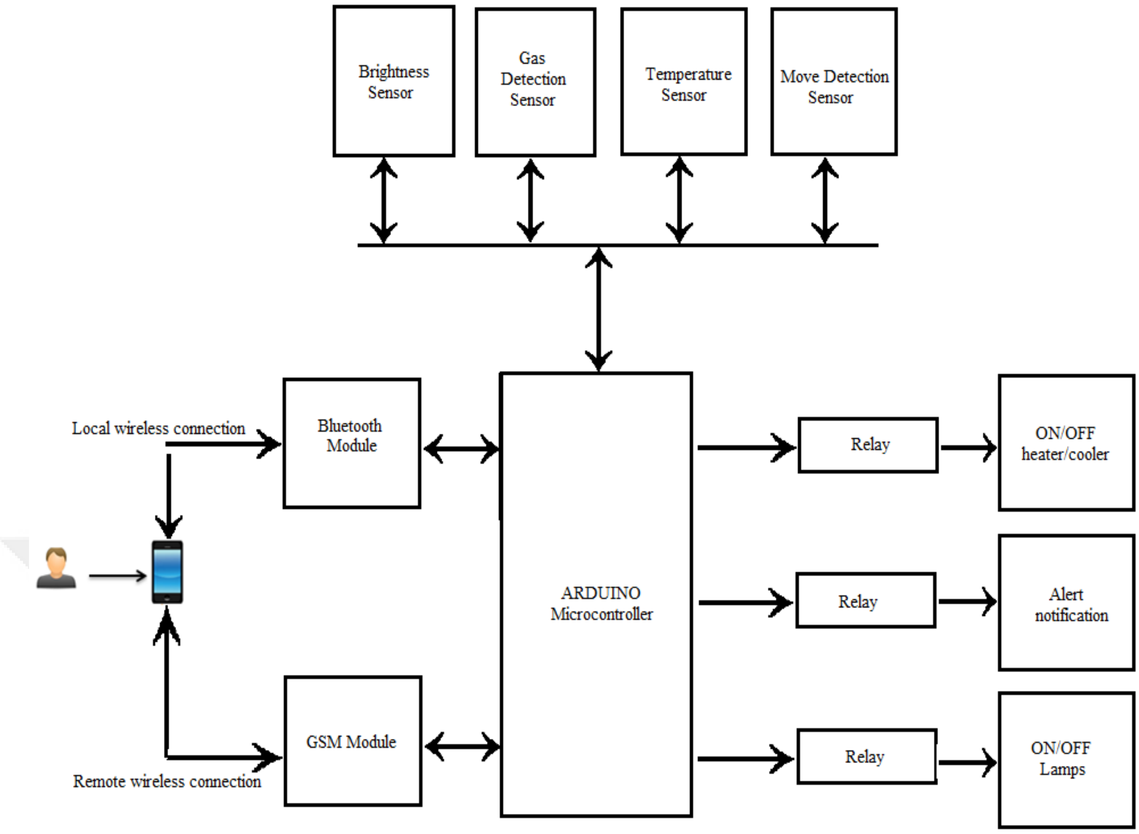


Figure 16. Block diagram of the proposed system

In the proposed system shown in Figure 16, whenever the sensors provide information related to the status of domestic appliances to the microcontroller, it can control the equipment and domestic appliances according to the conditions specified. Also, regarding user requests via Bluetooth or GSM-based communication, the microcontroller can provide this information to the user. In this case, and according to the current conditions, the user can send the necessary commands to microcontroller via Bluetooth or GSM, then after receiving user commands, the Microcontroller executes them and controls the domestic appliances based on the commands received that are sent by user.

To sum up, in this chapter, the smart home system has been proposed and its capabilities described. The proposed smart home system included four models called Security, Safety, domestic appliance control via Bluetooth devices, and via GSM devices. In the next chapter, the process of the practical implementation of the proposed system and its performance are discussed.

CHAPTER 4

PRACTICAL IMPLEMENTATION OF THE PROPOSED SYSTEM

In this chapter, based on the content presented in Chapter III, the proposed system has been designed and implemented in practice. Accordingly, firstly, the requirements and components used in the proposed system are presented, and then details of the implementation of the various models of the proposed system are described.

As mentioned before, a smart home system must be able to provide users with easy accessibility, be easy to use and have low-cost implementation, while providing security and comfort, and be able to exchange remote commands sent by the user to control their devices too.

Therefore, considering the above requirements, the proposed system has been implemented in four distinct models, namely the Security model, Safety model, Home appliance Control using Bluetooth-based model, and Home Appliance Control using GSM-based model.

4.1. Prerequisites and devices used

In this section, all the components and equipment used to implement the four models of the proposed system are described. In this study the Arduino board has been used to implement a smart home automation system. The Arduino device is a microcontroller board, and not a full computer and cannot execute complex tasks. Arduino microcontrollers cannot run using a complete operating system, but simply execute imputed code interpreted by its firmware. Other microcontrollers, such as Raspberry Pi, are a general-purpose computer, which come with their own native operating systems (Linux), and have the ability to perform more complicated tasks compared to the Arduino boards. In general, the main purpose of using the Arduino board is for it to serve as an interface between the written codes and the sensors or devices. On the other hand, the Raspberry Pi is the whole package needed to handle complex or more repetitive tasks, which make it a favorite in the advanced robotics community. As a result, we have selected to use the Arduino Microcontroller, and its details are summarized below.

1. ARDUINO UNO

ARDUINO UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; it can be simply connected to a computer with a USB cable it can be powered with an AC-to-DC adapter or battery to get started. The Uno board is the first in a series of USB ARDUINO boards, and the reference model for the ARDUINO platform [27]. Table 4.1. shows the characteristics of the ARDUINO microcontroller and Figure 17 shows the microcontroller.

