Vol 1 No 2 (2019) *e*-ISSN: 2682-8383

Journal of Engineering Technology and Applied Physics

Development of A Prototype of An IoT Based Smart Home with Security System Flutter Mobile

Nur Asyiqin Bt. Amir Hamzah[1,*], Muhammad Radzi B. Abu Saad[2], Wan Zakiah Bt. Wan Ismail[3], Thangavel Bhunaeswari[4] and Noor Ziela Bt. Abd Rahman[5]

[1, 2, 4, 5]*Faculty of Engineering and Technology, Multimedia University, Jalan Ayer Keroh Lama, 75450 Melaka, Malaysia.*

[3]*Faculty of Engineering and Built Environment, Universiti Sains Islam Malaysia, Bandar Baru Nilai, 71800 Nilai, Negeri Sembilan, Malaysia.*

*asyiqin.hamzah@mmu.edu.my

https://doi.org/10.33093/jetap.2019.1.2.7

Abstract **– This paper describes the development process of an IoT based Smart Home Security system prototype. The development of the prototype includes research on IoT based security systems and smart home systems. The aim of the study is to demonstrate an IoT smart home system that can benefit the user and at the same time, create a safe environment for the society. The system designed is an IoT based smart home system security equipped with a series of sensors which consist of temperature, light, flood and motion all controlled by an Arduino UNO which acts as a device manager then connected to a Raspberry PI microcomputer. The Raspberry PI acts as the command centre and connects the system to the Internet. The reason why the system uses both Raspberry-PI and Arduino is for simplicity, efficiency and cost-effectiveness. The development successfully shows that it is possible to enhance the daily lives by efficiently reducing human contact and increasing security for a home which lead to reduced crime rates. Besides that, the utilization of an open source Flutter mobile application platform is proven to be as good as other paid platforms.**

Keywords* — *Arduino, Raspberry Pie, Flutter-mobile framework, IoT, smart-home

I. Introduction

Internet of Things (IoT) is a network of objects or devices that are interconnected which can be managed by the user via the Internet. This means that the user is able to access without having to be physically near to the objects/devices. With this attribute, IoT offers to improve convenience, comfort, efficiency and security. As far as the Internet is concerned, IoT becomes quite handy since the fact that nowadays almost everyone is connected to the Internet through their computer, smartphone, smartwatch, tablet or other smart-electronic-devices. And this makes the development of IoT growing so fast and rapid. IoT is applied to a wide range of fields and areas i.e. industrial, retail, surveillance, agricultural, healthcare, poultry, farming etc.

A smart home is one of the areas that IoT is currently applied to. In this paper, the development of an IoT based device is focused to ensure the safety and security for home, hence the name of “IoT based smart home security system”. It is able to enhance the security and comfortability of a home without much human involvement and energy usage which comes hand in hand with savings of energy and costs. Since smartphones are reported to have been used by almost 2.71 billion people around the world [1] therefore, it will be deployed in our study as a device controller/manager. The attempt to connect the system with a smartphone will definitely promote flexibility and convenience.

Smart home security is a combination of home-devices and -appliances that can be controlled conveniently through a single controller or a series of sensors that will process the condition and safety in the home and thus acting upon it. This technology was first developed for monitoring of the environment. The smart home security also requires sophisticated control in its different gadgets and appliances. With the advancement of the smartphones and tablets which now includes multiple ways to connect through a system or other appliances such as Bluetooth, Wi-Fi and NFC (Near-field communication) it gives an exposure to a wide variety of control and interact to the smart home system depending on the type of connection it uses [2].

The IoT is basically a huge network of connected devices that can minimize human effort and involvement to control appliances and equipment. It is all controlled by pre-programming on the appliances and equipment to function based on a specific set of calibrations of a stimulant. For example, a fan is pre-programmed to turn on or off when the temperature sensor detects a change in the temperature whether it is hot or cold. All these devices and appliances are linked together to enable control by a single controller which is also connected to the Internet.

One of the most important factors to consider when it comes to a smart home system is the security of the home. In the past, home security is mainly an alarm system that will trigger when there is an intruder that enters the premises. However, with the development of IoT, it is now possible to make the system better in efficiency by enabling the user to detect any intrusion by the use of multiple sensors attached to the home, for example, the PIR sensor, heat sensor, IR sensor and many more [3]. Users will be able to detect if the premise is at risk of fire with the help of a fire detector or flame sensor. This would help early detection and consequently prevent the loss of lives, injuries and damages to the premise [4]. The user will be able to be notified directly through the smartphone when there is an intrusion. Not only that, the user will also be able to switch on or off the alarm by a single touch on their smartphones.

The development of IoT based smart home system security enhances the quality of living and security of a home [5]. As we are progressing towards the future this kind of enhancements will make our daily lives more comfortable and safer due to the security and the level of reliability it provides. Based on the study, a home that is equipped with an IoT based smart home system saves more electricity than a regular home where the owner will need to control everything by switches manually. Homes that are equipped with a security system also are less likely to be broken into because of the alarm system. By combining both the smart and security features to an IoT platform, it would result into a very efficient and safe environment for a home and which is conveniently controlled by user's fingertip.

