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Development of Low Cost Safety Home Automation System using GSM Network

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Abstract

This paper describes home automation system and its individual components and evaluates its performance. With a home automation system, people are able to program many objects to work automatically, which is automation of the home, housework or household activities. The paper presents a microprocessor-based smart home system. This paper demonstrates and explains the design and implementation of a digitally controlled interface between different sensors and an Arduino microprocessor. The proposed system is implementing alarm system based on Global System for Mobile (GSM) communication network to send Short Message Service (SMS) to the owner. The proposed system is aimed at the security of home against theft, Fire, CO and gas. In case of risk the device sends SMS to the emergency number which is provided to the system. The system is made up of basic components: sensors, GSM Module, Arduino, relays to control the device and buzzers to give security alert signals in terms of sound. The objective of this paper is to use Arduino Mega2560 microcontroller to design and build a smart home automation system which provides the user with new features such as door access control, fire alarm system, control home appliance and objects by mobile application. This paper tries to emphasize the point of advantages of new microprocessor technologies which could make many more houses smart with lower cost. By using this system, we can solve the problems faced by home owners in daily life and made their life easy, flexible and comfortable by proposing cost effective and reliable solution.

Keywords: Android Application, Arduino, Fire sensor, GSM, Motion sensor, SMS.

1. Introduction

Safety Home has been a necessary want for everybody because of increased crime every day. Theft, leaking of raw gas and fire, are the biggest risks to homes and cause big damage so it is necessary to solve these problems by designing a device to give a warning in case of any these risks.

An automated home is an integrated system to gather security systems and appliances. This house system is connectable to a smart grid system over a network, which causes energy saving as well as decreasing the cost. Security is an important subject that could be added to a home automation system. Gathering all different security systems such as alarm, the fire alarm, access control (door lock), TVs, etc. makes our life safer. All the security systems mentioned above could be integrated into a home automation system [Azid et al., (2011)].

Energy saving is another benefit of the smart home system. It enables us to save energy and cost with having a smart control of the heating and air conditioning system, lighting system, water sprinkler system, solar system, etc.

A remotely accessible environment is an environment in which each appliance can be remotely accessed and controlled using software as en interface, which include an Android application [Daraghmi, Y. A., & Daadoo, M. (2016), Intelligent].

This paper mainly focuses on providing security when the user is away from home. SMS is a GSM mobile technology that can perform remote communication wherever they are [Khan et al., (2012)]. Mobile phone with SMS facility will be very useful when applied to integrated security systems, where the information send by a security system and the information received by the user mobile phone in the form of SMS. Through this facility messages can send quickly, accurately and at a low cost.

2. GSM Network Overview

The wireless voice services started by the first generation circuit switched analogue service, which was for voice only; this technology did not provide SMS or other data services. Upgrading from first generation to Second digital system Generation (2G); this transition was posted due to several services provided by 2G technologies such as: data storing, coping, encryption and compression, and permits data transmission without loss be supporting error correction.

The Second generation technologies 2G, includes GSM that is based on both Time Division Multiple Access mechanism (TDMA), and Frequency Division Multiple Access mechanism (FDMA), where a spectrum is divided into small slices, as well each slice is divided in time to multiple time slices, where users are allocated in turn to specific spectrum slice, and specific time slice as well.

Moving from 2G to 2.5G technologies, GSM/GPRS (General Packet Radio Services) that is a data-oriented technology extending the GSM voice services where GPRS theoretical can provide up to 200Kbps; which made an introduction to another revolutionary change.

The Third Generation cellular networks (3G) were developed with the aim of offering high speed data and up to 2 Mbps in the served areas or more which allow the operators to offer a multimedia connectivity and other data services to the end customers. A few technologies are able to fulfill the mentioned data rate such as Code Division Multiple Access (CDMA), Universal Mobile Telecommunications System (UMTS) and others. High Speed Packet data Access (HSPA) has been an upgrade to Wideband Code Division Multiple Access (WCDMA) networks used to increase packet data performance. The required downloads and data volume demand has been recently increased per user. The High Speed downlink Packet Access (HSDPA) is developed to provide more data rates and up to 14.4Mbps to meet the users demand. HSDPA using different telecommunication techniques to increase the down-link data flow by developing different modulation and using Multiple-Input and Multiple-Output (MIMO) technology.

Moreover, the upgrading to the Fourth Generation system 4G means that more data demand going to be booming during the coming decades, the fourth generation which called Long Term Evolution (LTE) is developed to meet the rapidly data demand.

The 4th generation still not utilizing major part in the market share due to the lack of devises that can support the LTE Orthogonal Frequency-Division Multiple Access (OFDMA) technique and the existing network infrastructure required **[**Daadoo, M., & Daraghmi, Y., (2015), Searching**]**.

Nowadays, the LTE still supporting the data services only and not the voice, but it is in the process and development to support the voice also, after that, it will be called as "advanced LTE". The LTE can support more than 100 Mbps depends on the network structure and spectrum used [Tarapiah et al., (2016)].

This paper mainly focuses on providing security when the user is away from home. SMS is a GSM mobile technology that can perform remote communication wherever they are. The aim of paper is to use Arduino Mega2560 microcontroller to design and build a smart home automation system which provide home security device, that give us send fast information to user GSM mobile device using SMS and also activate - deactivate system by SMS. The design of this home security system makes expandable their capability by add more sensors on that system.

