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IoT-Enabled Fire Alarm System with Cloud-Based Storage and Monitoring

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Abstract: The purpose of a fire alarm system is to warn us of an emergency so that we can take precautions to safeguard ourselves, our employees, and the public. However, modern fire alarm systems require a significant amount of wiring and labor during installation. The most frequent issues that was encountered during monitoring commercial and residential fire alarm systems are false alarms, inappropriate installation, lost connections, malfunctioning or aged equipment, and careless maintenance that discouraged users from putting them in their houses as a result. Hence, the researcher developed an IoT-based fire alarm system connected to several types of sensors and micro-controller distributed over the building and house. Each of these nodes is made up of an Arduino microcontroller that is coupled with smoke, temperature, humidity, flame, methane, and carbon monoxide (CO) sensors. Thus, an innovative system is designed with the help of Internet of Things (IoT) that records live reading of sensors and stored in cloud interface which also lessens the investigation process of the authorities concerned. Results shows that majority of the evaluators responded to the functionality of the proposed system to be Superior and provide all the functionality required for the system to detect and prevent fire occurrences.

Keywords: IoT, Cloud Computing, Micro-Controller, Sensor, Fire Alarm.

I. Introduction

Internet of Things (IoT), we know it's the future of things. It is the new era in transforming the existed systems to amend the cost-effective quality of services for society. We can connect it to almost any gadgets there is. But one thing bothers me, and that is fire prevention with not that much specificity on it. Previous systems have fire prevention and alarm features based on IoT but not with the specific and precise reporting on where the fire started, what floor is affected if there is any and send SMS to the homeowner about the occurrence of fire. In the Philippines, the Bureau of Fire Protection or also known as the BFP, is the sole government agency mandated to protect lives and properties against destructive and killer fires. This entity delivers public awareness on life safety and fire prevention to preserve the lives and wealth of every individual and is also tasked to provide several measures. Ways to lessen fire accidents, and one of these methods is installing fire alarms at homes, offices, schools, or structural buildings. From 2013 to 2017, the BFP recorded a total of 77,724 fire incidents, or an average of 15,545 fire incidents every year or 42 fire incidents a day. During the period, the total estimated damage to property reached P23.273 billion or an average of P4.65 billion every year. Also, during the period, 1,257 people were killed or an average of 251 deaths every year. During the five years, the number of injured persons reached 4,239, or an average of 848 persons suffering from fire-related injuries to be avoided. According to the BFP, the top three causes of fires are electrical connection, lighted cigarette butt, and open flame. A fire originating from electrical connections may either triggered by electrical overload, an electrical arc or an electrical short circuit. Lighted cigarette butts that caused fires are those usually indiscriminately thrown away by cigarette smokers, accidentally touching flammable material that starts a fire.

Using cloud storage, users can store their data remotely and enjoy the on-demand high-quality applications and services from a shared pool of configurable computing resources without the burden of local data storage and maintenance [5]. [Wei] stated that cloud computing emerges as a new computing paradigm that aims to provide reliable, customized, and quality of service guaranteed computation environments for cloud users. Applications and databases are moved to the large centralized data centers, called cloud. [10] sited the design of a home fire alarm with Arduino-based System utilizing GSM Module. [2] sited that review of existing fire-detector types has been carried out along with the development of a low cost, portable, and reliable microcontroller based automated fire alarm system for remotely alerting any fire incidents in household or industrial premises. Various wireless technologies that can support some sort of remote knowledge transfer, sensing, and management like Bluetooth, WiFi, and cellular networks are used to enter sufficient levels of understanding within the home. [3] Despite these advantages, home automation has received extensive approval and attention due to its high significance and complexness [1]. [9] stated in their study that in a near soon, any object will have a unique way of identification and can be addressed so that every object can be connected. [4] mentioned that as fluctuation in demands, the Fire and Rescue Service must equip with the best techniques, training regime, and equipment to meet public expectations. [15] also mentioned that these high-cost systems could not be deployed in all average income homes; thus, developing Fire monitoring and Warning System using Arduino is economical and affordable by all. [7] mentioned that different fire types emit different gases in changing concentrations. Open flaming fires, for example, are often related to higher combustion temperatures and also emit NO_2 with a minor contribution of CO. The remote alarm system provides the benefit of monitoring the premise from a distant location and taking immediate action based on the

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message received, unlike the manual System. These Remote monitoring systems can be developed in various ways using wireless sensor networks, Ethernet, image processing, and other digital communication technologies [2].