In this proposed system, users are given real-time updates on the well-being of their premises while they are not around and thus allowing the user to take desired actions on the situation, for example, to alert the authority if there is any break-in event.

II. LITERATURE REVIEW

There are many smart home security systems in the market that supplies to the demand of customers but most of them are considerably complicated and quite hard to manage. The home security system has evolved from the simplest security to a very complex system and even uses artificial intelligence in these days [6].

In 2015, Pavithra *et al.* implemented IoT for monitoring and controlling the appliances in a home via the Internet [7]. This made the system able to communicate with the available smart home system with an Internet gateway. The connection used a low power communication protocol called Zigbee. Users were able to control the system through a web-based application over the Internet. In this paper, it was stated that the server was interfaced together with relay hardware circuits that control the contraption in the house. The communication with the server permitted the user on picking the contraption then the server established communication of the relays of the selected contraption. If there was a disturbance of the Internet or if the server malfunction, the system will be still operating domestically through the embedded system board. The sensors were connected together with the appliances which connected to the Raspberry PI, the device controller. The Raspberry PI was connected to a camera for the user to view the surrounding and it has a two-way connection to an IoT platform/server for input and output either from the user or from the sensor. The IoT was connected to a web portal and to a mobile platform or a computer for ease of access to the user. The infrared sensor was used to detect light and it results in giving a notification to the Raspberry PI. With the connection of Wi-Fi or IoT system, the user can then switch ON or OFF the light. The motion sensor was also controlled the same way as the IR sensor but it detected movement and thus will trigger the fan ON/OFF. Pavithra also proposed the level of IoT which in the first layer of the proposed IoT architecture – all the devices are placed which will then be connected with the data link layer where Raspberry PI is implemented for the IoT Gateway Router, device manager and other communications protocol. The Raspberry PI communicates with multiple items like the personal computer or mobile phones via the Internet on the network and transport level of the proposed solution and in the last level, the applications and presentation layer which is the web page where the user can use to control all the appliances and monitor the condition of the home. There can also be an app to control all the equipment and monitoring.

Rakesh K. Deore developed an IoT based home appliances control using Bluetooth technology for home appliances control. With the Bluetooth based system, the functionality of the system was highly restricted as the users needed to be in close range to the appliances to perform functions and control [8]. There might be some disruption of the signal even from a short distance due to unstable connections. By implementing IoT into the system, users were able to control the equipment from anywhere as long they were connected to the Internet. In this paper the proposed solution given is by designing a system consisting of a web-server based on Arduino Ethernet and interfacing it with multiple hardware modules then control it with an Android-compatible smartphone application [8]. The objective of the proposed solution is to allow users to manage the appliances via Wi-Fi through an app on smartphones. Thus, at the same time providing security.

In 2016, Ravi Kishore proposed a smart security and home automation system that utilized IoT. It implemented TI CC3200 LaunchPad, Wi-Fi network processor and system that managed the power. It also used the ARM Cortex M4 core processor for fast execution and included an internal memory of 256 KB RAM [9]. It has a development platform that provided features like sensors, buttons, and LEDs. The board was programmed through Energia IDE by USB cable. In the paper, the system did not utilize any smartphone applications and any user interface [9]. It mainly used the digit keypad on the phone and making it easy to access by any kind of phone with other types of the operating system. In addition, there was an optional smartphone application that can be used if the user wanted to access the appliances while not triggering the other sensors. The connection on the phone did not need data as the system run when the launchpad was connected to Wi-Fi. The prototype can be run in two ways as a smart security system or even as a smart home automation system. The system was then named as Smart Security System. If the PIR sensor detects movement a signal will be produced. The signal was the input for the microcontroller (TI CC3200). This will then send a voice call to the owner alerting the about the trespass and stating, "There is an intruder in the house". The owner may turn on the light by pressing 'L' on the mobile keypad which will then serve as a warning for the intruder. The system uses a time delay which was fixed and will turn off the light and alarm. If there is another trigger in the system, the user will receive the same alert again. Another feature was that the user will receive a video call if the owner was not around and there was a visitor, user may select the fixed digits for each appliance to operate and the may also disable the security system. By the time the visitor leaves the premises the owner will receive another video call and the user can then switch off the appliance and turn on the security system back again all by a single pressing of the fixed digits on the mobile phone keypad [9]. In this particular system, the functionality and efficiency of the system depend highly on the user's interpretation of the situation and the discretion.

Vamsikrishna *et al.* designed the system that enables the user to control all the home appliances by smartphone and PC as long as it was connected to the Internet. The system used Raspberry PI as it is able to interface with multiple sensors and providing connection to the Internet. In this system, computer vision methods are used [10]. The Raspberry PI in the system operates all the sensors and the camera for the usage of sensing and monitoring the surroundings. The camera will capture an image when the PIR sensor was triggered and then uses Computer Vision Technique when the image was captured. Then an alert will be sent to the user through SMS. The system was also able to get live streaming through the camera that had been connected to the Raspberry PI. The program in the system was also used to get the status of the appliances and then the status was stored on the designated database. HDMI extension switch was used to connect it to multiple monitors for live streaming.