Table 4.1. ARDUINO microcontroller specifications

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by boot loader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
LED_BUILTIN	13
Length	68.6 mm
Width	53.4 mm
Weight	25 g

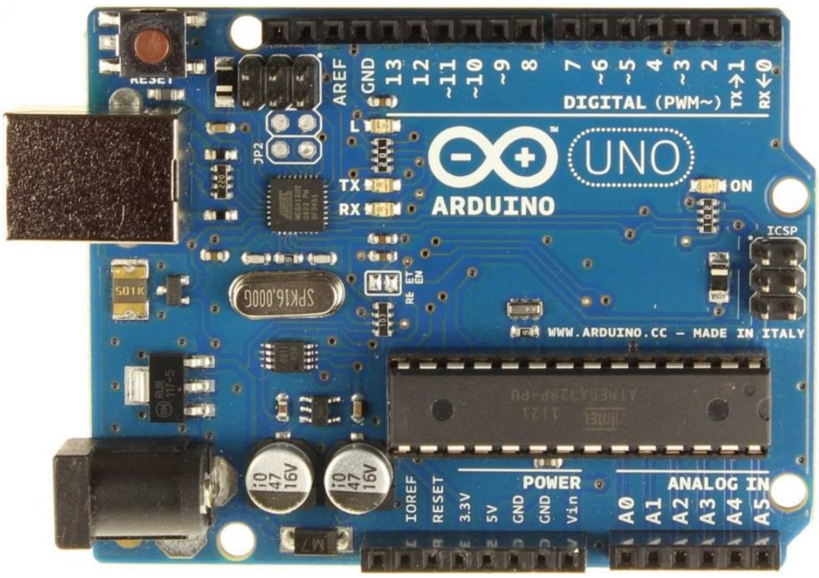


Figure 17. ARDUINO Microcontroller

2. Relay

A relay is an electrically operated switch. It means that it can be turned on or off, letting the current go through or not. Controlling a relay with the Arduino is as simple as controlling an output such as an LED. Relays have 3 possible connections, namely COM: common pin, NO (Normally Open): there is no contact between the common pin and the normally open pin. So, when you trigger the relay, it connects to the COM pin and supply is provided to a load and NC (Normally Closed): there is contact between the common pin and the normally closed pin. There is always a connection between the COM and NC pins, even when the relay is turned off. When you trigger the relay, the circuit is opened and there is no supply provided to a load [28]. Figure 18 shows the schematic of a Relay.

Figure 18. Schematic of a Relay

The connections between the relay module and the Arduino are as follow:

- **GND**: goes to ground
- **IN1**: controls the first relay (it will be connected to an Arduino digital pin)
- **IN2**: controls the second relay (it should be connected to an Arduino digital pin if you are using this second relay. Otherwise, you don’t need to connect it)
- **VCC**: goes to 5V

3. Ultrasonic sensor

Ultrasonic sensors, or sonar sensors, are a form of sensors that use echolocation to sense objects around them. It's the same principle as the echolocation that whales and bats use to find food or objects when they travel. By emitting a certain frequency, and seeing how long it takes to come back, we can determine the location and even the speed of an object [9].

According to the echolocation principle, in this proposed system we use an ultrasonic sensor as a motion detector; when there is a visible change in distance, we will consider it as an indication that an object is passing in front of the sensor. In general, if the sensor is placed near to a door, it will be receiving a constant distance. On the other hand, as soon as someone walks by, the received distance by the sonar sensor will be changed. This means that the system will be able to understand that there is something moving. Figure 19 show the schematic of an ultrasonic sensor.

Figure 19. Schematic of an ultrasonic sensor

4. LDR (Light-Dependent Resistor)

A photo resistor (or light-dependent resistor, LDR, or photo-conductive cell) is a light-controlled variable resistor. The resistance of a photo resistor decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. This resistor works on the principle of photo conductivity and depends on light intensity. A photo resistor is made of a high resistance semiconductor. In the dark, a photo resistor can have a resistance as high as several mega ohms (MΩ); while in the light, a photo resistor can have a resistance as low as a few hundred ohms. Figure 20 shows the schematic of an LDR.

Figure 20. Schematic of an LDR

5. Gas sensor

A gas sensor or gas detector is a device that detects the presence of gases in an area, often as part of a safety system. This type of equipment is used to detect a gas leak or other emissions and can interface with a control system so a process can be automatically shut down. A gas detector can sound an alarm to operators in the area where the leak is occurring, giving them the opportunity to solve the problem quickly or even to leave the place. This type of device is important because there are many gases that can be harmful to organic life, such as humans or animals [10].

Figure 21. Schematic of gas Sensor

6. Temperature sensor

In general, a temperature sensor is a device which is designed specifically to measure the hotness or coldness of an object.LM35 is a precision IC temperature sensor with its output proportional to the temperature (in °C).With LM35, the temperature can be measured more accurately than with a thermistor. It also possesses low self-heating and does not cause more than 0.1 ℃ rise in temperature rise in still air. The operating temperature range is from -55℃ to 150℃. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry easy. Recently, many applications have started to use this sensor, such as power supplies, battery management, appliances, etc. [29].

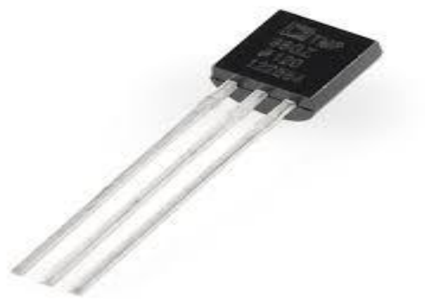


Figure 22. Schematic of a Temperature Sensor

7. Bluetooth Module

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wireless communication. This serial port Bluetooth module is a fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses a CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature) [27].

