Smoke Detection Alert System via Mobile Application

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ABSTRACT
Nowadays, security is very important, everyone wants to secure their assets at home since the occurrence of fire hazard is unpredictable. Fire can bring a significant threat to human life and property. Fire hazard can be greatly reduced if early warning of the fire can be detected. Therefore, the system with advance technology is needed so user does not worry when getting away from their home. The purpose of this system is to provide home security with the smoke sensor device, which able to detect smoke and give alert to users by notifying the users via SMS (Short Messaging System) together with the sound of an alarm. The authorized users able to activate and deactivated the system via the mobile application based on Android platform. Arduino Uno (R3) Board is used as the hardware platform of the system. It is very significant to have the apps nowadays because its mobility and convenience to users. Besides that, it is highly importance as early detection of smoke which can prevent economical, ecological and human-life endangering threats from fire hazard.

Categories and Subject Descriptors
K.6.5 [**Security and Protection**]: Authentication, physical security, unauthorized access

General Terms
Performance, Design, Security, Verification.

Keywords
Smoke sensor, smoke detection system, Arduino, SMS.

1. INTRODUCTION
It is well-known that smoke precedes flame in a fire accident. In addition, the range of smoke spread is much larger than the flame. Smoke is a collection of airborne solid and liquid particulates and gases emitted when a material undergoes combustion or pyrolysis, together with the quantity of air that is entrained or otherwise mixed into the mass. Smoke inhalation is the primary cause of death in victims of indoor fires [1].

A fire is a chemical reaction in which a carbon based material (fuel), mixes with oxygen (usually as a component of air), and is heated to a point where flammable vapors are produced. These vapors can then come in contact with something that is hot enough to cause vapor ignition, and a resulting fire. In simple terms, something that can burn touches something that is hot, and a fire is produced [2]. Fire can brings a significant threat to human life and property security. Fire hazard can be greatly reduced if early warning of the fire can be detected [3].

Previously, humans can be an excellent fire detectors. Healthy person is able to sense multiple aspects of a fire including the heat, flames, smoke, and odour. For this reason, most fire alarm systems are designed with one or more manual alarm activation devices to be used by the person who discovers a fire. Unfortunately, a person can also be an unreliable detection method since they may not be present when a fire starts, may not raise an alarm in an effective manner, or may not be in perfect heath to recognize fire signatures [4].

Therefore, in order to prevent and reduce fire's risk to people, the outstanding smoke detection system is required. This system is highly importance as early detection of smoke can prevent economical, ecological and human-life endangering threats which can arise as the result of a fire disaster [5].

In this paper, the methodology used in developing the smoke detection alert system is divided into two components which are hardware and software. The system uses the Arduino Uno (R3) Board as the hardware platform while the software is based on the mobile application. This mobile application is based on android platform. This system is able to detect smoke by using analog smoke sensor. When the smoke trigger, the system will give an alert to the mobile application by sending Short Messages Service (SMS) and alarm will beeping with LED flashlight. The alarm will continue beeping until it is stopped by the receiver. It is very significant to have the apps nowadays because its mobility and convenience to the users. Process of integrating hardware and software with the wireless communication for smoke detection alert system is mentioned in section 3. By having this system, it can continuously secure our place from fire hazard even though we are away from the place and it is cost-effective. Besides that, it may also reduce the percentage of fire disaster contribution and can secure our property and life.

2. METHODOLOGY
The method used in detecting smoke is analog arduino smoke sensor. This sensor is not only sensitive to smoke, but also to flammable gas [6]. Therefore, it is suitable to implement at home for surveillance security.

2.1 Analog Arduino Smoke Sensor (MQ Series)
The MQ series gas sensors used a small heater inside with an electro-chemical sensor. It is sensitive for a range of gasses that used for indoors at room temperature. They can be calibrated more

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or less but a known concentration of the measured gas or gasses is needed.

The voltage for the internal heater is very important. Some sensors use 5V for the heater, others need 2V. The 2V can be created with a PWM signal, using analogWrite() and a transistor or logic-level mosfet. The sensors that use 5V or 6V for the internal heater do get warm. They can easily get 50 or 60 degrees Celcius [7]. After the "burn-in time", the heater needs to be on for about 3 minutes (tested with MQ-2) before the readings become stable.