III. METHODOLOGY

This section discusses how the prototype was developed. A brief description of the components used and software development were also explained.

A. Circuit Development and Flowcharts

The schematic was designed according to each requirement for the prototype and all the components were connected to the Arduino which will be placed under the PCB board (see Fig. 1 and Fig. 2). Flowchart of each sensors and the flow of the prototype is also shown (see Figs. 3 - 8). Upon completion of the schematic, all the components were connected on a breadboard to test its functionality and to ensure that it will run well. Autodesk Eagle software was used to design the circuit, the sensors include the PIR sensor for motion detection, temperature sensor to detect the level of temperature in the environment, flame sensor for fire detection, LDR sensor to detect light intensity, and lastly the soil humidity sensor used as a water level sensor for flood detection.

B. Sensors

The sensors play a huge role in the success of the proposed smart home security system prototype. In this part, we described the principle and basic fundamentals of the sensors that were used in the hardware.

PIR Sensor: The Passive infrared sensor (PIR sensor) is a type of sensor which allows the user to detect movement when it is in range with a moving object. They operate on low power. The PIR sensor is made up of a pyroelectric sensor which detects infrared radiation that is emitted from an object or human. The infrared radiation becomes higher if the object or human has higher temperature. The sensor is splitted into two halves where they set in order to cancel out each other. If the first part detects higher or lesser infrared (IR) radiation, the output will result in a high or low [11].

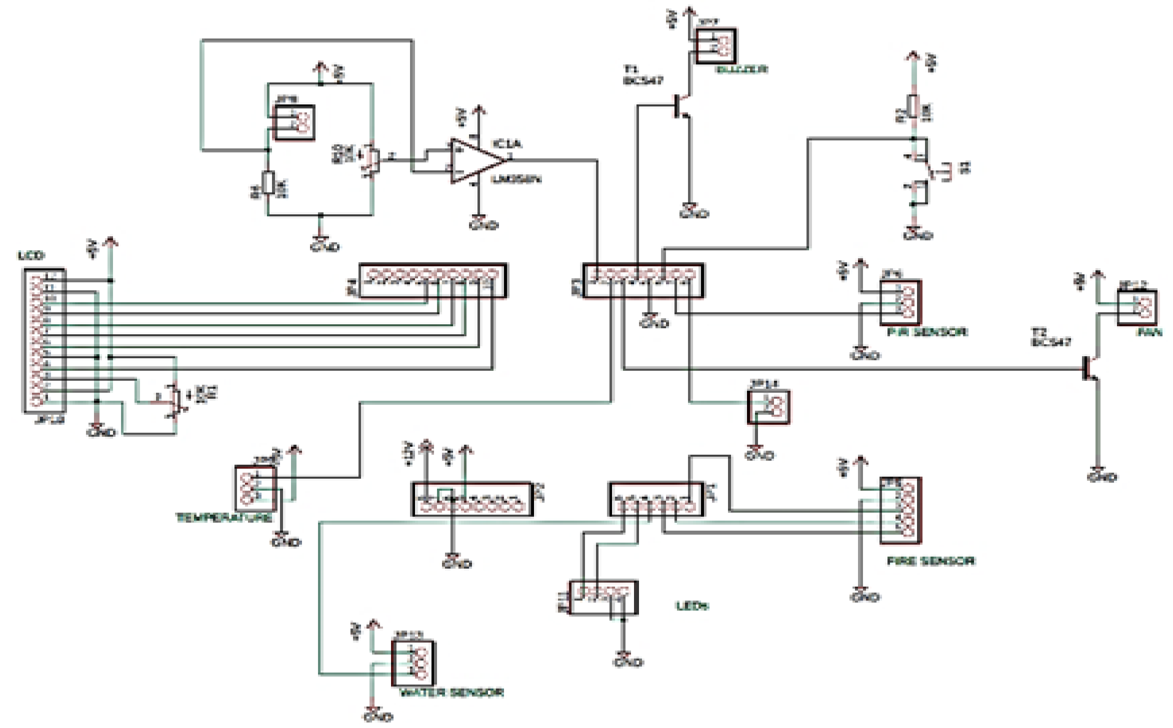


Fig. 1. Full schematic of prototype.

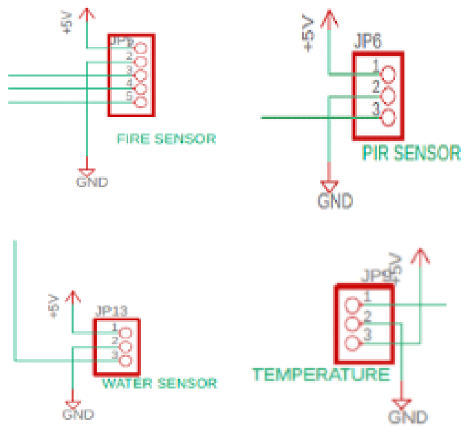


Fig. 2. Main sensors of prototype.