Figure 23. Schematic of a Bluetooth module

8. Arduino GSM Shield

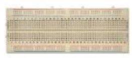
The Arduino GSM Shield allows an Arduino board to connect to the internet, make/receive voice calls and send/receive SMS messages. The shield uses a radio modem M10 by Quectel. It is possible to communicate with the board using AT commands. The GSM library has a large number of methods for communication with the shield. To interface with the mobile phone network, the board requires a SIM card provided by a network operator [28].

Figure 24. Schematic of a GSM module

9. Other devices

In addition to the aforementioned devices and components, Table 4.2. shows the other devices that have been used in the implementation of the proposed system.

Table 4.2. Other devices used in implementing the proposed system.

	Device	**Picture**
General devices	Breadboard	
	Jumper wires	
	Power cable	
	LED	
	Buzzer	
	Arduino uno	
	Relay	

Devices used in security Model	Ultrasonic sensor	
	Mobile device	
Devices used in safety Model	LDR	
	GAS Sensor	
	Temperature sensor	
	LCD	
Devices used in Bluetooth **Model**	Bluetooth module	
Devices used in GSM Shield **Model**	GSM Shield	
	SIM card	

10. App Inventor

In this thesis, App Inventor was used to build an android application. The purpose of the implementation of this app is to communicate between the mobile phone and the Arduino microcontroller via Bluetooth, send the command to the microcontroller and receive environmental information such as the temperature or the amount of gas leakage in the environment. In the internal structure of the app, two modules, namely gas leak detection and temperature control have been implemented.

Overall, App Inventor allows users to develop applications for Android phones using a web browser. In addition, it allows the apps to be tested using either a mobile phone or an emulator. Furthermore, App Inventor's servers can be used to store the apps built and to help in tracking the modifications and updates of the projects. Using App Inventor, users can build their projects and apps by working with:

- The App Inventor Designer, where the interface's components can be selected.
- The App Inventor Blocks Editor, where the behave of the selected components, in the previous step, through blocks will be specified. One can assemble programs visually, fitting pieces together like pieces of a puzzle.

Moreover, the App Inventor platform is supported by Mac OS X, GNU/Linux, and Windows operating systems, and support most of the popular Android phone models. Figure 25 shows the general processes of generating an app using App Inventor.

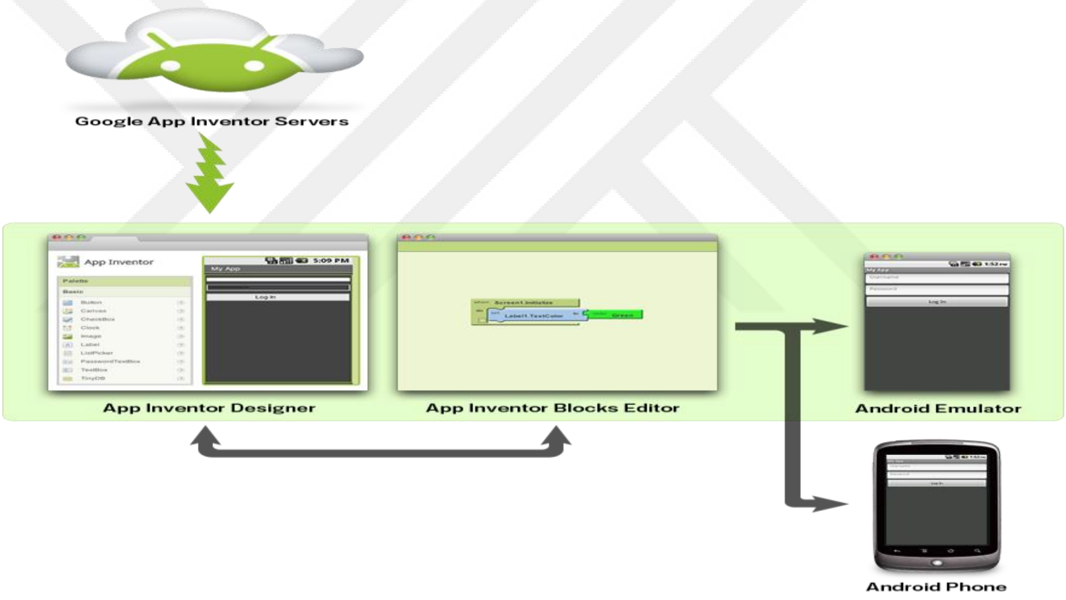


Figure 25. The general processes of generating an app using App Inventor [30].

4.2. The Developed Models

4.2.1. Security model

The security model is responsible to monitor home environment, identify motion and notifies the owner of the home by calling. The necessary components for implementing this model shows in Table 4.2.

In implementing the security section of the proposed system, at the first, ultrasonic sensor collect the data and send them to the microcontroller, after receiving this data, the microcontroller analyses them and if motion detect condition was approved, through the relay and using the mobile phone connected to itself Report the potential robbery to the homeowner. Figure 26 shows the implementation of the security section of the proposed system. Also, the program used to control the block of this section is included in Appendix A.