Due to these, the researcher got inspired to propose and develop an IoT-based fire alarm and precise notification through mobile communication or SMS. The proposed System is capable of detecting smoke, different flammable gases, and fire. It is capable of sending SMS notifications of exact and specific details of the origin of the fire and the address of the affected area to the nearby fire department. This kind of fire prevention sensing system with a systematic IoT framework emphasizes application innovation to the public safety and livelihood service sector. Thus, an intelligent innovative system is designed with the help of IoT. That lessens the investigation process of the authorities concerned.

Research Objectives

This study aimed to design, develop, and evaluate IoT-Enabled Fire Alarm System with Cloud-Based Storage and Monitoring.

1. To developed a Fire Alarm System that will measure the following:
    - 1.1 Smoke;
    - 1.2 Heat; and;
    - 1.3 Gas.
2. To evaluate the developed system in terms of:
    - 2.1 Functionality;
    - 2.2 Performance;
    - 2.3 Robustness; and;
    - 2.4 Workmanship.

Conceptual Framework of the Study

The process flow of the proposed fire response mechanism shown in Fig. 1 starts with the smoke and temperature detection device installed in a structural building, specifically in the "trial house." The plot is set up in a commonplace in a house, which is considered the prone area of a fire occurrence where data reading from the sensor is gradually recorded and saved in the cloud server. Once an unexpectedly high degree of fire is detected, the device will send a signal to the microcontroller that will transfer codes to the GSM module serving as the receiver. The receiver device will then wirelessly send a notification to the homeowner and the nearest fire station. The SMS message will serve as the guide of the BFP personnel, mainly firefighters, to quickly locate the fire. With the real-time identification of the fire's exact location, delays in response will be avoided; thus, immediate rescue and emergency services will be provided.

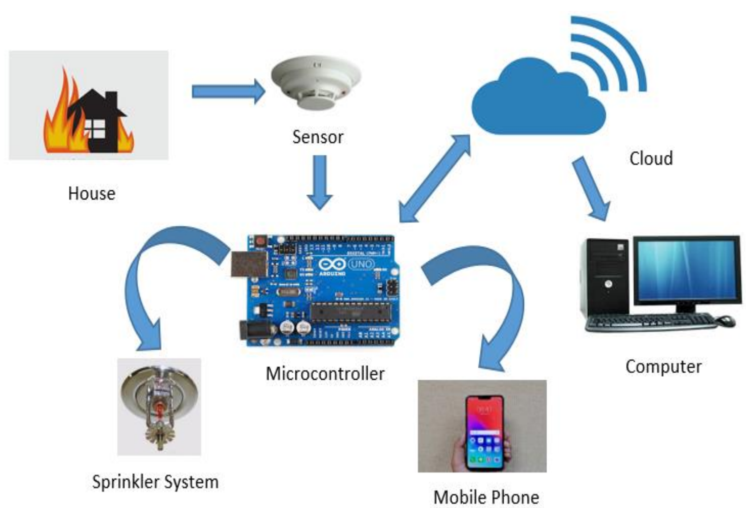

Fig. 1 Conceptual Framework of the Study

II. Methodology

Research Flow

Figure 2 shows the research flow of the study. It gives the vital step by step outlined and procedure of the study. Data are captured through sensors and interpreted to Arduino controller to convert electrical signal to numerical data readings. Arduino

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sends data to the cloud and check for abnormal data readings. If data reaches critical state, the system will send warning messages to homeowner and BFP personnel. Evaluate the developed system in terms of functionality, performance, robustness, and workmanship.