When the sensor is idle both halves of the sensor detects the same level of IR. When an object or human with a warm body moves past the sensor, one half of the sensor will cause a positive differential change from the other half and when the object or human moves away from the sensor, the opposite of the first will happen and the sensor generates a negative differential change. The pulses that were produced from the detection and the differential changes were what triggered the sensor which resulted the triggers of the alarm. The lens that covered the sensor is mainly used to focus the detection range into specific parts.

Soil Humidity Sensor: The soil humidity sensor used in this prototype is to simulate the flood detection scenario. The sensor is more sensitive and reliable than a normal water sensor. This sensor uses capacitance to measure the surrounding it is in. The sensor will create a voltage that is proportional to the dielectric permittivity of the environment that its being immersed in and detect the content of water. The plates on the sensor detects the humidity and water level. In this prototype, the sensor functionality is demonstrated by placing it into a cup containing water and when the water touches the detection plates it will then trigger the alarm for flood warning [12].

LDR sensor: Light-Dependent resistor (LDR) which is also known as photo resistor is a type of resistor which the resistance changes based on the intensity of light that comes in contact with the surface. When the light hit on the surface of the sensor, the conductivity of the material becomes lower and the electrons in the valence band are moved towards the conduction band which then either turns the connection on or off. The sensor can be programmed to function as an ON or OFF switch for a connection. When light hit on the LDR, the resistance becomes lower and it becomes higher when there is less light [13]. In this prototype, the sensor is made to turn ON the light when there is no light illuminating on the surface and turns OFF when there is light.

Humidity, Moisture and temperature sensor (DHT 22): The sensor uses an NTC temperature sensor or a thermistor. The thermistor is a variable resistor that will change its resistance depending on the surrounding temperature. The semiconductive materials that are placed in the sensors by sintering it, will result in making big differences of resistance when there are small changes in the surrounding temperature, and the NTC which means "Negative Temperature Coefficient" results the increment of the temperature when the resistance is lower [14]. Besides that, the sensor is mainly used to detect the surrounding temperature which results in the increase or decrease of the fan speed.

5-way Flame Sensor: The sensor is used to detect fire in a wider area which is more than 120 degrees. This makes it to become more efficient than the 1-way flame detector. The sensor is highly sensitive to heat and the radiation it produces thus making it highly efficient to be implemented in a security system. The sensor also can detect the light source. The sensor is easily triggered when there is a much larger fire source but can also detect the smaller range fire as long as it is in the proximity range. The sensor features analog and digital outputs and even has its own on-board potentiometers and indicators when there is flame detected.

C. Device Manager and Command Centre

For the development of this prototype the Arduino is selected as the device manager because of its property where it has a microcontroller and does not need an operating system (OS) and able to respond in real time to the stimulus. On the other hand, the Raspberry PI is selected as the command center. It has a microprocessor and requires an OS to run thus making it more reliable in sending command to the device manager and able to connect to the Internet without additional components.

ARDUINO: The ARDUINO is a simple and compact electronic platform with a microcontroller that eases the programming and control of the prototype and capable to perform multiple instructions and control many components, sensors, and output with simple instructions sent to the microcontroller [15]. In this prototype, the ARDUINO is considered as the brain and it is placed directly under the board and connected to a series of pins for control of the sensors and LCD.

Raspberry PI 3 model B: The Raspberry PI is a credit card sized computer which is designed for education. It is a device with low cost and can be used to help improve programming skills and even hardware understanding. Due to its small size, the Raspberry PI is suitable to be implemented in electronic connections. The Raspberry PI is slower than a modern laptop but is still a complete computer [16]. The Raspberry PI is designed for Linux operation system. It has many system calls and libraries. It even has various window systems and is able to be used with C or C++. Other libraries include Python, Java, and Ruby also have their libraries installed in the Raspberry PI library.

D. Software Development

In this part, the development of the software and the method used are discussed. The server used is the Digital Ocean virtual private server (VPS) also called as a droplet. In the prototype development, it is connected to the server through the Internet. The software's used to develop the codes and the application in the mobile platform are listed as the following:

ARDUINO IDE: The ARDUINO integrated development software is a cross-platform application that is used to write and upload all the program into the ARDUINO board. For the prototype, the application is used to write codes for the device manager ARDUINO. The programming language used is ARDUINO SKETCH (Figs. 3 – 8).

Android Studio IDE: The software is used for the development for the interface on the mobile platform of the mobile app. It uses the Dart programming language.

E. Framework Development

There are multiple development frameworks used in this prototype, the frameworks are used to speed up the development process of the prototype.

.NET Core 3.0: This framework eases the development of applications because of the collections of libraries it contained. Version 3 is used because when this report is written the version 3 is still in preview. Version 3 also enable us to use serial port Linux which is used by the Raspberry PI.

ASP .NET Core SignalR: The SignalR is broken into two parts which are server and client. This framework is used in three components which are server, Raspberry PI and Android device. It helps to simplify the adding real-time web functionality to the applications. It also enables server-side code to send contents to the client.