3. Proposed System

A proposed system model of smart home is prepared using low cost materials like acrylic, plywood etc., having sufficient strength as shown in Figure 1 and Figure 2 to test the prototype of developed system. It system contains sensors to detect motion, flame, temperature, CO and gas. The sensor collects information and the system is controlled by the mega Arduino, the controller decides the danger and sends SMS to the owner using a GSM module, according to the sensors information. And another SMS is sent to the police if there is a stealing danger, to the fire bridge if there is a fire danger.

Figure 1: Model of Safety Home from Outside

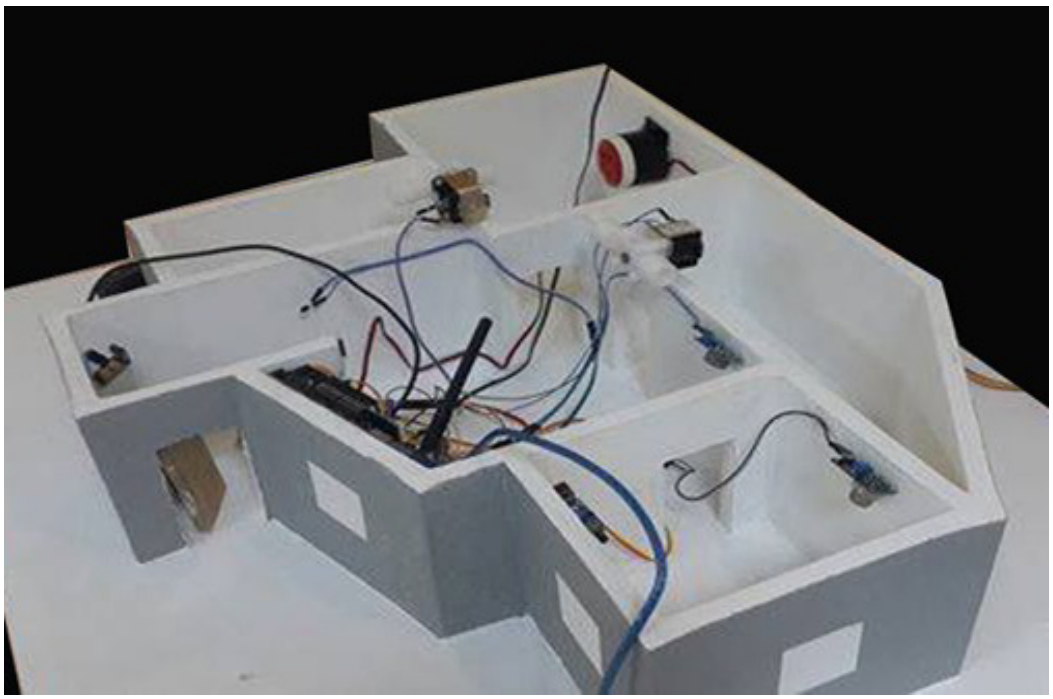
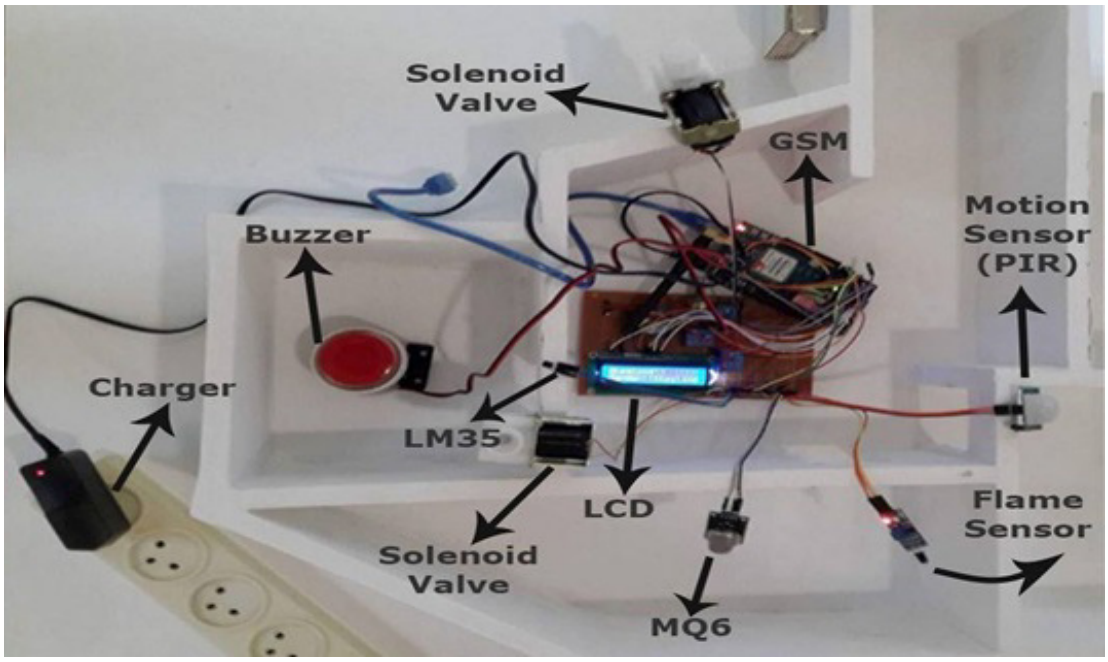


Figure 2: Model of Safety Home from Inside



The proposed system is controlled by an Arduino MEGA2560 microcontroller. It collects all information from the sensors, process that information makes a decision and sends SMS to a corresponding GSM mobile phone number by using a GSM modem.