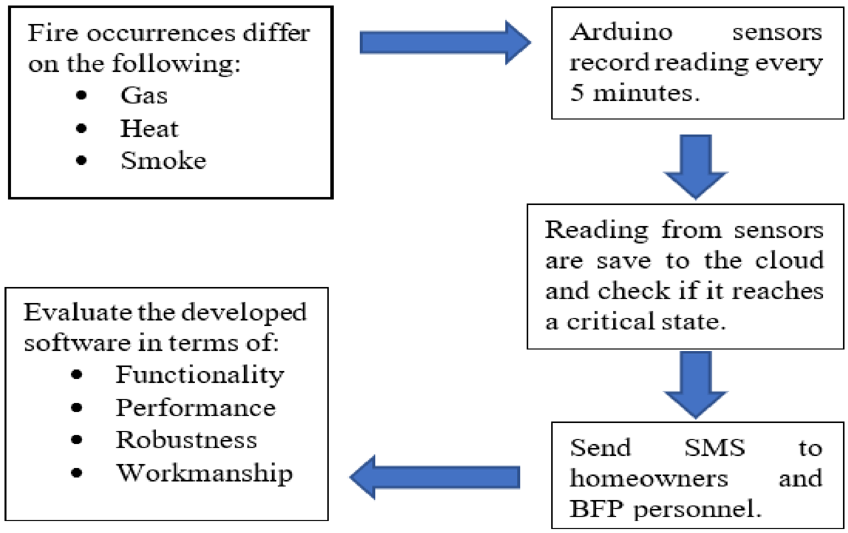

Fig. 2 The Research Flow

The Prototyping Model is a Systems Development Methodology (SDM) within which a paradigm output (or an early approximation of a final system or product) was constructed, tested, and then reworked. It is done until an appropriate paradigm is achieved to help develop the entire System or product. This model works best in situations when all the details or requirements are not known well in advance. It is majorly a trial-and-error process that works iteratively. Figure 3 presents the Software Development Life Cycle Prototype Model of the study.

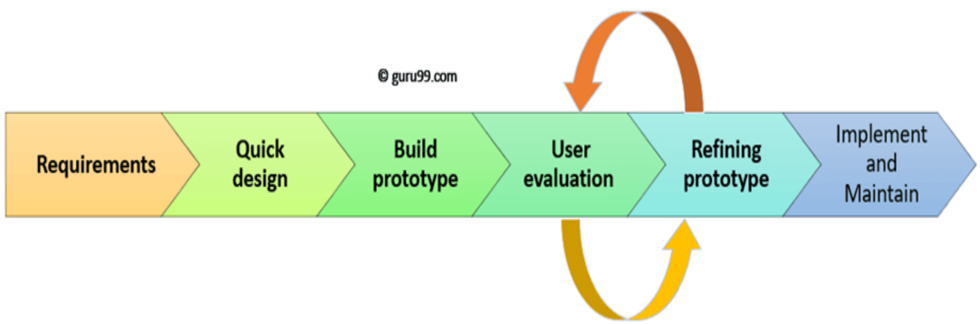

Fig. 3 Software Development Life Cycle Prototype Model

Requirements gathering and analysis. A prototyping model started with requirement analysis. In this phase, the needs of the System were defined in detail. During the process, the System users were interviewed to know their expectations from the System.

Quick design. The second phase was a preliminary design or a smart design. In this stage, a simple model of the System is created. However, it is not a complete design. It gives a brief idea of the System to the user. The quick design helps in developing the prototype.

Build a Prototype. In this phase, an actual prototype was designed based on the information gathered from a quick design. It is a small working model of the required System.

Initial user evaluation. In this stage, the developed System is presented to the client for an initial assessment. It helps to find out the strength and weaknesses of the working model. Comment and suggestions are collected from the customer and provided to the developer.

