Home Security System with IOT Based Sensors Running On House Infra Structure Platform

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Abstract. In this research a system that is based on IOT technology was developed. The system itself is a subsystem of a home security system. The subsystem is one of the essential parts of a home security system that protects its inhabitants, the house itself and the environment around it. It is based on technology that is related to Internet of Things (IOT). The IOT technology being utilized depends on the data communication infrastructure that is running in a house. The infrastructure is built and based on Lora (long Range) technology and in particular Lorawan. The Infrastructure complies with the demand that it is useful and fulfils the requirements of IOT. Lorawan is quite recent but technically comply with the demands for IOT. This research focused on gas leakage detection using a detector. Gas leakage that needs immediate detection is generally used for home use such as LPG. LPG is generally used in house kitchens or sometimes bath rooms. The developed module is for detection and issuance of warning the existence of LPG in its environment. The data for issuance of warning is communicated to a system called Premises Controller. The protection of a house against gas leakage is essential due to its sensitivity to fire sparks. Fire sparks can trigger fire and often explosion. A sensor’s sensitivity and the time of early warning determine the effectiveness of mitigating efforts.

Keywords: Gas Sensor, Internet of Things, Lorawan, Sensor Location.

1. Introduction

Current family home is equipped with appliances that are able to support various home chores. Those appliances help simplify daily household chores. There are some precautions that need attention for human safety and environment security. If the precautions are ignored either deliberately or more often unintentionally, fatal accidents could happen. To lessen the possibility of unintentional accidents, it is advisable to have a system that can monitor within a house and its environment from unexpected incidents. The system would do the monitoring and warns the house inhabitants and the security personnel in charge of any suspicious events. Generally such system is called Home Security System. Home Security System could prevent incidents such as house intrusions, gas leakage or its presence that could lead to fire. It could increase the inhabitants comfort and improve the owner’s peace of mind. If such a system is installed in a house, it could provide added value to the house itself. If the houses in the housing complex are equipped with such a system, the value of the housing...
complex could increase as well. A security system should be able to monitor the house under its responsibility for 24 hours [1]. If necessary it could be equipped with the capability of preventing intrusion efforts, forced entry, or other unexpected incidents.

In this research, a house will be protected from gas leakage as households often use gas for cooking purposes and in some cases water heating. Liquefied gas that is common in use is LPG. Even though the gas can be detected by its odour, but human presence is needed. To monitor the possibility of gas leakage continuously a suitable gas sensor is needed. The sensor could be designed to give warning if it senses certain gas amount in its vicinity.

The major problem in detection of gas leakage is choosing the right sensor that is sensitive to the particular gas in use. As LPG is highly flammable, the choice of sensor and particularly its placement should be carefully considered. Power required for the sensor and supporting elements should be properly selected due to its location and risks involving fire sparks possibility and the presence of flammable gas. The infrastructure for electronic data conveyance that is used is based on Lorawan. Lorawan is selected as it is wireless, low power and IOT suitable. IOT is essential for remote monitoring possibility. Wireless transmission is suitable for gas leakage detection where the sensor is placed close to the gas source. Placing the sensor close the gas source location is critical due to the nature of gas that is similar to electromagnetic wave radiating to all directions. A room without proper ventilation could increase the concentration of gas that is highly flammable. Small spark of fire could result in tremendous damage. Early warning of gas concentration built up is essential for decreasing the possibility of fire. In a house the current method of preventing further danger because of gas leakage is manually shut-off the gas source.

To lessen the danger the sensor should be able to transmit early warning [2]. Each house will have a Premises Controller to accept data from Internet of Things (IOT) object such as from the sensor. The controller is compatible with Lorawan which is the house infrastructure and can connect to the Internet for global access.

2. Technical Description Review

2.1. Gas sensor

Gas sensor could detect the presence of certain gas in its coverage vicinity [3]. It is an essential part of physical home security system where gas is used for several daily purposes such as cooking or water heating. It is normally connected to control system that can give warning or start a security process. Gas sensor is important as gas being used in household such as LPG is highly flammable. Not only it is flammable but it has also explosive effect that can endanger human life and the environment. Technology could improve the safety of houses from flammable gas. Automatic shutting of gas leakage in a household is unheard. Shutting off gas flow in household environment is manually performed due to the nature and economic value of mechanical gas regulator. The sensor is part of early warning system effort. Early types of sensor is able to detect a certain gas only, but currently it can detect the presence of more than one type of gas both poisonous gas and flammable gas [4].