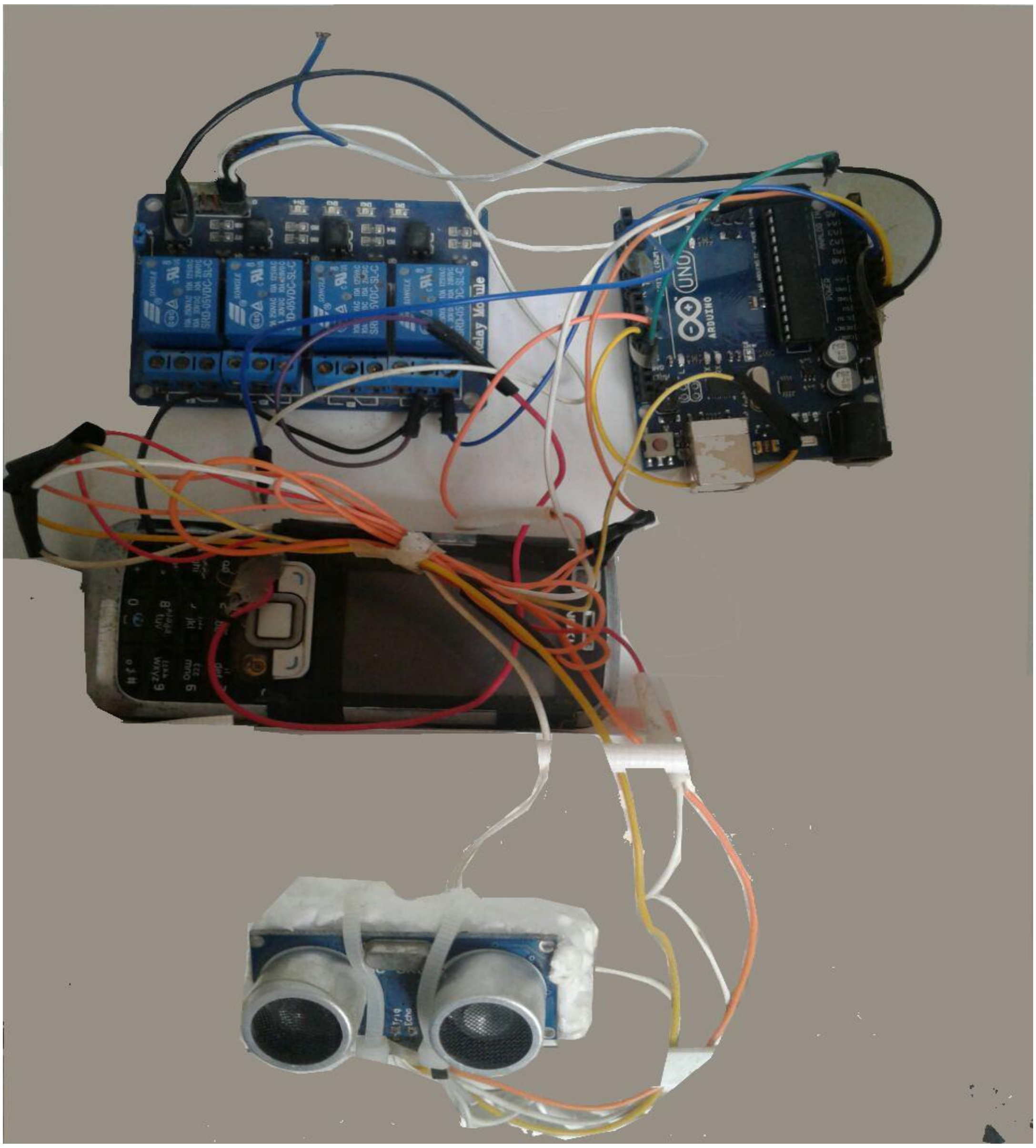


Figure 26. Implementation of security model on proposed system

4.2.2. Safety model

The safety requirement considered in this thesis are 1) setting the home temperature, 2) monitoring and detecting leakage of gas and making timely warning to the residents, and 3) adjusting home lighting based on the environment and various hours of the day and night. To implementation of safety model of the proposed system, various sensors and devices are used and summarized in Table 4.2.

In the implementation of the safety model of the proposed system, three sensors namely light intensity, gas leak and temperature sensors have been used. When the gas sensor detects the gas leaks, it will inform the microcontroller, and then microcontroller will also issue a warning through the buzzer.

The LDR sensor is also aware of the brightness of the home based on the brightness and intensity of the ambient light. When this information is provided to the microcontroller, the light bulbs will be switched off or on based on the predefined scheduling.

In the case of the temperature sensor, it provides the ambient temperature to the microcontroller. Based on this information, the microcontroller can adjust the ambient temperature of the home based on the predefined scheduling. In this manner, the mobile app communicates with the micro-controller using Bluetooth, and the user sets the threshold temperature for the microcontroller. If the ambient temperature is below the threshold temperature, or if the ambient temperature is higher than the threshold temperature, the ambient temperature will be adjusted to the favorable temperature. As shown in Figures 27, the mobile app can be connected to the microcontroller using Bluetooth, and the optimal temperature was set to 23 ° C as an example. Note that the program used to control the block of the safety model is included in Appendix B.