Refining prototype. If the user is not happy with the current prototype, you need to refine it according to the user's feedback and suggestions. This phase will not be over until all the requirements specified by the user are met. Once the user is satisfied with the developed prototype, a final system is developed based on the approved final prototype.

Implement Product and Maintain. Once the final System is developed based on the final prototype, it is thoroughly tested and deployed to production. The System undergoes routine maintenance for minimizing downtime and prevent large-scale failures.

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Research Design

This study used the Developmental-Descriptive Design utilizing the adopted-evaluation form as the primary tool to collect the necessary data from the respondents [17]. Developmental Design supports the development of innovation and adaptation in dynamic environments. Developmental research seeks to create knowledge grounded in data systematically derived from practice. The researcher followed the assessment method used by a private graduate college in New York City at the Rochester Institute of Technology. In its Engineering Design Guide and Environment (EDGE) software, RIT uses this assessment method. EDGE is an open-source platform to support project developers and development teams. The researcher believes that the material is adequate for the evaluation of the developed system. The form involves grading the prototype/model from A+ (96 percent and higher) being the highest to F (60 percent and lower) being the lowest. It also involves grading the prototype/model in various factors such as Functionality, Performance, Robustness and Workmanship. Using evaluative analysis, the researcher interpreted the results of the proposed computer software model.

Research Environment

This study was conducted at the Municipality of Sogod Southern Leyte Philippines shown in Appendix C. Since the place was part of the homeland of the researcher and this Municipality considered as one of the most aggressive and impressive Municipalities in the Second District of Southern Leyte and as a whole in the entire province of Southern Leyte.

Research Respondents

The target respondents of this study were that 1 homeowner, 2 IT Professionals, and 2 Fire Personnel who used the proposed system as their Fire alarm system.

Table 1. Respondents of the Study

Evaluators	No. of Evaluators
Homeowner	1
IT Professionals	2
Fire Personnel	2
TOTAL:	5

Research Instrument

The standardized adopted-evaluation form from Rochester Institute of Technology was used as an instrument in this study shown in Appendix B. The researcher used the said research instrument in conducting rounds of assessment for the evaluation of the proposed computer software model. Determining the effectiveness of the computer software model; the evaluators used the following scale:

Table 2. Research Instrument Likert-Scale

GRADE	INTERPRETATION	REMARKS
A+	96.1-100	
A	93.1-96.	Superior
A-	90.1-93	
B+	86.1-90	
B	83.1-86	Above Average
B-	80-83	
C+	76.1-79	
C	73.1-76	Average
C-	70-73	
D+	66.1-69	
D	63.1-66	Below Average
D-	60.1-63	
F	<60	Failing

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Data Analysis Procedure

After the data was gathered, it was tabulated to get the mode, value that occurs most frequently in the dataset, to evaluate the proposed computer software model. The researcher followed the assessment method used by a private graduate college in New York City at the Rochester Institute of Technology.

III. Results and Discussion

Fire Alarm System Using Internet of Things (IoT)

The developed Fire Alarm System is built on commercializing demand growth in the fire alarm market. It consists of three sensors, temperature, smoke, and fire sensor, controlled with the central controller. [13] stated that wireless sensor networks are an emerging technology consisting of small, low power, and low-cost devices that integrate limited computation, sensing and remote communication capabilities. The Temperature sensor, smoke sensor, and Fire sensor were installed in a structural building, or a trial house where the System will be implemented. The unit was mounted in a specific position in a home that is known as the susceptible location of a fire incident. Once an unexpectedly high degree of fire is detected, the device will send a signal to the microcontroller that will transfer codes to the GSM module sending the homeowner and fire department warning text messages. The sprinkler system will automatically disperse water to the affected area of fire occurrence. According to [8], determination of room fire associated temperatures provides a means of assessing an important aspect of fire hazard: the likelihood of flashover occurrence. The frequency of flashover was consistent with layering temperatures over 60 ° C. Rapid changes in temperature must be closely monitored in case temperature reaches over 60 ° C so that the System can do necessary actions. The LM35 temperature sensor is used to read the data in the trial house. The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin. The user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range. Lower cost is assured by trimming and calibration at the water level. The low-output impedance, linear output, and precise inherent calibration of the LM35 device make interfacing to readout or control circuitry especially easy. The device is used with single power supplies, or with plus and minus supplies. As the LM35 device draws only 60 µA from the supply, it has a very low self-heating of less than 0.1°C in still air. The LM35 device is rated to operate over a −55°C to 150°C temperature range, while the LM35C device is rated for a −40°C to 110°C range (−10° with improved accuracy). LM35 temperature sensor showed in Figure 4.