Flutter mobile framework: The Flutter framework (see Fig. 9) is an open source mobile application created by Google that is used to develop applications for smartphones that are operated on Android or iOS. It is used in this prototype because it can help with developing the application quickly instead of using the Native Android development platform [17]. Not as the other platform, Flutter offers no limitation to devices that may be uploaded onto.

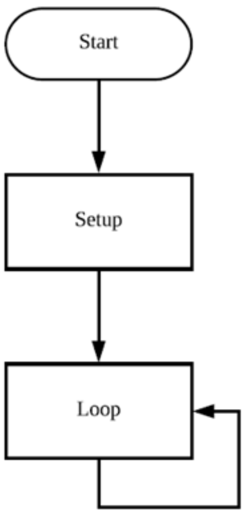


Fig. 3. Arduino basic.

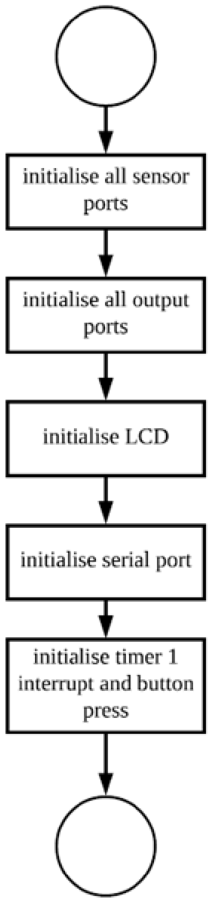


Fig. 4. Setup function.

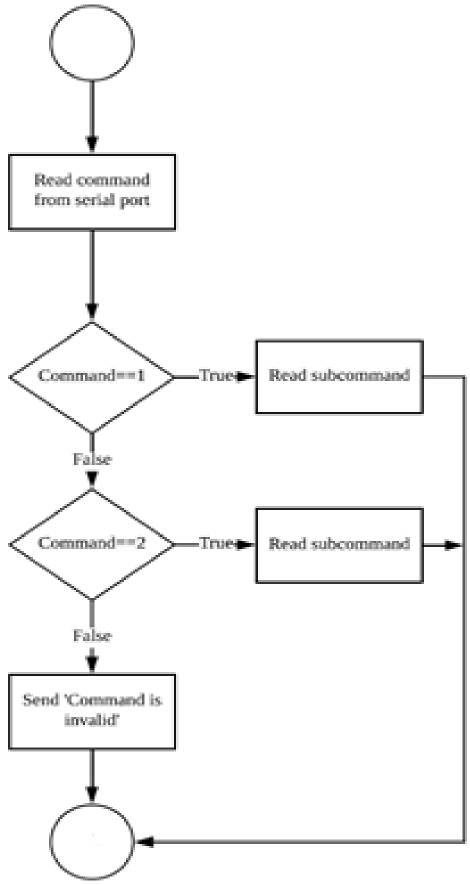


Fig. 5. Loop function.

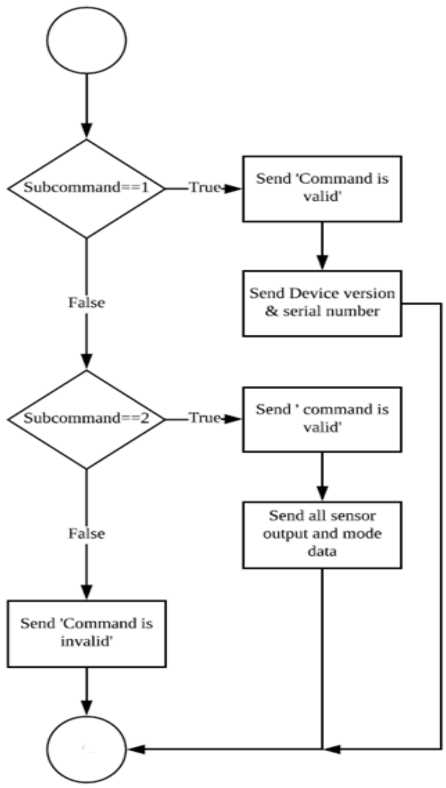


Fig. 6. Read subcommand for command '1'.