4. Hardware Design

Hardware of the system contains sensors, Arduino MEGA2560 microcontroller, SIMCOM SIM 900 (GSM module), Buzzer, as shown in Figure 3 the outputs of all the sensors are connected to data processing unit which controlled by an Arduino MEGA2560 microcontroller. One Passive Infrared Sensor (PIR) is connected at window and other is at door.

Figure 3: Functional Block Diagram of the Safety Home System

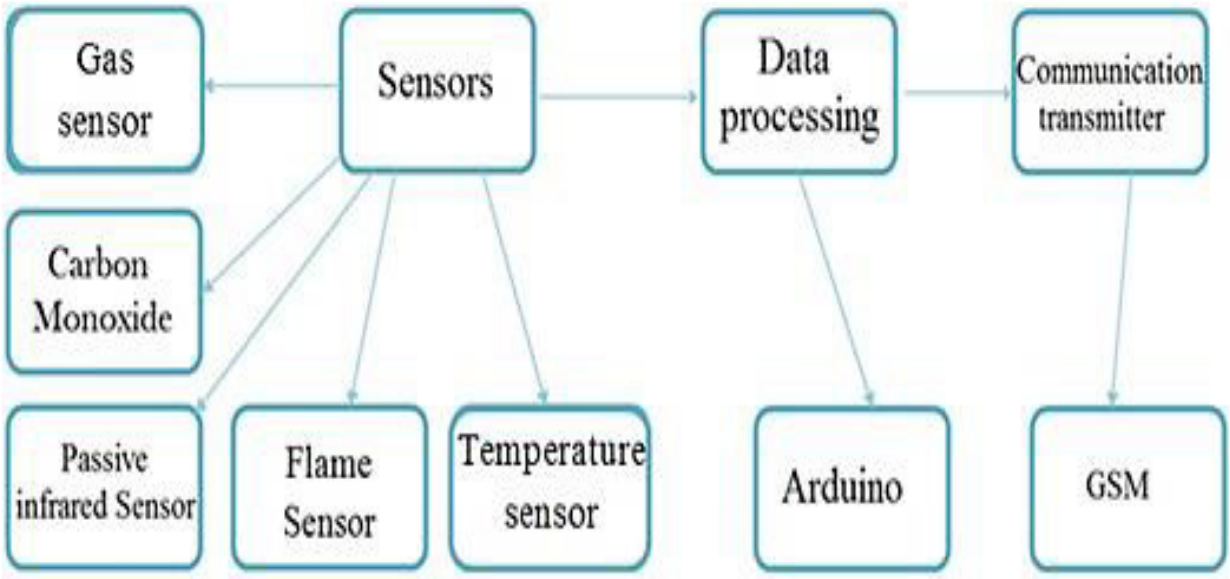
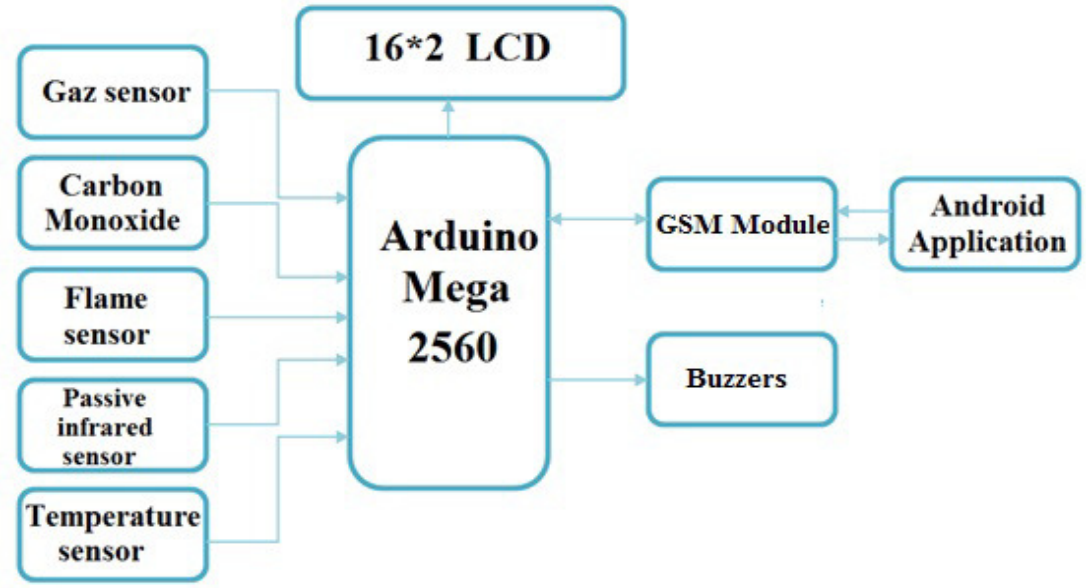


Figure 4: Block Diagram



The entry from the window is treated as unauthorized entry and entry from door is treated as authorized entry. If there is authorized entry inside the home, lights will be turn ON after checking the light intensity in a room and for unauthorized entry buzzer will be turned ON then the Arduino controller activate Buzzer alarm and send a SMS to the home owner mobile phone using the GSM Module as shown in Figure 4. Temperature is continuously monitored, if it is high greater than 45 degree in case of fire, a SMS is sent "There is a Flame" to the home owner. If gas sensor is ON indicating the gas leakage then SMS will be send to the owner "There is a Gas Danger". If CO sensor is ON indicating the Carbon Monoxide in home then SMS will be send to the owner "There is a CO".