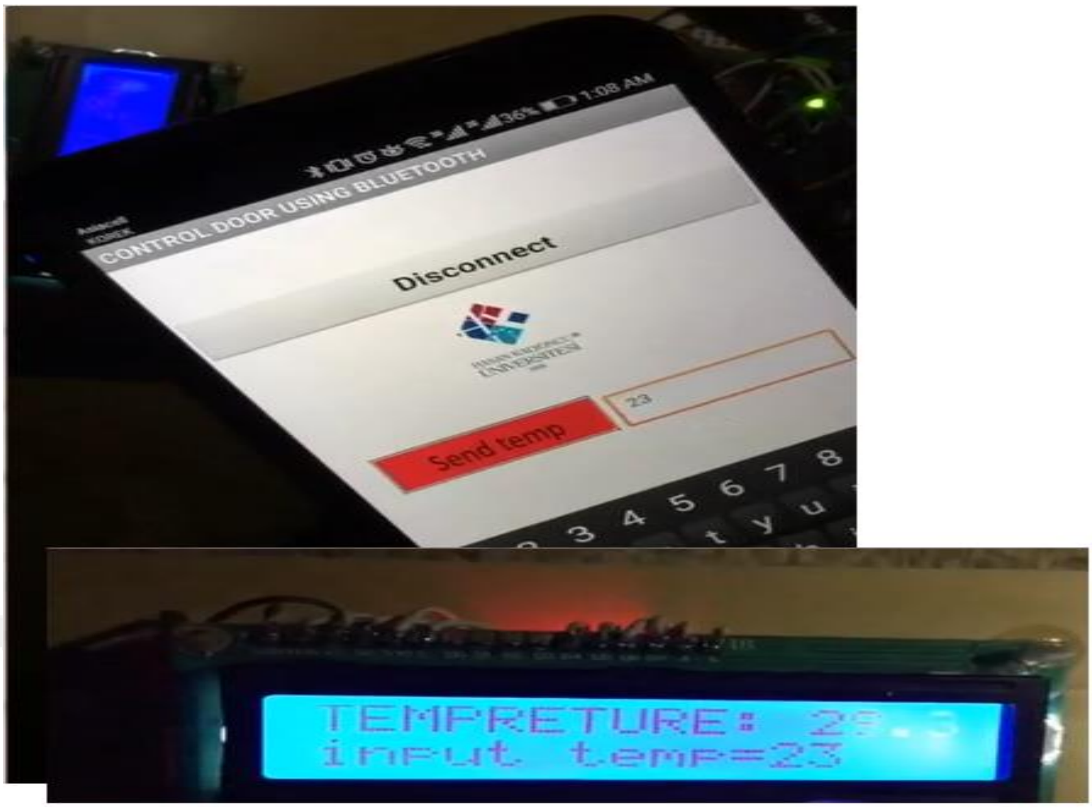


Figure 27. Connect mobile app to the microcontroller and setting the desired temperature.

In addition, related to the Gas Leak Detection module, when a gas leak is detected, the system will inform the homeowner in two ways, i.e., text messaging and phone calls. Figures 28-30 show a demo of the gas detection module.

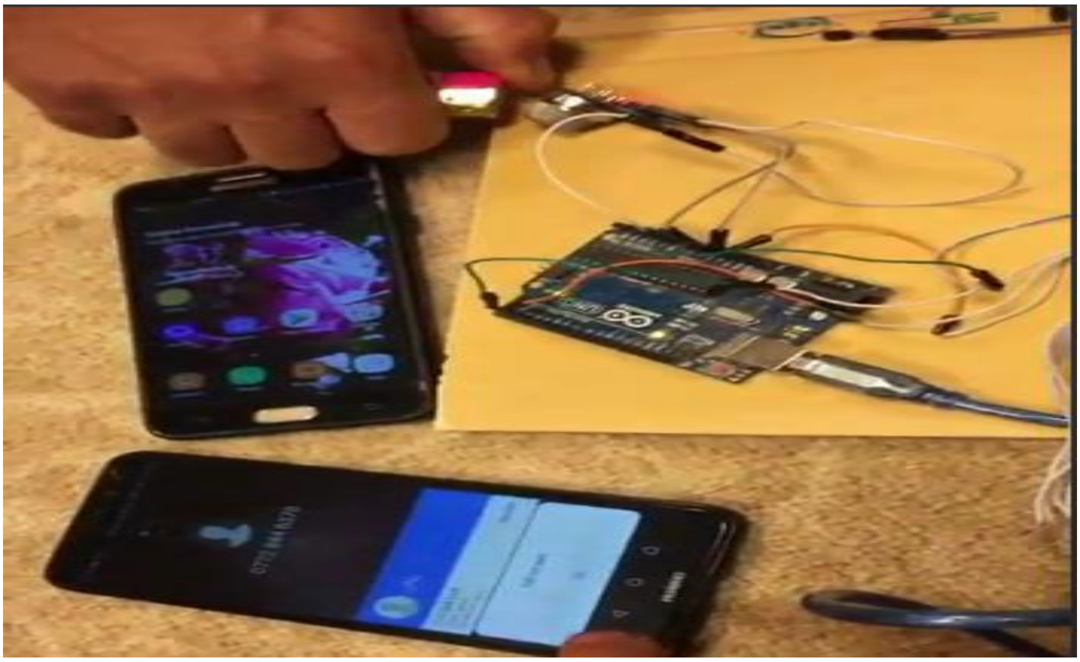


Figure 28. Smart system detects gas leakage

The app then calls the property owner through the mobile phone (Figure 30) and sends a text message (Figure 29).

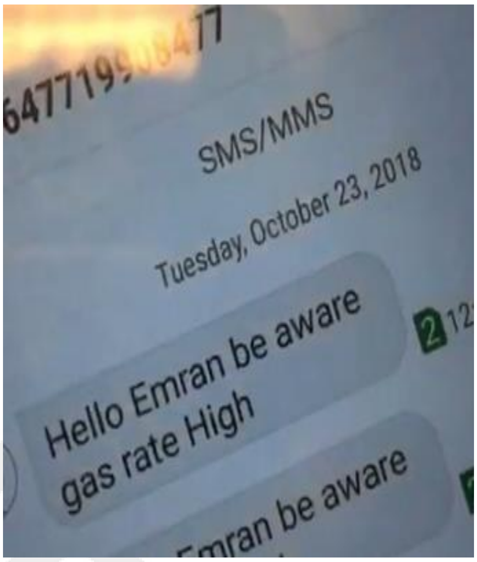


Figure 29. Send text message to the property owner.

Figure 30. Calling the property owner.

4.2.3. Home Appliance Control via Bluetooth

As mentioned in chapter three, one of the main requirements for a smart home system, is to control home appliances through wireless communications. Using Bluetooth technology and devices that support Bluetooth technology, we can respond to these requirements and meet the needs of the above. As shown in Table 4.2., to implement home appliance control via Bluetooth we used various devices. In order to implement this model, the Android-based program has been designed to allow you to connect between the smartphone and the Bluetooth module. When the connection is made, the Bluetooth module receives the necessary commands from user and places it on the microcontroller, and then the microcontroller will execute it according to the program. Figure 31 shows the implementation of this model and the program used to control the block of the Home Appliance Control via Bluetooth model is included in Appendix C.