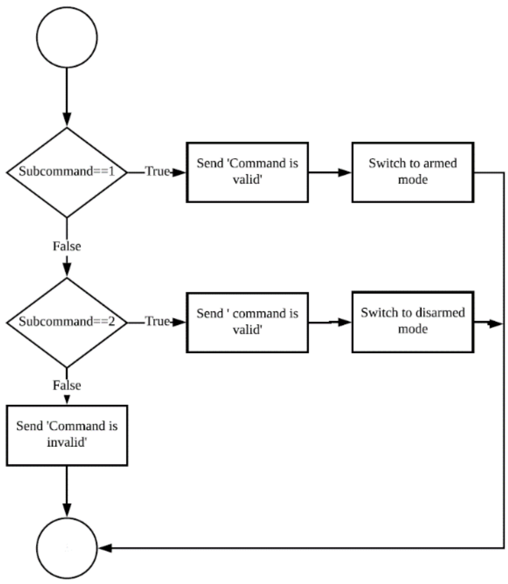
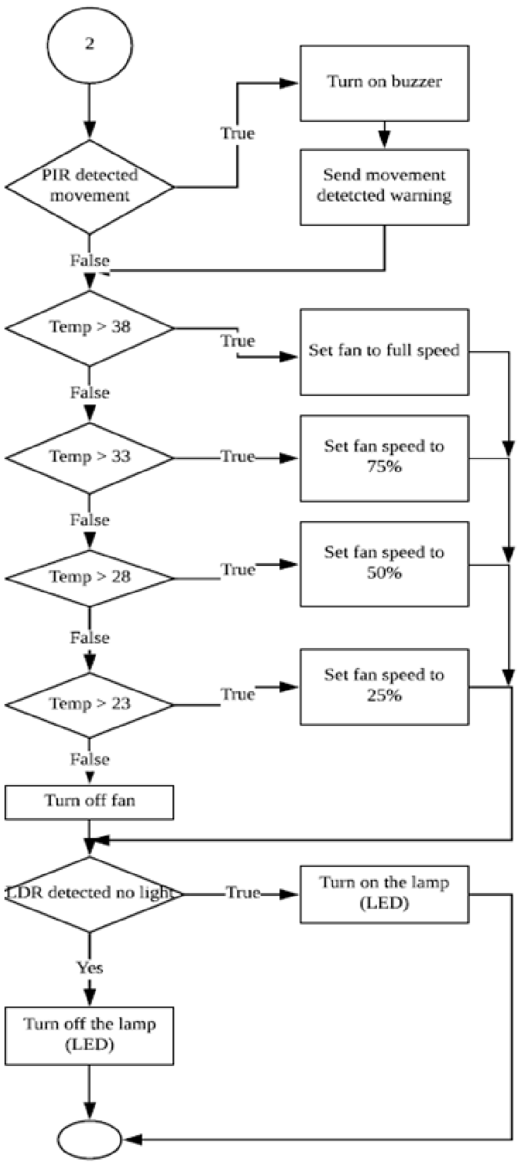


Fig. 7. Read subcommand for command '2'.



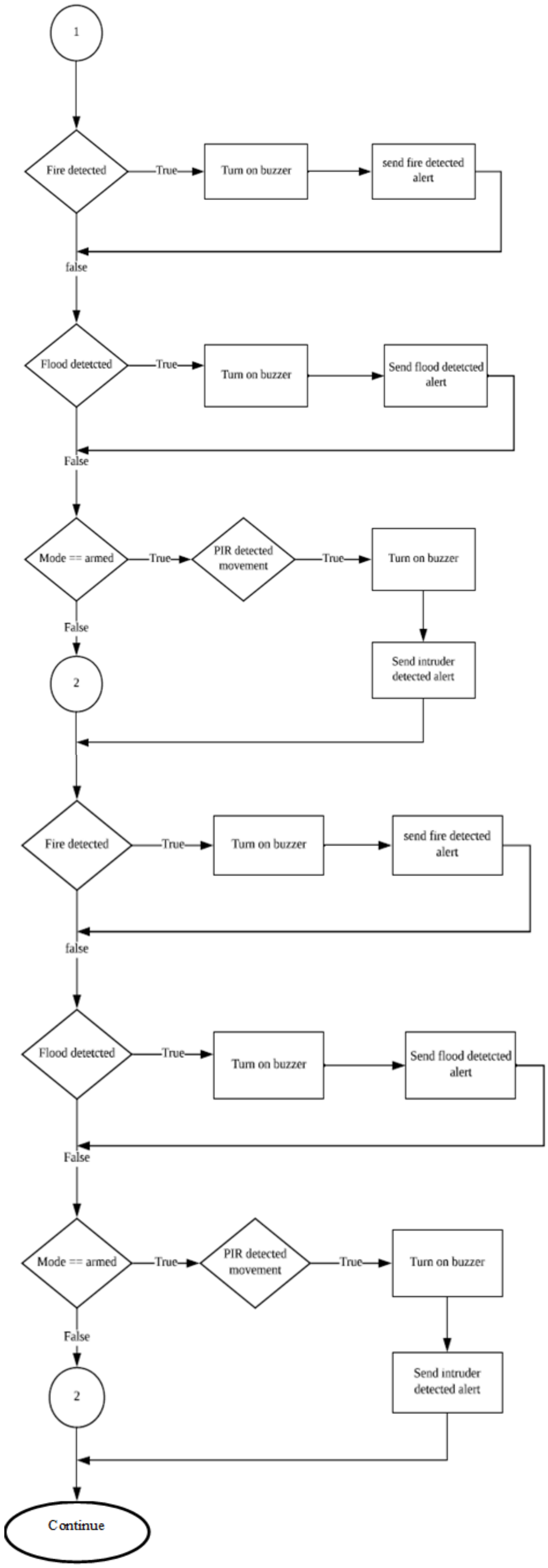


Fig. 8. Timer 1 interrupt.