Based on the design requirements and specifications[Daadoo, M., & Daraghmi, Y., (2016), Design]., the system block diagram shown in Figure 3 is developed. This block diagram defines all the function to be performed by the system. A modular approach to project design was taken. The system is designed based on an Adriano Mega2560 microcontroller which based on ATmega2560 microprocessor. The basic concepts of circuits that are used in the system design are explained.

4.1 Arduino MEGA2560 Microcontroller

This paper is using an Arduino MEGA2560 (Figure 5), which is based on an ATmega2560 microprocessor. An Arduino MEGA2560 Microcontroller has been designed based on an ATmega2560 microprocessor that runs at the speed of 16MHz. As Table 1 shows, it contains 54 digital input/output pins, 15 of them could be used as PWM (Pulse Width Modulation is a method for getting analog results with digital means) outputs. Furthermore, it contains 16 analog inputs and 4 hardware serial ports.

Figure 5: ArduinoMega2560

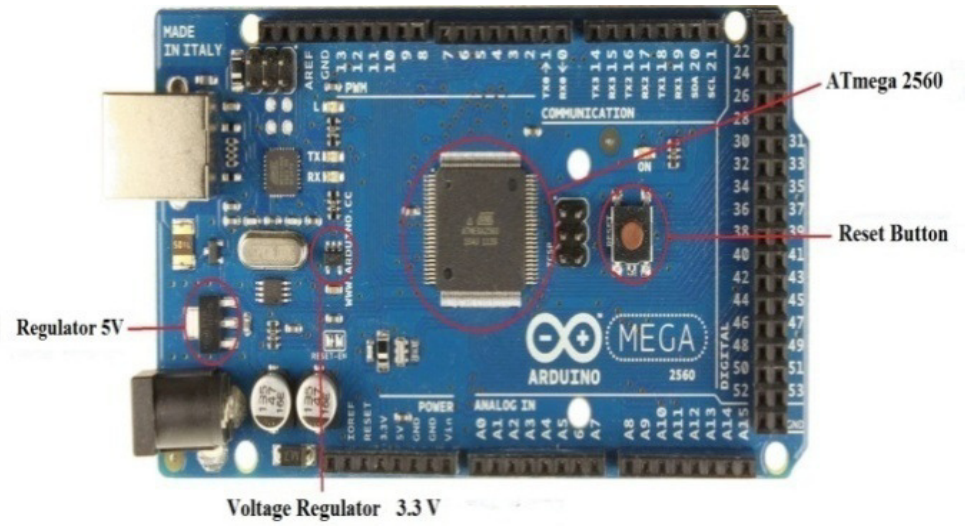


Table 1: Specifications of Arduino MEGA2560 Microprocessor.

• **Specifications**	• **Arduino MEGA2560**
• Processor	• ATmega2560
• Flash Memory	• 256 KB
• Data Memory	• 8 KB
• EEPROM	• 4 KB
• Digital I/O Pins	• 54
• PWM outputs	• 15
• Analog outputs	• 16
• Clock Speed	• 16 MHz
• Serial Ports	• 4

4.2 GSM Module Unit

The GSM modem unit is built using SIMCOM SIM900 modem that specialized for arduino controller and support GPS technology as shown in Figure 6. This unit can send SMS to user mobile phone and also can receive SMS from user.

Figure 6: SIM 900 for Arduino Controller

The working of GSM modem is based on commands, the commands always start with AT (which means ATtention) and finish with a <CR> character. The AT commands are given to the GSM modem with the help of PC or controller. The GSM modem is serially interfaced with the controller with the help of MAX232. Here MAX232 acts as driver which converts TTL levels to the RS-232 levels. For serial interface GSM modem requires the signal based on RS-232 levels. The T1_OUT and R1_IN pin of MAX232 is connected to the TX and RX pin of GSM modem.

The AT commands for GSM-GPRS support is as follows in Table 2:

Table 2: AT Commands for GSM-GPRS.

• +CMTI: SMS has been received • +CREG: Network registration indication • +CMGS: To send the message • +CMSS: To Send Message from Storage • +CMGW: command writes an SMS to the first location available • +CPMS: command allows the message storage area to be selected (for reading, writing, etc.) • +CMGR: Read Message • +CCLK: Clock Management • +CUSD: Unstructured Supplementary Service Data

4.3 Gas Sensor

This sensor module utilizes an MQ-6 (Figure 7) as the sensitive component and has a protection resistor and an adjustable resistor on board. The resistance of the sensitive component changes as the concentration of the target gas changes. They are used in gas leakage detecting equipment in family and industry, are suitable for detecting of LPG, iso-butane, propane, LNG, avoid the noise of alcohol and cooking fumes and cigarette smoke.

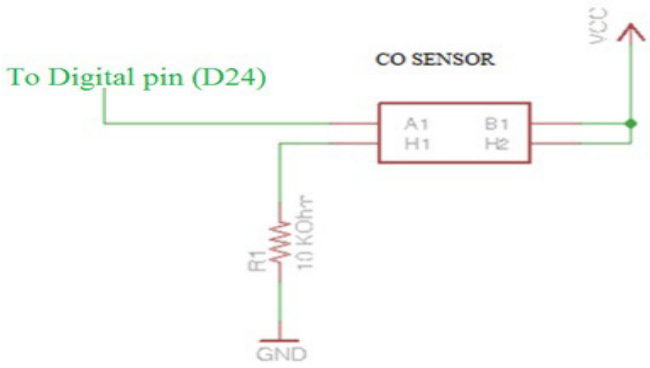
Figure 7: MQ-6 Gas Sensor

4.4 CO Sensor

The CO Gas Sensor is used in gas detection equipment for detecting Carbon Monoxide in home, automotive or industrial settings. MQ-7 gas sensor has high sensitivity to Carbon Monoxide. The sensor could be used to detect different gases contains CO.