Figure 31. Implementation of home appliance control via Bluetooth

4.2.4. Remote control of home appliances

As mentioned in previous chapter, due to the short radio range of Bluetooth and the inability to use it over long distances, the proposed system also considered the ability to control home appliances via GSM. The equipment and components used to implement this part of the proposed system are shown in Table 4.2 and Figure 32 shows the implementation of this model. The program used to control the block of the Home Appliance Control via GSM Shield model is included in Appendix D.

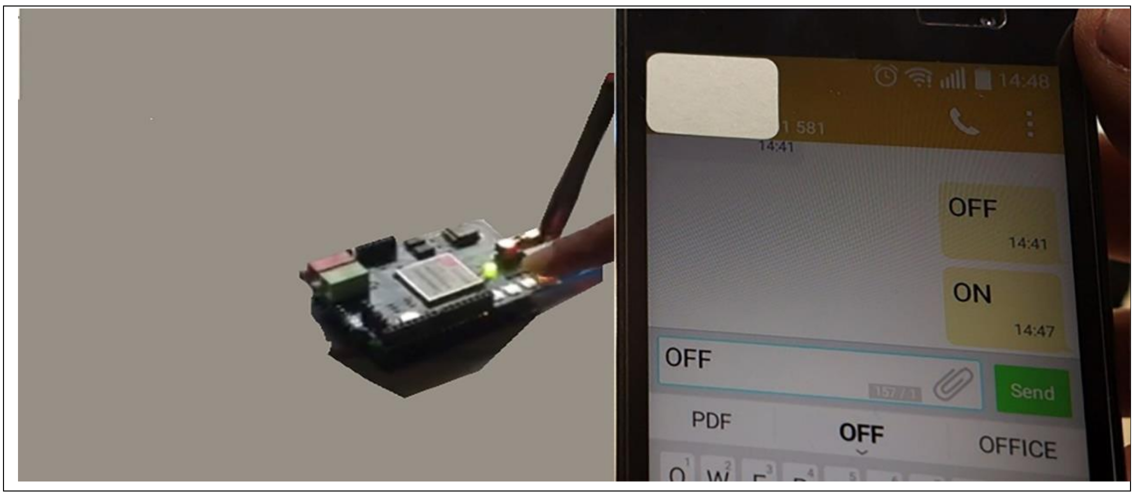


Figure 32. Implementation of home appliance control via GSM Shield

4.3. Comparing the proposed method with recently developed approaches

In this section, in order to demonstrate the capabilities of the proposed method, the capabilities of the proposed method are compared with recently developed approaches. To demonstrate the effectiveness of the proposed method and compare it with other methods, the following performance criteria have been used: availability of security, safety, and communication technologies.

Table 4.3. shows the available features in the developed approach and some recently developed approaches [19-26], and the results of comparing the mentioned approaches can be summarized as follows.

1. Related to safety component, the features can be: 1) control home temperature, 2) gas leak detection, 3) home lighting control, and 4) fire detection and alerting. Among the compared methods, only our approach has fully implements the safety component.

2. Related to Security component, we have implemented a reliable smart security system, which is able to detect abnormal movements efficiently.

3. Available communication technologies, In general, a smart home system should have the ability to use various communication technologies such as Bluetooth, GSM and the Internet. In addition, in underdeveloped and developing countries, the Internet in not available always, however, accessing mobile phones, Bluetooth and text messages is much easier. Hence, in the proposed method, with the priority of ease of use and public access to the smart home system, two Bluetooth and GSM communication technologies are used.

4. Implementation costs: Since all of the methods discussed here have used similar sensors and equipment for the implementation of the smart home system, they all have the same cost in safety and security components.

Table 4.3. Available features in the developed approach and some recently developed approaches

Approach	Smart home component							
	Safety				**Security**	**Communication technology**		
	Temp control	Gas leak detection	Brightness	Flame detection	Motion detection	Bluetooth	GSM	Internet
[19]	Yes	NO	NO	NO	NO	NO	NO	Yes
[20]	Yes	NO	Yes	Yes	Yes	NO	NO	Yes
[21]	Yes	NO	Yes	NO	NO	NO	Yes	NO
[23]	Yes	NO	Yes	Yes	NO	Yes	NO	NO
[24]	Yes	NO	Yes	NO	Yes	NO	Yes	NO

[25]	NO	Yes	Yes	NO	Yes	NO	Yes	NO
[26]	NO	NO	Yes	NO	NO	Yes	Yes	NO
The Proposed approach	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NO

In summary, the proposed system was practically implemented. Our goal was to implement an efficient, reliable and low-cost smart home system that could perform multiple tasks such as security, safety and remote control of home appliances. The results of the implementation and analyzing the proposed system can be an appropriate option to be used in the smart home industry.

CHAPTER 5

CONCLUSION

The smart world starts from the smart home. In recent years, with the advent of electronic component manufacturers and their ability to manufacture small and low-cost components and sensors, and the use of other technologies such as cloud computing, the Internet, the concept of a wireless sensor network (WSN), a new concept which is called Internet of things (IoT) has been developed. These technologies allow us to control various home appliances and remotely sending the relevant commands based on the appliances status.

Due to the fantastic benefits of the smart home system, this technology is expected to become the most commonly used technology in the world in the future. This technology can do things automatically; it can remotely control the devices and implement remote health care system for monitor status of the young and old people who are at home.

In implementing the smart home system, it should pay attention to the cost of its implementation, so that everyone can use it with minimal cost. In addition to cost of management issues , the smart home should be implemented in a way that is easy to use and use technologies that are accessible to everyone.