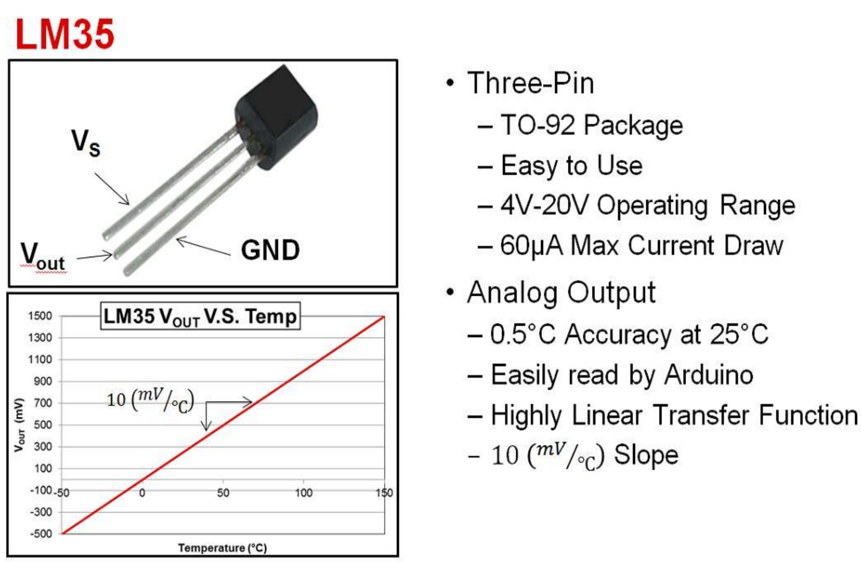

Fig. 4 LM35 Temperature Sensor

LM35 can be used in two circuit configurations. Both yield different results. In the first configuration, you can only measure the positive temperature from 2 degrees Celsius to 150 degrees Celsius. In this first configuration, we simply power lm35 and connect the output directly to analog to digital converters. In the second configuration, we can utilize all the sensor resources and measure the full range temperature from -55 degrees centigrade to 150-degree centigrade. This configuration is a little complex but yields high results. We have to connect an external resistor, in this case, to switch the level of negative voltage upwards. The external resistor value can be calculated from the formula given below the configuration circuit. The second configuration circuit can be made in various ways. To see about the second configuration circuits, visit the LM35 datasheet by Texas Instruments. Texas Instruments datasheet enlists the circuit with clear component values. Figure 5 shows the LM35 temperature sensor circuit configuration.