In terms of the wiring of this sensor, it is preferred to connect both 'A' pins together and both 'B' pins together. It is safer and it is assumed that is has more reliable output results. Figure 1 shows the architecture of analog smoke sensor wiring.The heater is for +5V and is connected to both 'A' pins. This is only possible if the heater needs a fixed +5V voltage. The variable resistor in the figure 1 is the load-resistor and it can be used to determine a good value. A fixed resistor for the load-resistor is used in most cases. The Vout is connected to an analog input of the Arduino.

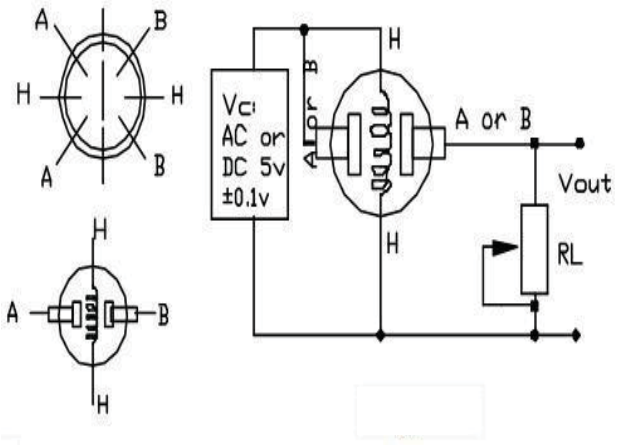

Figure 1. Wiring of Analog Smoke Sensor

The sensor needs a load-resistor at the output to ground. The value could be from 2kOhm to 47kOhm. The lower the value, the less sensitive. The higher the value, the less accurate for higher concentrations of gas [8]. Choosing a good value for the load-resistor is only valid after the burn-in time. Burn-in time means it is the time to burn-in the sensor. This is meant to make the sensor readings more consistent. A time of 12 or 24 hours is usually used for the burn-in time. The Burn-in is achieved by applying normal power to the sensor (to the heater and with the 'A' and 'B' pins connected, and with a load-resistor). In some special cases a specific burn-in is needed.

2.2 Bluetooth Technology for Home Security System

Due to the advancement of wireless technology, several different types of connection are introduced such as GSM, WIFI, ZIGBEE, and Bluetooth. Each of the connection has their own unique specifications and applications. Bluetooth is one of the four popular wireless connections that often implemented in home security system. *Bluetooth* technology is a wireless communications system intended to replace the cables connecting many types of devices, from mobile phones and headsets to hear monitors and medical equipment. [9]. It is also the ideal wireless home automation technology that allows controlling household appliances like light, door, fan and air-conditioner. Besides that, it provides home security and emergency system to be activated.

Home automation not only refers to reduce human efforts but also energy saving and time efficiency.

Bluetooth technology with globally available frequencies of 2400Hz is able to provide connectivity up to 100 meters at speed of up to 3Mbps depending on the Bluetooth device class [10]. Moreover, a Bluetooth master device is able to connect up to 7 devices in a “Piconet” [11].

2.3 Home Security System with Short Messaging System (SMS)

Mobile phones have become one of the most common communication devices amongst the people all over the world. SMS became popular as it provides cheap, convenient and faster method of communication [12]. SMS is a GSM mobile technology that can perform remote communication wherever they are [13]. Based on this facility, messages can be sent quickly, accurately, and at a low cost. 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.

Besides that, SMS also is safe from network security threats and can be operational from anywhere in the world where there is a mobile network. The advantage of SMS over ZigBee, Bluetooth and Wi-Fi is that the communication range also is from anywhere in the world where there is a mobile network [12].

SMS facility also able to activate and deactivate system by using two-way information through SMS. Mobile phone user can use SMS for monitoring the security sensors (smoke sensor) and obtain response in in the same mobile phone about the status of the location. According to this facility, the security system capable to works automatically which can make two-way communication with mobile phone user by notifying the user when there is smoke detected in the place. The two-way communication is used to turn off the alarm after the smoke is detected.

2.4 Comparison of Previous System

There are various types of smoke and fire detection system that currently available. The differences between these systems were based on the method used. Table 1 below shows the comparison between the previous system with the system that been developed. According to the Table 1, it shows that the significant of the developed system were based on the cost where everyone can afford it because it based on the Android smartphone. Besides that, only simple configuration are required and it is easy to be used. Furthermore, it aligned with the current environment where smartphone become one of the important devices to everyone because people always carrying their smartphone to anywhere and everywhere. Thus, by installing this application, it may secure our place by notifying the person.