Detection of gas is based on various mechanisms such as electrochemical, oxidation, and ionization. In electrochemical gas will pass through porous membrane toward electrode. Electric current being produced will determine the presence of gas of dangerous concentration. Electrochemical detector is reasonably stable and reliable. It is simple and relatively maintenance free. Gas detector has limited productive life as it is influenced by contamination from its environment. It must be replaced periodically recalibrated if necessary. Sensors can be developed to portable units or fixed unit. A fixed unit is usually installed at the probable gas leakage source to monitor it and its surroundings.

2.2. Gas sensor MQ-2

MQ gas sensors are a family of sensors that can detect certain gas economically [5]. MQ-2 is quite popular. It has the capability to detect LPG, isobutane, and propane having concentration between 300 ppm to 10,000 ppm [6]. MQ-2 can be used for home appliances such as oven or water heater. It is
even better being placed at the gas source such as LPG container. MQ-2 uses Al$_2$O$_3$ ceramic tube, and tin dioxide (SnO$_2$). Its conductivity is low in clean air. If the air is contaminated with LPG, isobutane or propane, the conductivity will increase as the gas concentration increases. For better result, it is advisable to preheat MC-2 first. MQ-2 is able to detect smoke as well. If it indicates the presence of smoke, it will have high conductivity. High conductivity means low resistance. The contacts of gas or smoke after preheat process changes sensor resistance. Connecting it to a microcontroller the change in resistance can be read by the microprocessor. The change in resistance is translated to change in voltage for reading by a microcontroller. The change of voltage will depend on the gas type. Calibration is advisable to have reliable result. MQ-2 is then connected to a microcontroller with additional capability to transmit data. Data transmission capability could be wireless [7]. In this system the presence of gas due to leakage is detected by MQ2. MQ2 sensors are connected to the house infrastructure through TTGO module. TTGO module is a microcontroller that includes LoRa as its data transmission facility. For IOT compatibility the power consumed should be small. In this research the infrastructure within a house is based on LoRa. LoRa is suitable for IOT within a house for most sensors that need small power. Sensors that need more power will use different data transmission method.

2.3. LoRa
IOT means various objects that are able to communicate via the Internet [8]. These objects have intelligence to collect and communicate their findings. They are usually sensors or others that are equipped with some intelligence that enables them to have Internet connections. The connection could be direct or to other device acting as gateway to the Internet. The intelligence and connection to Internet provide a capability for anytime and anywhere control. Internet gives convenience but need precaution related to access security. IOT is a technology that enables communication between devices and human. The objects acted as if they have intelligence [9].

To support the possibility for objects to communicate their data, they should have the capability to transmit their data accordingly. Objects that are IOT capable need transmission technique which is preferably wireless. Wireless is preferred due to its ease of installation. Low-power wide-area networks (LPWAN) was developed to support the need of infra-structure for IOT [10]. Various IOT objects could send their data. The data itself is normally very small. Lorawan is one of the LPWAN implementation. Lorawan is based on LoRa (Long Range) which is a physical layer specification. Lorawan is the specification for Wide Area Network is released to the public [11]. Lorawan is specified for data communication wireless infra structure for IOT objects. Lorawan has advantage in low power consumption and consequently limitation in data size [12].

Lorawan provides low power wireless communications protocol and system architecture. The low power consumption is suitable for infra structure within a house typically devices operating with batteries [13]. Lorawan can fulfil the needs of IOT for data communications and limited mobility. Lorawan is specified to follow star of star topology. It has a wireless base station called gateway. A gateways could be connected a server using common protocols. As the server is in the Internet, the interaction could provide value added to the system. Internet access could use available Internet access services such a Wi-Fi, 3G/4G, common fixed TCP/IP connection. The connection enables the possibility that other objects could have presence in the Internet. Lorawan only transmit sensors monitoring results. A Premises Controller to receive sensors result could be developed to fulfil the task. IOT devices in Lorawan are considered as End Node which is generally a transmitter element. End Nodes are commonly remote sensors or applications. They have a certain related receiver known as gateway. Data transmitted by an End node is received by gateways that are able to detect the data. A gateway has the intelligence to discriminate which data to forward to the server. The server will be programmed to have the capability to take appropriate action and store the data for further processing.
3. Methodology

Functional system diagram is shown in Figure 1. If the sensor detects the presence of LPG gas in its environment, the sensor will send an indicator through its Lorawan to the gateway as the Premises Controller. Premises Controller is also a concentrator for various other sensors within the house. Premises Controller concentrated sensor information. They are sent to Cluster Controller for storage in a database. Information of each house can be accessed via the cluster controller either from a fixed, nomadic or mobile position by the house inhabitants or guards in charge. Cluster controller is the central control and monitoring system of the cluster of houses in that particular housing complex. Sensors only sent data indicating what the conditions it finds, consequently the data size is small. Power required to transmit the data is small. Verbose information resulted from processing indicator data is provided by both the Premises Controller and Cluster Controller. Warning alarms could be issued by either the Premises Controller, Cluster Controller or both. Warning alarms could be audible alarm, or messages sent to recipients subscribing to cellular service provider. In this research both Premises Controller and Cluster Controller are not developed yet.