A simple circuit as shown in Figure 8 is used to map the changes in conductivity to the corresponding output signal of the gas concentration. The main advantage of the MQ-7 gas sensor is that it has high sensitivity to Carbon Monoxide. Additionally, it has a very long life time and is available at a low cost. Also it can be used for a wide range of applications.

Figure 8: Measuring Circuit for CO Sensor



4.5 PIR Sensor

This Passive Infrared sensor has a potentiometer to calibrate distance and delay time. Sensor unit is easy to use, affordable price as shown in Figure 9. This sensor requires 100_{uA} - 150_{uA} and voltage conditions 3_{Volt} – 5_{Volt} to operate, has accuracy from 0.1 to 6 meters with the ability to work at a temperature of -200C to 700C. Other than that, this sensor module also has a working wave length 7_{um} - 14_{um} and angle of coverage in 1200.

Figure 9: Passive Infrared Sensor

4.6 LM35 Temperature Sensor

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the Celsius (Centigrade) temperature .Temperature is directly measured by the PK7 pin of Arduino MEGA2560.

4.7 Flame Sensor

This module is sensitive to the flame and radiation. It also can detect ordinary light source in the range of a wavelength 760_{nm}-1100_{nm}. The detection distance is up to 100_{cm}. The Flame sensor can output digital or analog signal.

4.8 Solenoid Valve

A solenoid in figure 10 is a simple electromagnetic device that converts electrical energy directly into linear mechanical motion, but it has a very short stroke (length of movement), which limits its applications.

Figure 10: Solenoid Valve Device

4.9 Relay 5v

As Figure 11 relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts.

Figure 11: Physical Representation of Relay 5V

4.10 Police Siren Alarm

This unit will be able to control the buzzer sounds as Figure 12. It used in combination with the Arduino board sensors, to achieve the control of an interactive.

Figure 12: Police Siren Alarm

4.11 RTC (Real Time Clock)

Is a computer clock as shows in Figure 13 (most often in the form of an integrated circuit) that keeps track of the current time, although the term often refers to the devices in personal computers, servers and embedded systems, RTCs are present in almost any electronic device which needs to keep accurate time.

Figure 13: Physical Representation of RTC

5. Software Design

In this system arduino software from arduino developer is used to develop program for arduino controller.

5.1 Arduino

Arduino IDE is an integrated development environment (IDE) used in computer programming. It contains a base workspace and an extensible plug-in system for customizing the environment. Arduino IDE is written mostly in Java, but it may also be used to develop applications in other programming languages through the use of plug-in, including: Ada, ABAP, C, C++, etc., the environment is written in C++ and based on Processing and other open-source software. This software can be used with any Android board.

5.2 Android Application

An android application is a software application that runs on the android platform. An android application is designed for a Smartphone or a tablet running on the android OS [Daraghmi, Y. & Daadoo, M., 2016, Intelligent Smartphone] . Android application are written in Java programming language and use Java core libraries. Users can extend its abilities by installing plug-ins written for the Eclipse Platform, such as development toolkits for other programming languages, and can write and contribute their own plug-in modules.

5.3 Flow Chart

Figure 14 and Figure 15 shows the flow chart of the Arduino and Android, which also show process of how to turn on or turn off the home security system by sending SMS from user mobile phone. After the home security system on, the system will check the area capture by PIR sensor, if there are obstacles detected system will send notification via SMS to user mobile phone, and also can turn on buzzer alarm.

6. Results and Analysis

The proposed systems are tested on the model of smart home which is shown in Figure 1. As shows in Figure 14 and Figure 15 the system contains sensors, Arduino MEGA2560 microcontroller, SIMCOM SIM 900 (GSM module), Buzzer. One Passive Infrared Sensor (PIR) is connected at window and other is at door. The entry from the window is treated as unauthorized entry and entry from door is treated as authorized entry. If there is an authorized entry inside the home, lights will be turn ON after checking the light intensity in a room and for unauthorized entry buzzer will be turned ON then the Arduino controller activate Buzzer alarm and send a SMS to the home owner mobile phone using the GSM Module as shown in Figure 16. Temperature is continuously monitored, if it is high greater than 45 degree in case of fire, a SMS is sent "There is a Flame" to the home owner as shown in Figure 17. If gas sensor is ON indicating the gas leakage then SMS will be send to the owner "There is a Gas" as shown in Figure 18. If CO sensor is ON indicating the Carbon Monoxide in home then SMS will be send to the owner "There is a CO" as shown in Figure 19.