Table 1. Comparison of the System

Feature	Fire Detection based on Video-Based System	Surveillance Monitor System Using Image Processing (Monitoring Fires)	Smoke Detection Alert System via Mobile Application
How it works	The system trigger an alarm in response to the detection of fire such as flame or smoke.	- The system used to monitoring fires. - Design to warn of fires by monitoring images from television camera. - Detects fire by using images of surveillance area.	-Smoke sensor use to detect smoke. -Short Message Services (SMS) will notify to the receiver phone once smoke detected. -Design to alarm on receiver phone even though in silent mode.
Detection	-Flame -Smoke	-Temperature -Fire -Distance -Fire	-Smoke
Indicator	-Video Detector -Fire Alarm -Smoke Sensor	-Television Camera -Fire sensor -Alarm -Temperature Detection	-Smoke Sensor -Alarm Detector -Short Message Service (SMS)
Hardware	Video Processor	Image Processor	Bluetooth
Functionality	Moderate	Moderate	Easy
Limitation	The top of a smokestack which detect smoke are not triggering of an alarm	-Use of conventional fire sensors -Difficult to distinguish the signal whether it is either fires or other causes such as sunlight or reflected light	For sender phone: user need to have credit balance and stay active
Cost	High	High	Low

3. DEVELOPMENT OF SMOKE DETECTION ALERT SYSTEM

The development process of this system was divided into two parts which are hardware and software. The hardware is the part where the integration of components needs to be setup and configure. The software part is the development of the mobile application that integrates with the smoke detector. For this system, there are five modules that were developed which are Bluetooth module, smoke sensor module, sender module, receiver module, and alarm application module. The details of the development process were discussed in the following section.

3.1 Hardware Development for Smoke Detection Alert System

The components used for this development were Arduino Uno Board, Analog Carbon Monoxide Sensor (MQ-7), Cytron Xbee Shield, BLUEBEE Cytron Bluetooth Module, USB cable, AC 5V Adapter, and jumper cables. The process starts with the BlueBee Bluetooth Module. The BLUEBEE need to be inserted into Cytron Xbee shield. The BlueBee module comes with an on-board antenna, the antenna provides better signal quality. It acts like a transparent serial port, which works with a variety of Bluetooth adapter and Bluetooth phone. Figure 2 shows the combination of both of BlueBee and Cytron Xbee shield.

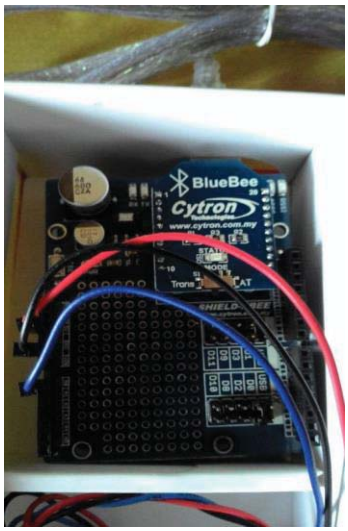

Figure 2. Cytron Xbee Shield and BLUEBEE Cytron Bluetooth

The next process is to combine the Xbee Shield and BlueBee that built on the Arduino Uno R3 board. Xbee shield pins should slot respectively into the Arduino board and make sure all pins are in correct position in order to make the device function properly. Figure 3 shows the combination between Xbee shield and Arduino Uno.

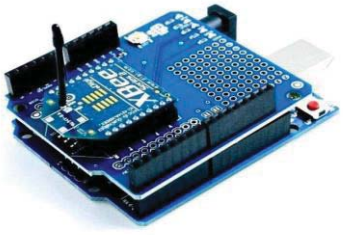

Figure 3. Xbee shield combines with Arduino Uno R3 Board

After that, Analog Carbon Monoxide Sensor (MQ-7) is connected to the Arduino Uno R3 board by using jumper wires. The hardware configuration needs three jumper wires to connect with Analog Carbon Monoxide Sensor (MQ-7). The jumper wires are black, red and blue. All the wires need to be connected properly and follow the code colour. This connection is shown in Figure 4.