Fig. 9. Flutter mobile framework application.

IV. RESULT AND DISCUSSION

To simulate the results, the prototype (see Fig. 10) was tested for each of the sensory functions. The prototype has two modes: armed and disarmed. In the armed mode, user can press the push button on the board or control it using the mobile platform application. The sensor worked in all mode but the buzzer will sound when there was a detection of fire, flood, and movement in PIR sensor when in armed mode.

After turning on the prototype, the Raspberry PI was connected to a LAN through a cable for Internet connection. The application on the mobile platform (see Fig. 11) was also turned on. The app will display the control and the button to select the armed mode or disarmed mode. When the armed mode was selected, there will be a timer countdown for the owner to exit the house before it become armed. When armed, the PIR sensor will detect any movement. When the system detected a movement a notification on the mobile application will be given.

The prototype was then tested for all other sensors. In the disarmed mode, the fire sensors were tested. When a fire source was taken close to it, the sensor will detect the radiation of the fire and trigger the LED on the sensor. This then triggered the system to send a notification to the mobile platform which the user will receive a notification on the phone.

Next, the result of the testing of the soil humidity sensor which represented as a flood sensor. When the sensor comes in contact with water it will trigger the system to send an alert to the homeowner through a buzzer and notify the owner through the mobile platform application.

The LDR was also tested for its functionality where it acted as a switch for the lights in the prototype. When the light was shone onto the LDR sensor the LED will turn off and when the light was blocked from the LDR sensor the LED will turn on. The details on the temperature, humidity, and light were shown in graph form in the mobile application (see Fig. 12). Notifications were then sent to the user for easy detection. The speed of the fan was also indicated in the mobile application. The user can easily keep track of the speed and environmental factors of the home (see Fig. 13). Table 1 summarize the testing status of each sensor.

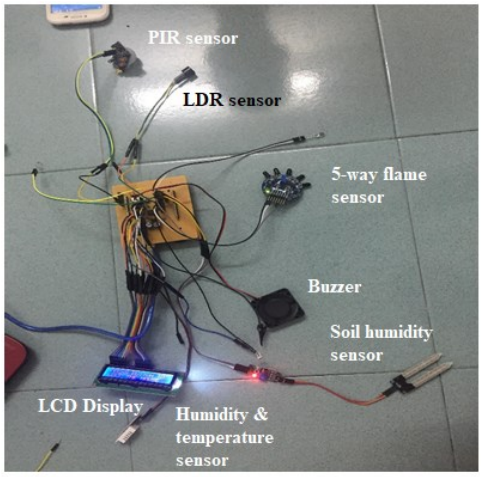


Fig. 10. Full layout of prototype.

Fig. 11. Mobile app using flutter.

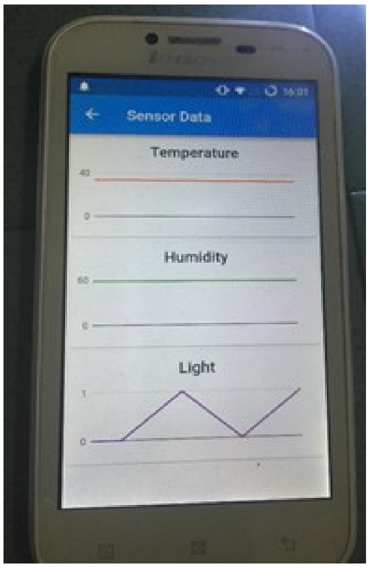


Fig. 12. Graph on mobile platform.

Table 1. Summary of sensory functions tests.

Sensory Functions	Working?	Remarks
PIR sensor – movement sensor	Yes	Notification to mobile phone if detected any movement.
5-way Flame sensor – fire sensor	Yes	Notification to mobile phone if detected any fire radiation
Soil humidity – flood sensor	Yes	Buzzer and notification to mobile phone if detected any fire radiation
LDR – turn on/off the light	Yes	-
Humidity, Moisture and temperature sensor (DHT 22) – turn on/off the fan	Yes	-

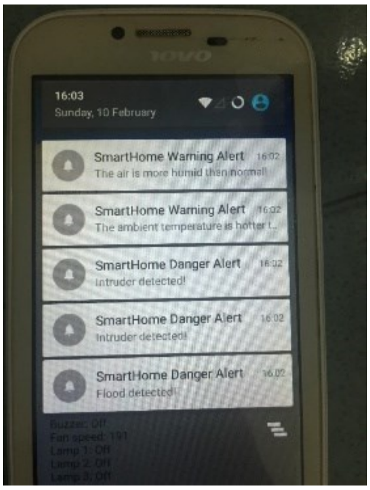


Fig. 13. Notification on the status of the premise environment.