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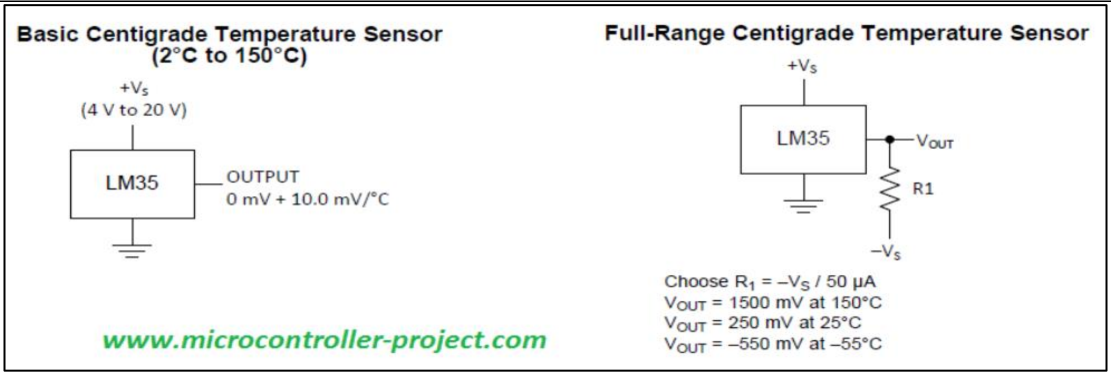

Fig.5 LM35 temperature sensor circuit configuration

The smoke inside the trial house must also be closely monitored. According to [11], fire and gas alarm detection systems are important tools for protecting our home, building, office, market and other places of residence. A well-designed fire and gas system is designed to automatically detect and, in some cases, mitigate fire, flammable gas and toxic gas hazards. The combustion process results in a rapid release of stored energy. The three broad phases are pre-ignition, flaming, and smoldering. The amount and type of smoke produced will vary during each step. During pre-ignition, the fuel consumes energy. The temperature of the fuel is raised to ignition temperature. Around the same moment, much of the heat is evaporated and washed dry. Small quantities of white smoke are produced-mainly water vapor. Once the fuel exceeds the combustion point, the burning process starts and erupts into flames. Petrol also undergoes a chemical transition, producing vast quantities of heat and pollutants. The heated gases ignite when mixed with oxygen, and rapid oxidation occurs, producing large amounts of smoke. The heat which is being produced lifts the smoke off the ground. At this stage, the combustion process is very useful. All smoking is carbon dioxide and water vapor. Figure 6 shows the MQ2 Gas and Smoke Sensor.

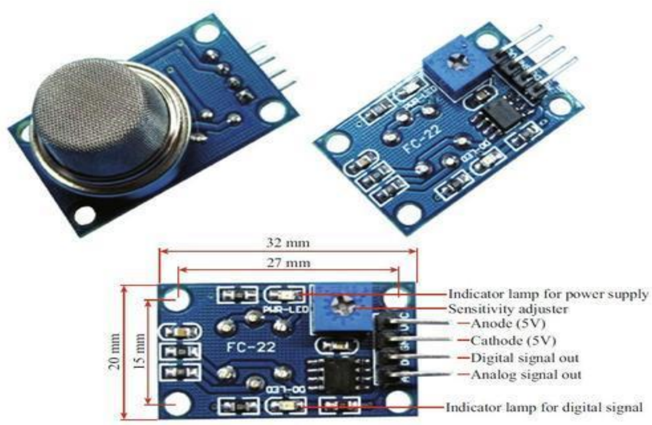

Fig.6 MQ2 Gas and Smoke Sensor

MQ2 Gas sensor operates on 5V DC and draws about 800mW. This is capable of detecting amounts of LPG, dust, gasoline, propane, petrol, methane and carbon monoxide somewhere between 200 and 10000ppm (create.arduino.cc, 2016). Parts-per-million (abbreviated as ppm) is the ratio of one gas to the other. For an instance, 1,000ppm of CO means that in a million gas molecules, 1,000 of them would be of carbon monoxide and 999,000 molecules would be some other gases. Figure 7 shows the MQ2 Gas sensor complete specification.

Operating voltage	5V
Load resistance	20 KΩ
Heater resistance	33Ω ± 5%
Heating consumption	<800mw
Sensing Resistance	10 KΩ – 60 KΩ
Concentration Scope	200 – 10000ppm
Preheat Time	Over 24 hour

Fig.7 MQ2 Gas sensor complete specification

With all the data being gathered and processed by the central controller, it will be sent to the Internet of Things Platform and recorded. Activity identification is the last part of the process. If the System detects abnormal sensor data readings, the following activities are carried out:

•If smoke and gas reading is high, the SMS module is triggered and send warning text messages to the homeowner about the reading abnormality.