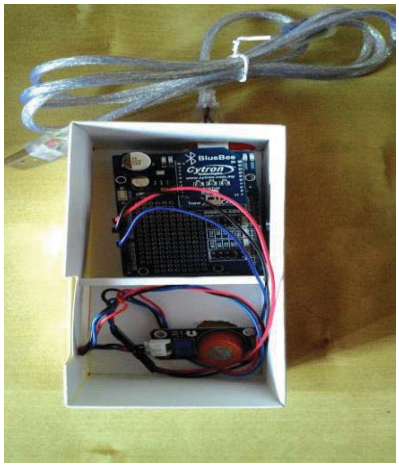

Figure 4. The connection between the Arduino Uno R3 board and Analog Carbon Monoxide Sensor using jumper wires

Besides that, the LED also needs to be embedded on the Arduino Uno R3 board as the indicator of the alert system. The LED will blink in normal mode every 50 seconds and in alarm mode for every 3 seconds. Figure 5 shows the blinking LED when the power is on. For the configuration, Arduino and Analog Smoke Sensor used Java language to connect between each other.

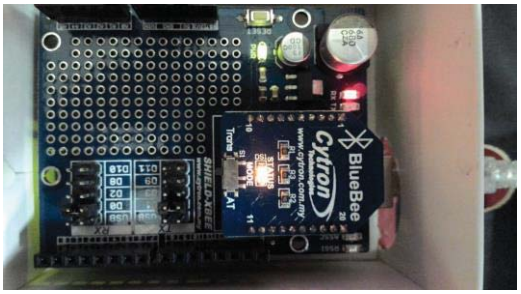

Figure 5. LED Flashlight

The overall architecture of the system can be depicted in Figure 6 below.

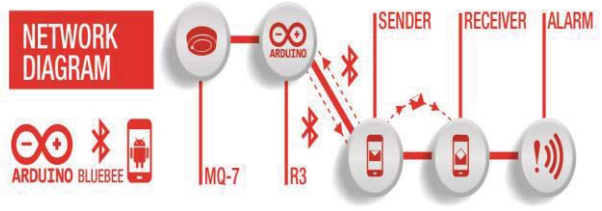

Figure 6. The Architecture of Smoke Detection Alert System

Based on the figure above, it explains that when analog smoke sensor (MQ-7) detects smoke in range of 400, MQ-7 sends the information via the Arduino (R3). The R3 is programmed to send information via all the devices if smoke occurs. After that, the sender Android phone needs to switch on the Bluetooth to receive the information from R3 through Bluetooth module (BlueBee). Then, the information will passes to the receiver Android phone by alerting on Short Message Services (SMS).

3.2 Software Development for Smoke Detection Alert System

The software that was used for this system was Android Studio Tool, and Eclipse Java Development Tool. Java language was used in developing this system because of the compatibility, and robustness.

In order to login the system, user need to enter their username and password for authentication and activation of the system. The username and password that were entered need to be registered earlier. Besides username and password, other information that is needed during the registration is the smart phone number (emergency number) for the notification purpose. This number (emergency number) refers to the sender's phone number. Figure 7 shows the registration interface of the system.

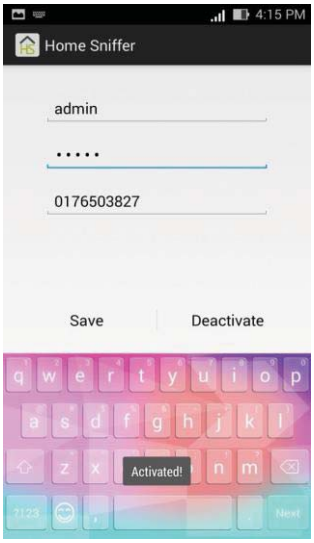

Figure 7. Interface for Registration

The alarm application will beep when smoke is detected even though the phone is in 'silent mode' together with the SMS notification. The alarm will keep beeping in Android receiver phone until the owner click it to stop the alarm. It can be depicted in the following figure.