Figure 14: Flow Chart of the Arduino

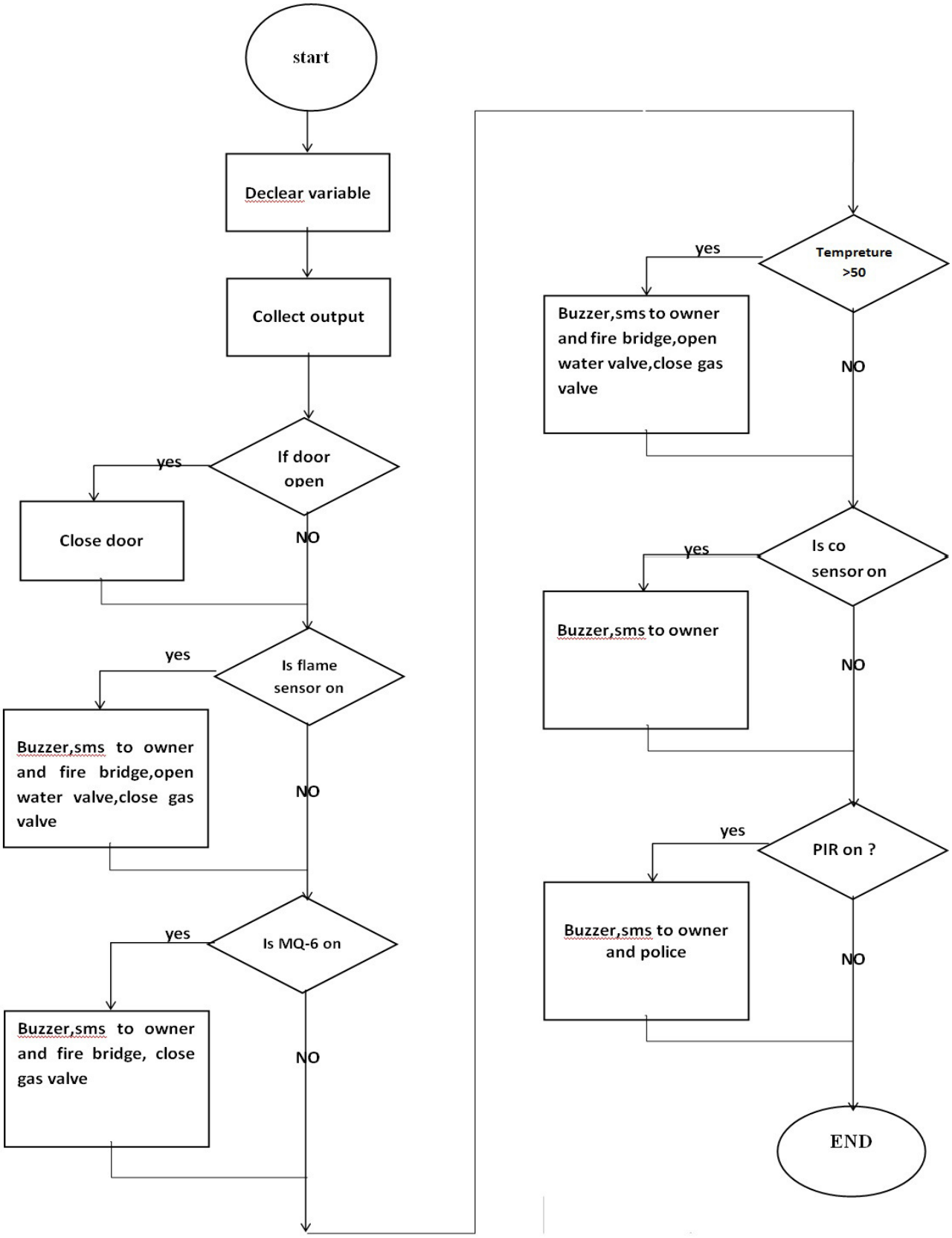


Figure 15: Flow Chart of the Android

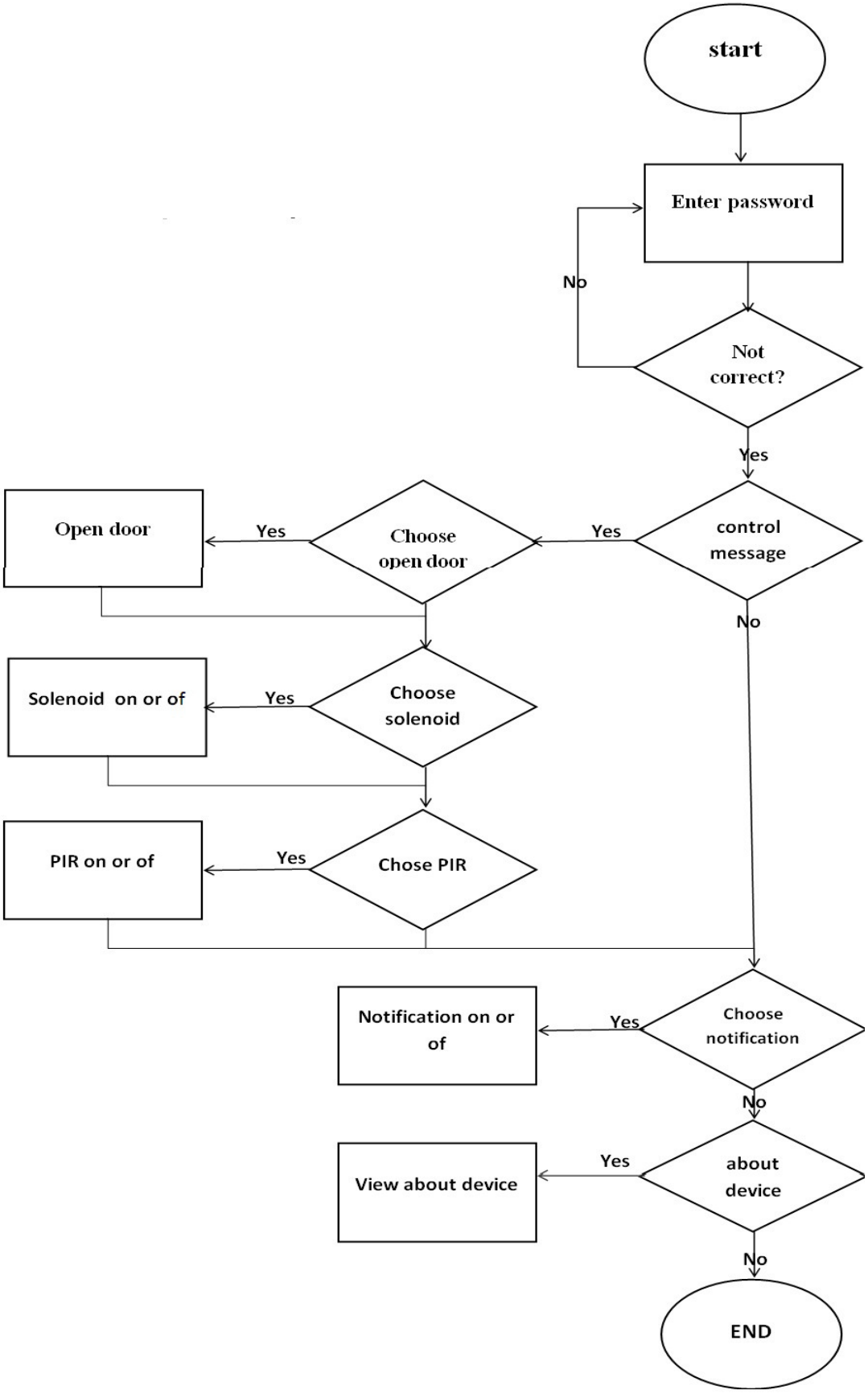


Figure 16: Result when Stealing

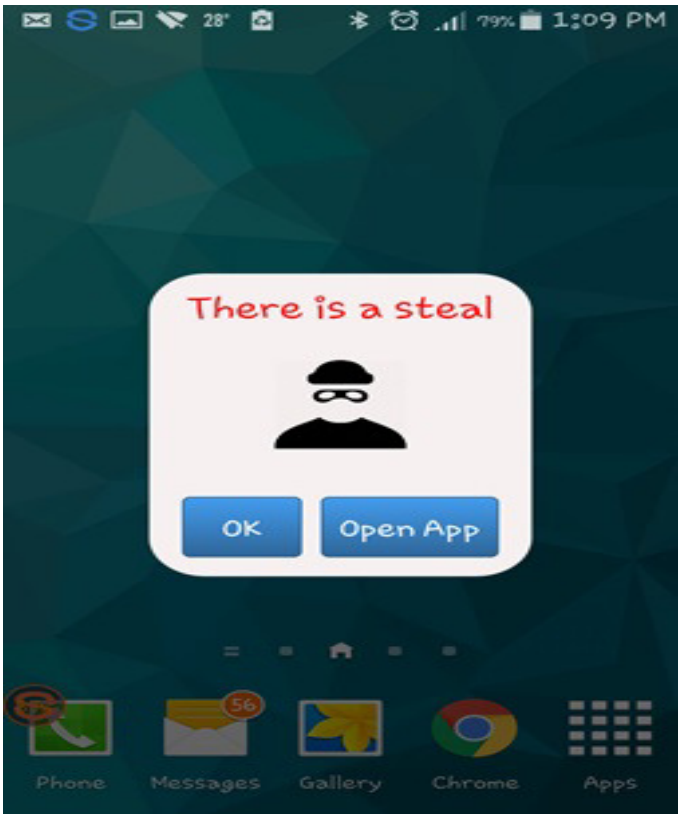


Figure 17: Result when Flame Happen

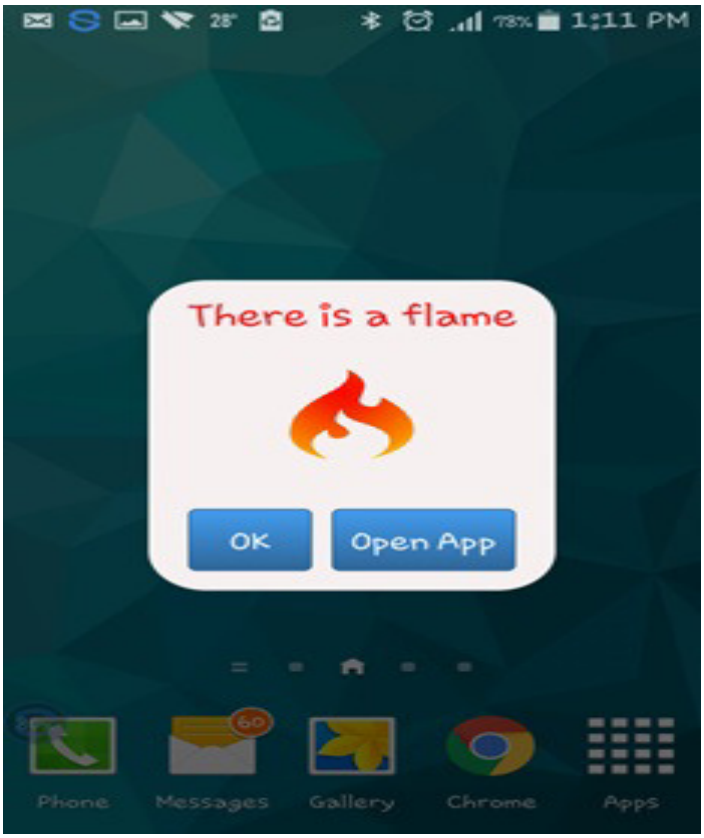


Figure 18: Result when Gas Leaking

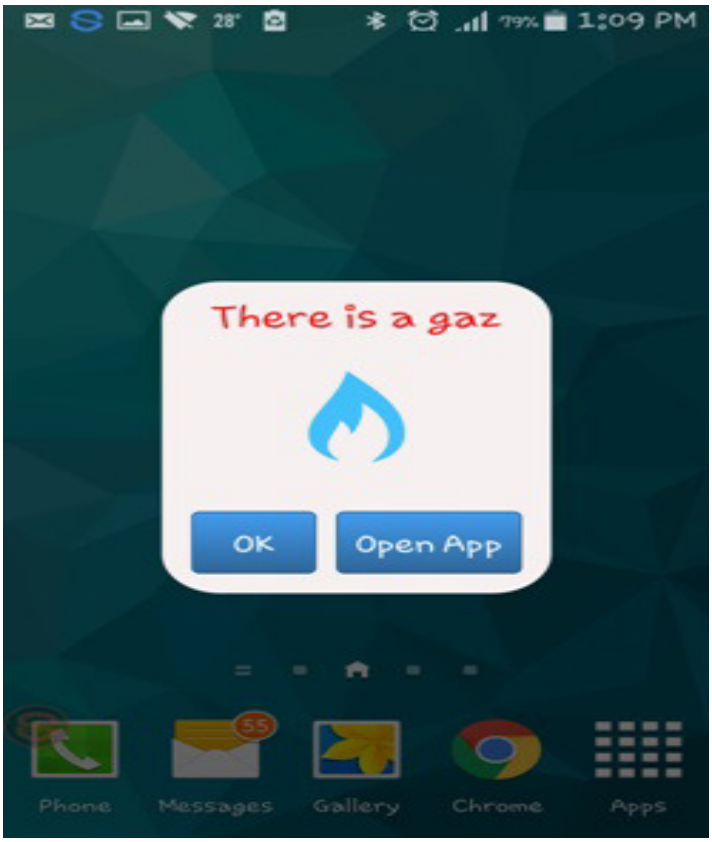
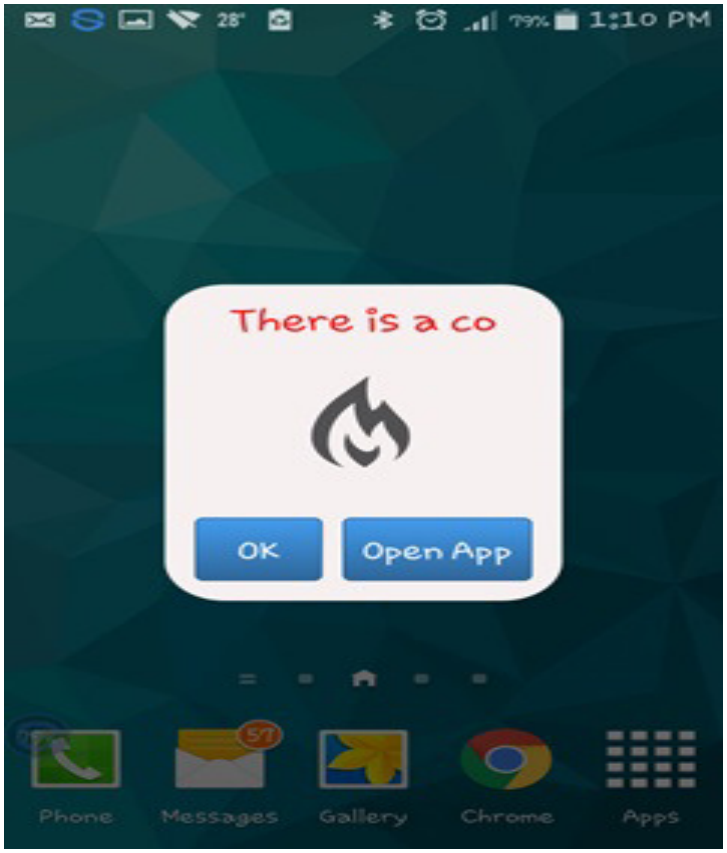


Figure 19: Result when CO Leaking



7. Directions for Future Research

The developments of GSM based security system have been done. In its development, the cost incurred is very competitive and relatively cheap compared with the systems available on the market. Several tests must be conducted to adjust the appropriate parameter such as time delay or the time which taken by the system to deliver the SMS for the optimal work. In our future works, we will continue to enhance different aspect of the GSM based security system. The system is developed for educational purpose and is currently in use at Microprocessor Control Lab at An-Najah National University.

8. Conclusion

This safety house feature is expected to draw much attention in the next decades. People getting more concerned to protect their house from unauthorized people. This system can monitor a house by use of sensors that integrated with a microcontroller and a GSM unit. SMS use to alert users via mobile phone. This system is design using modularity to become a flexible system that can be add more sensors without change the whole system, only add some sensors to increase systems functionality. This paper has successfully presented a functional, low cost and low complexity microcontroller based GSM security system. We solved in this system the problems faced by home owner in daily life and made his life easy, flexible and comfortable by proposing cost effective and reliable solution.

Acknowledgment

The authors would like to thank Palestine Technical University – Kadoorie (PTUK) and An-Najah National University for supporting this research and allowing us to conduct this work in the university labs. The system is developed for educational purpose and is currently in use at Microprocessor Control Lab at An-Najah National University.

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