![Figure 1. Functional System Diagram](image1)

To detect the presence of gas due to leakage, MQ2 sensors that are connected to the house infrastructure through TTGO modules are implemented. TTGO module is a microcontroller that includes LoRa as its data transmission facility. The TTGO connected to a sensor acts as a data transmitter and a module that acts as a receiver will be part of a Premises Controller. The required intelligence is embedded in it. The embedded software is based on Arduino IDE and ESP 32 [14], [15]. MQ2 could provide indication on its environment if there are changes in gas concentration. This module can run on batteries which suitable for IOT objects and safety in detecting flammable gas.

Test of system component were performed at Computer Engineering laboratory to ensure the capability of Lorawan module as integral part of TTGO module. TTGO module has a microcontroller that is compatible with Arduino IDE for its intelligence. MQ2 was also connected to TTGO. MQ2 can provide analogue or digital indication to TTGO. The sensitivity of TTGO for digital indication can be set. As soon as the digital indicator is triggered, the indication was sent directly to its gateway or concentrator. The test diagram of MQ2 is as following:

![Figure 2. Sensor Sensitivity Test](image2)

Sensor sensitivity and its placement were measured to determine the right location to detect as early as possible the presence of LPG. As LPG is highly flammable, the location of the sensor should
as close as possible to the gas source in order to avoid the possibility burns and explosion due to gas burns. The location where gas can be detected at the earliest possible moment is critical. If gas has spread out the danger of explosion would increase. TTGO can be programmed to function as a switch. If there were many sensors, TTGO could send to the Premises Controller to forward to the Cluster Controller and stored in a database or issued audible alarm.

4. Results
Measuring the sensitivity of MQ2 in detecting the presence of LPG in its surrounding is related to the safety of human within the house and its surroundings. In performing measurements, the researcher and its surrounding must be protected from fire and explosion possibilities. The parameters of interest were distance of sensor to the LPGs source, the time it took to detect the presence of LPG at that distance, and the time LPG would burn if a fire source is present at that distance. The measurement was performed in a kitchen that is commonly part of a house and oven using LPG. The kitchen of choice is a well ventilated kitchen to mitigate the risk of fire and explosion. A fire source in the form of a lighted candle was used. If the fire source was placed 5 cm close to the LPG source, it took less than 5 second to burn the gas. If the fire source is moved to 10 cm away from the gas source, it took more than 50 seconds to burn the LPG. The fire it caused was quite big and accompanied with explosive sound. If LPG gas flowed more than 60 seconds, its fire size was already being dangerous and explosive. Further measurement was not carried out within this set-up. Need properly designed laboratory set-up

5. Conclusions and Discussions
Measurements showed that MQ-2 was sufficiently sensitive. It could detect the presence of gas before its concentration endangered the environment provided its location is within 5 cm of the gas source. This location enabled MQ-2 to inform the presence of concentration of LPG before fire source caused it to burn. Placing the sensor away 10 cm from LPG gas source would need time for the sensor to react as its concentration spreaded out to all direction. MQ-2 needs at least 300 ppm before it reacted. Measurement showed it needed 30 seconds to reach concentration that could burn dangerously. Gas source located 5 cm could be detected by MQ-2 within 10 seconds. If the gas source could not be controlled within a short time, gas would spread out and endanger house inhabitants and environment. Bad ventilation does not only increase the possibility of fire due to the increase of gas concentration and explosion due to pressure increase. In home set-up the sensors placement should be close to the probable gas source leakage which is the gas container itself and not the oven. Placing the sensor at the gas container could be close to the gas outlet. Gas leakage can be detected as early as possible. Even though best practice sensor location needs close to an oven due to the possibility of human error or forgetfulness, but in practice it is not possible. It is best practice to have good ventilation for a room that has gas source to dissipate gas concentration. Currently to overcome gas leakage in a house is only manual action with precaution. Either to let the gas dissipate until the sensor does not detect dangerous gas concentration or closed the leakage until the gas concentration trigger off the detector.

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