Figure 8. Interface for Stop Alarm

3.3 Process Flow for Smoke Detection Alert System

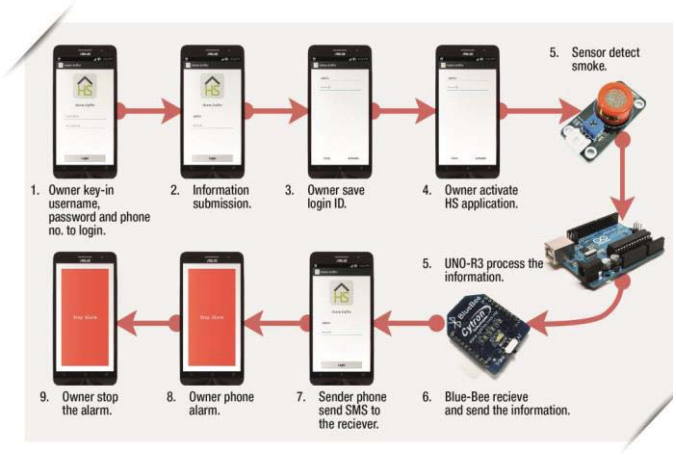

Figure 9. Process Flow

Figure 9 shows the overall process of the system. The figure illustrates that when the smoke detected, the registered information will passes through the Arduino Uno R3. The Uno R3 acts as a control panel that controls all the devices that was programmed on it. Once the information is taken by the Uno R3, it will send the message to the Bluetooth (Blue Bee) and connecting it to the Android phone sender. The sender of the Android phone will use it to pair the device with Blue Bee. Then, the Android phone receiver (owner of the smart phone) will receive the message via SMS.

4. RESULTS AND FINDINGS

For this system, types of testing method has been conducted which are unit testing and user acceptance test. The purpose of this testing process was to check any defects or errors that were made during the development phases and to gain confidence regarding program functionality. It is also to ensure the functionality and operations meet the objectives.

4.1 Results of Unit Testing

Unit testing is the method of testing where it tests the individual units of source code, and program module to determine whether it can function appropriately. Once all of the units in a program are workings and free from errors, the larger components of the program were evaluated through integration testing. In this testing process, there were five modules that were tested. The modules are Bluetooth, smoke sensor, sender phone, receiver phone, and alarm application. The results according to these test cases were shown in table 2. This testing process was conducted by the developer of the system.

Table 2. Summary of the Results for Unit Testing

No.	Test Cases	Test Condition	Expected Results	Actual Results
TC01	Bluetooth Module	Test the connection between the device with the sender phone	Bluetooth paired the device with sender phone	Pass
TC02	Smoke Sensor Module	Test the detection of the smoke	Smoke detected in range of >400	Pass
TC03	Sender Phone Module	Test the connection for sending SMS	Able to send SMS to receiver phone	Pass
TC04	Receiver Phone Module	Test the SMS notification alert	Received the SMS notification alert	Pass
TC05	Alarm Application Module	Test the alarm sound and LED flashlight	The alarm able to 'beeping' and 'STOP ALARM' message will appear on the mobile screen	Pass

Based on the table, it shows that all components were performed as expected.

4.2 Results of User Acceptance Test (UAT)

User Acceptance Test (UAT) was conducted to determine if the requirements of the system specifications are met. This testing also used to evaluate the product or system by testing it with end users. Besides that, it can assist the user to understand the overall flow of the system and test whether the graphical user interface (GUI) is easy to use or complicated.

For this UAT, a specific questionnaire was designed and 20 respondents were participated. This testing process was conducted

on the real platform of the system which is Android smart phone. All questions were measured based on Likert Scale of five points starting from strongly agree to strongly disagree. According from the respondents' feedback it shows that this system is beneficial for them to use. This is because of the functionality and the cost is affordable compared to other devices. In addition, it is easy to setup and to configure the application even though for non-technical user. It can be concluded that this system able to performed well and meet the users' requirements.

5. CONCLUSION AND RECOMMENDATION

A Smoke Detection Alert System is a device that detects smoke and alert via SMS to authorize person if there is a potential fire. It can detect fire in early stages and give precious minutes to enable you and your family to leave your house in safety.

Moreover it is a kind of security features that significant to our house, office, and personal area. People getting more concerned to protect their place from fire hazard. Since, if it happens it can cause loss of properties, traumatized, and most worst is can threat human life. Therefore, the development of this system is significant where it is able to prevent from the fire hazard. This system is able to detect smoke by using a smoke sensor that is integrated with the Arduino platform and Android smartphone. SMS and alarm is used to alert users via their smartphone when smoke detected.

In order to make this system more significant and valuable, some recommendations can be implement in the future. This system is able to give high impact to users by having automatic water sprinkle function. Water will sprinkle when the sensor detect smoke. Besides that, adding a motion sensor to the system in order to prevent from intrusion of unauthorized people. The motion sensor will be able to detect object movement. Moreover, it will assist the users in monitoring their house when they are away for working, holiday, and others.

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