V. CONCLUSION

In this project, we managed to develop a prototype which demonstrated safety and smart functionalities of an IoT based smart home system. A total of five sensors were used in the prototype to detect movement, fire, flood and turning the light/fan on/off. Raspberry Pie was used as command centre while Arduino as the device manager. The challenges faced while designing the prototype were that most of these sensors required a lot of calibration and trial and error for software development. The sensors were also highly sensitive and easily damaged as encountered where the LDR and PIR were damaged due to handling. In addition to that, due to the bypassing of the LDR, the 5-way flame sensor IR has been reduced to 1 sensor instead of 5.

We also implemented the wireless communication to interface it with a mobile platform called Flutter. Flutter offers no limitation to devices that may be uploaded onto when most of other platforms usually offers up to only two devices. It also has many other advantages. One of the advantages is that it has high productivity which means the code used can be used for both iOS and Android. Besides that, its compatible with any OS. The platform is the only mobile SDK that able to reactive views without requiring a JavaScript bridge. The development of the coding is fast and very simple where users are able to instantly view the changes made in the flutter environment. Because of this feature, even non-programmers or layman who has no programming background can use Flutter. Another important benefit is that it is an open source and free to use. One may get help from reading the detailed documentation manual or get advice from its community support.

REFERENCES

[1] P. Neumann, "Development of a Prototype of the "Smart Home" System," *Projects Development for Collaboration*, 2016.

[2] B. Ali and A. I. Awad, "Cyber and Physical Security Vulnerability Assessment for IoT-based Smart Homes," *Sensors*, vol. 18, no. 3, pp. 1–17, 2018.

[3] H. Ghayvat, S. Mukhopadhyay, X. Gui and N. Suryadevara, "WSN- and IOT-based Smart Homes and Their Extension to Smart Buildings," *Sensors*, vol. 15, no. 5, pp. 10350–10379, 2015.

[4] A. Imteaj, T. Rahman, M. K. Hossain, M. S. Alam and S. A. Rahat, "An IoT based Fire Alarming and Authentication System for Workhouse using Raspberry Pi 3," *ECCE 2017 - Int. Conf. Electr. Comput. Commun. Eng.*, pp. 899–904, 2017.

[6] M. Y. Hossain, F. P. George and M. Halder, "IOT based Automated Intrusion Detection System," *Int. J. Comput. Appl.*, vol. 180, no. 35, pp. 975–8887, 2018.

[7] J. L. Ryan, "Home Automation," *IEE Rev.*, vol. 34, no. 9, p. 355, 1988.

[8] R. K. Deore, V. R. Sonawane and P. H. Satpute, "Internet of Thing Based Home Appliances Control," *Proc. - 2015 Int. Conf. Comput. Intell. Commun. Networks, (CICN)*, pp. 898–902, 2016.

[9] R. K. Kodali, V. Jain, S. Bose and L. Boppana, "IoT based Smart Security and Home Automation System," *Proceeding - IEEE Int. Conf. Comput. Commun. Autom. (ICCCA)*, pp. 1286–1289, 2017.

[10] V. Patchava, H. B. Kandala and P. R. Babu, "A Smart Home Automation Technique with Raspberry Pi using IoT," *2015 Int. Conf. Smart Sensors Syst.(IC-SSS)*, pp. 3–6, 2017.

[11] V. Govindraj, M. Sathiyanarayanan and B. Abubakar, "Customary Homes to Smart Homes using Internet of Things (IoT) and Mobile Application," *Proc. 2017 Int. Conf. Smart Technol. Smart Nation, SmartTechCon 2017*, pp. 1059–1063, 2018.

[12] P. Teixidó, J. A. Gómez-Galán, F. Gómez-Bravo, T. Sánchez-Rodríguez, J. Alcina and J. Aponte, "Low-power Low-cost Wireless Flood Sensor for Smart Home Systems," *Sensors*, vol. 18, no. 11, pp. 1–13, 2018.

[13] M. Putri and S. A. Lubis, "Design of Security Tools Using Sensor Light Dependent Resistor (LDR) Through Mobile Phone," *Int. J. Innov. Res. in Comp. and Comm. Eng.*, vol. 4, no. 10, pp. 168–173, 2018.

[14] M. C. Yuen, S. Y. Chu, W. Hong Chu, H. Shuen Cheng, H. Lam Ng and S. P. Yuen, "A Low-cost IoT Smart Home System," *Int. J. Eng. and Technol.*, vol. 7, no. 4, pp. 3143-3147, 2018.

[15] D. Kunal, D. Tushar, U. Pooja, Z. Vaibhav and V. Lodha, "Smart Home Automation using IOT," *Int. J. Adv. Res. Comput. Commun. Eng.*, vol. 5, no. 2, pp. 313–317, 2016.

[16] B. N. Dhondge and S. S. Jahdav, "IoT Based Home Automation Using Raspberry PI," *Int. J. on Recent and Innov. Trends in Comput. and Comm.*, vol. 6, no. 1, pp. 187–189, 2018.

[17] P. Kumar and U. C. Pati, "IOT-based Monitoring and Control of Appliances for Smart Home," *2016 IEEE Int. Conf. Recent Trends Electron. Inf. Commun. Technol. (RTEICT)*, vol. 769008, pp. 1145–1150, 2017.