Considering the above content, issues such as accessibility, ease of use and low cost in implementing the smart home should be taking into consideration. In this thesis we have developed a smart home system that could meet the above requirements and make the smart home available to everyone.

5.1. Conclusion and summary

In summary, the objectives of this study were to examine the various technical aspects of the smart home and implement it with the following four components:

- Providing security, i.e. Monitoring home environment, detecting movement and alerting via cellphone the target user or the homeowner about abnormal movements.
- Creating safe and comfortable home environment include identifying indoor lighting and decide whether to turn on or turn off the lights based on the home lighting level. In addition, this model includes gas leakage detection, which notify in case of gas presence in the home based on the threshold limit.
- Remote control of home appliances via Bluetooth
- Remote control using GSM (Global System for Mobile Communication).

Taking into account the above objectives, In the second chapter of this thesis, the technical aspects of the smart home were examined and related work was evaluated. Then in the third chapter, the smart home system was designed as a general system with four models called Security model, Safety model, Home appliance Control using Bluetooth-based Systems, and Home Appliance Control using GSM-based Systems.

Security Model's main task is to monitor home environment, identify motion and notifies the owner of the home by calling. The safety requirement considered in this thesis are items such as setting the home temperature, monitoring and detecting leakage of gas and making timely warning to the residents, and adjusting home lighting based on the environment and various hours of the day and night. Bluetooth and GSM were also used to control the remote control of the device.

5.2. Challenges and limitation

In the design and implementation of the proposed system presented in this thesis, there were some limitations and challenges, some of which are as follows: Selecting and testing different sensors in order to implement the different parts of the proposed system, programming of the microcontroller and fulfilling requirements such as low cost, availability and easy use were the limitations and challenges that we encountered during this study.

5.3. Future work

Adding Internet usage to a smart home system can be a topic for our future research. In addition, designing and implementing intelligent systems in the form of various box and packages can be the subject of our future research. In this thesis, the main purpose was designing and implementing the smart home system and we don’t consider its commercial aspects. Therefore, research on how packaging and industrialization of this product can be an attractive research topic for future studies.

APPENDIX A

The program used to control the block of the security model

```
int mootion =2; //set pin 2 as the motion sensor on Arduino
int tr1 = 4; //define variable tr as pin 4 on Arduino
int led =13;
void setup() {
  pinMode(mootion, INPUT); // define mootion as Input pin
  pinMode(tr1, OUTPUT);    //tr as output
   pinMode(led, OUTPUT); //led as output
   Serial.begin(9600);
}

void loop()
{
     long sensor = digitalRead(mootion); //read data from sensor
    if(sensor == HIGH){ // if a motion is detected
     Call_homeowner (); // Call the function that will call the selected number
    }

}
void Call_homeowner () {// function to call the homeowner
  Serial.println("umran");
  digitalWrite(led,HIGH);
  delay(1000);
   digitalWrite(tr1,HIGH);
   delay(1000);
   digitalWrite(tr1,LOW);
   delay(1000);
   digitalWrite(tr1,HIGH);
   delay(1000);
   digitalWrite(tr1,LOW);
   delay(1000);
   digitalWrite(tr1,HIGH);
   delay(1000);
   digitalWrite(tr1,LOW);
   delay(1000);
   digitalWrite(tr1,HIGH);
   delay(1000);
   digitalWrite(tr1,LOW);
   digitalWrite(led,LOW); }
```

APPENDIX B

The program used to control the block of the safety model

```
const int smokePin= A1; //set smoke sensor pin on Arduino as pin A1
int smoke_level;
int tempPin =A2; //set temp pin for temperature sensor on Arduino as pin A2
int led = 4; //set led on Arduino to pin 4
int motor1 = 13; //set motor on Arduino to pin 13
int motor2=8;
int sensorPin = A0; // select the input pin for the LDR
int sensorValue = 0;

void setup() { // declare the led Pin as an OUTPUT:
pinMode(led, OUTPUT);
pinMode(motor1, OUTPUT);
pinMode(motor2, OUTPUT);
pinMode(smokePin, INPUT);
pinMode(tempPin, INPUT);
Serial.begin(9600); }

void loop()
{
smoke_level= analogRead(smokePin); //read value from Smoke detector
sensorValue = analogRead(sensorPin);//read value from LDR

int val;   //integer
int dat;  // integer
val = analogRead(tempPin); // read value from temperature sensor
dat = (125*val)>>8; // Temperature calculation formula
delay(10);//delay 0.5s

if(dat > 60 && smoke_level > 400 && sensorValue < 50 )  //if temperature greater
than 60 and smoke detector greater than 400 and LDR less than 50 then led, motor
1 and motor2 will be turn on at same time
{
Serial.println(">60+>400 < 50");
digitalWrite(led,HIGH);
digitalWrite(motor1,HIGH);
digitalWrite(motor2,HIGH);
}
//if temperature less than 60 and smoke detector greater 400 and LDR less than 50
then led is turn Off, motor 1 and motor2 is turn on at same time.
if(dat < 60 && smoke_level > 400 &&  sensorValue < 50)
```

```
{
Serial.println("<60+>400 < 50");
digitalWrite(led,LOW);
digitalWrite(motor1,HIGH);
digitalWrite(motor2,HIGH);
}
if(dat > 60 && smoke_level < 350 &&  sensorValue < 50) ) //if temperature greater
than 60 and smoke detector less 350 and LDR less than 50 then motor 1  is turn off ,
and the with motor2 is turn on at same time.

{
Serial.println(">60+<350 < 50");
digitalWrite(led,HIGH);
digitalWrite(motor1,LOW);
digitalWrite(motor2,HIGH);
}

if(dat < 60 && smoke_level < 350 &&  sensorValue < 50)
{
Serial.println("<60+<350 < 50");
digitalWrite(led,LOW);
digitalWrite(motor1,LOW);
digitalWrite(motor2,HIGH);
}


if(dat > 60 && smoke_level > 400 && sensorValue > 50)
{
Serial.println(">60+>400 >50 ");
digitalWrite(led,HIGH);
digitalWrite(motor1,HIGH);
digitalWrite(motor2,LOW);

delay(20);
}
if(dat < 60 && smoke_level > 400 &&  sensorValue > 50 )
{
Serial.println("<60+>400 >50");
digitalWrite(led,LOW);
digitalWrite(motor1,HIGH);
digitalWrite(motor2,LOW);

delay(20);
}

if(dat > 60 && smoke_level < 350 &&  sensorValue > 50)
{
Serial.println(">60+<350 > 50");
digitalWrite(led,HIGH);
digitalWrite(motor1,LOW);
```

```
digitalWrite(motor2,LOW);

delay(20);
}
//if temperature less than 60 and smoke detector less than 350 and LDR less than 50
then led, motor 1 and motor2 is turn off  at same time.

if(dat < 60 && smoke_level < 350 &&  sensorValue > 50 )
{
Serial.println("<60+<350 > 50");
digitalWrite(led,LOW);
digitalWrite(motor1,LOW);
digitalWrite(motor2,LOW);

delay(20);

}
}
```

APPENDIX C

The program used to control the block of the home appliance control via Bluetooth model

```
int led = 13; // define led's pin
int relayState = 0;
String readString;
void setup()
 {
Serial.begin(9600); //define Serial port for receiving phone data
pinMode(led, OUTPUT);
 }
void loop(){
    while(Serial.available()){
         delay(3);
         char c =Serial.read(); // define a char variable
         readString +=c;  // add the content of char variable to readString value
 }
if (readString.length() >0){ //If readString contain any text then print it
  Serial.println(readString);
    if(readString == "L") //If readString =L then led is ON
   {
    ledon(); //function for led ON

    readString="";
   }
  else if(readString == "l") //if readString=l then led is Off
   {

    ledoff(); //function for led Off
    readString="";
   }
}
}

void ledoff(){ // function for turning Off the led
  digitalWrite(led,LOW);
}
void ledon(){ // function for turning on  the led
  digitalWrite(led,HIGH);
```

APPENDIX D

The program used to control the block of the home appliance control via GSM Shield model

```
#include <GSM.h> //define GSM library

int led=13; // set the SIM PIN Number

#define PINNUMBER "" //set homeowner phone number

// initialize the instances

GSM gsmAccess;

GSM_SMS sms;

// Array to hold the numbers of retrieved SMS

char senderNumber[20];

void setup()

{

  // initialize serial communications and wait for port to open:

  Serial.begin(9600);

  pinMode(led,OUTPUT);

  while (!Serial) {

    ; // wait for serial port to connect. Needed for Leonardo only

  }

  Serial.println("SMS Messages Receiver");

  // connection state

  boolean notConnected = true;

  // Start GSM connection

  while (notConnected)
```

```
{
  if (gsmAccess.begin(PINNUMBER) == GSM_READY)
    notConnected = false;
  else
  {
    Serial.println("Not connected");
    delay(1000);
  }
 }
 Serial.println("GSM initialized");
 Serial.println("Waiting for messages");
}

void loop()
{
 char c;
 if (sms.available())// true whenever an  SMSs is received
 {
   Serial.println("Message received from:");

   // Get remote number
   sms.remoteNumber(senderNumber, 20);
   Serial.println(senderNumber);

   // As nn example of disposal message, is messages starting with # will be
discarded
   if (sms.peek() == 'A')  // when receiving a SMS contains A then Led will be turn
On
```

```
    {
      digitalWrite(led,HIGH);
      Serial.println("Discarded SMS");
      sms.flush();
    }
    if (sms.peek() == 'B') // when receiving a SMS contains B then Led will be turn off
    {
      digitalWrite(led,LOW);
      Serial.println("Discarded SMS");
      sms.flush();
    }
      // Read and print message bytes
    while (c = sms.read())
      Serial.print(c);
    Serial.println("\n END OF MESSAGE");
    // Delete the read message from modem memory
    sms.flush();
    Serial.println("MESSAGE DELETED");
  }
  delay(1000);


}
```

APPENDIX E

```
float sensor=A0; // set the pin of gas sensor on Arduino

float gas_value;

int led=13;

void setup()

{

pinMode(sensor,INPUT); // set gas detector as input pin on Arduino

pinMode(led,OUTPUT); // set led as output pin on Arduino

Serial.begin(9600); // define serial port on Arduino

}

void loop(){

gas_value=analogRead(sensor);   //read value of gas detector

if(gas_value>180 && gas_value<300){   // if gas value greater than 180 and smaller than 300 the led is turn on and an SMS message will be sent to the selected phone number

digitalWrite(led,HIGH);
Serial.print("A");
delay(100);
Serial.print("A");
delay(100);
Serial.print("A");
delay(100);
Serial.print("A");
delay(100);
Serial.print("A");
delay(100);
Serial.print("A");
delay(100);
Serial.print("A");
delay(100);
```

```
Serial.print("A");
delay(100);
}

if(gas_value>300 && gas_value<700){  // if value of gas is greater than 300 and
smaller than 700 then  turn on the  led and the selected number will be called

digitalWrite(led,HIGH);
Serial.print("a");
delay(100);
Serial.print("a");
delay(100);
Serial.print("a");
delay(100);
Serial.print("a");
delay(100);
Serial.print("a");
delay(100);
Serial.print("a");
delay(100);
Serial.print("a");
delay(100);
Serial.print("a");
delay(100);
}

else{

  digitalWrite(led,LOW);

}

}
```

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