•If the temperature reading is high, the SMS module is triggered and sends warning text messages to the homeowner about the reading abnormality.

•If temperature, smoke and gas reading is high, the SMS module is triggered and send warning text messages to the homeowner about the reading abnormality. Water sprinkler is also turned on for preventive measures in case of fire.

•If the fire sensor is high, the SMS module is triggered and sends warning text messages to the homeowner and fire Department about the reading abnormality. Water sprinkler is also turned on for preventive measures of fire.

The developed Fire alarm system automatically uploads data to the Internet of Things platform every 10 seconds to save all data necessary for fire investigation.

Parts of the Device Detector

Arduino Yun is the first member of a new groundbreaking line of WiFi products, which integrates Linux power with Arduino quality and ease of use. Figure 8 Exhibits the fire detection Alarm elements. (1) GSM module which transmits and decodes data from a cellular network that establishes communication between a mobile network and the computer thus unwired data transmission. (2) Arduino microcontroller executes the data and instructions written in the Arduino language in C-like configuration to read inputs and produce outputs, the software is required. (3) The smoke sensor is charged with the optoelectronic techniques for detecting smoke and works on the light dispersal system. (4) The temperature sensor is a task to output an analog signal proportional to the instantaneous temperature. The output voltage can easily be interpreted to obtain a temperature reading in Celsius. (5) A flame detector is a sensor designed to detect and respond to a fire or fire, allowing the detection of fire with ultraviolet (UV) detectors to detect the UV radiation emitted at the moment of ignition. (6) Solenoid Valve is an electromechanically operated valve task to release and shut off the water supply. (7) The mini breadboard is a plug-and-play way to make connections between electronic components. (8) and Adaptor is the device used to attach all the detector device in the single main socket for power supply. Some of the hardware required for the System are not available due to COVID-19 Pandemic, and the equipment ordered is canceled out or not delivered successfully.

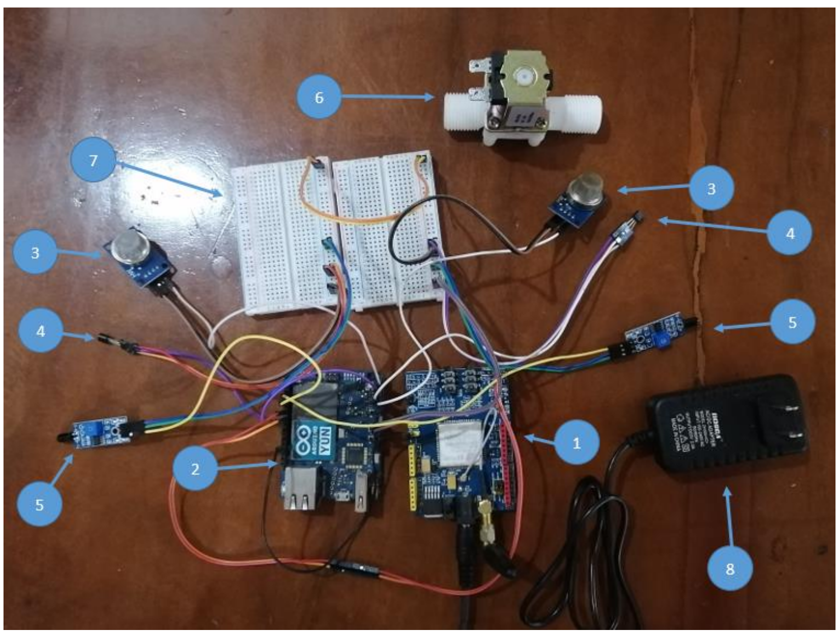

Fig. 8 Parts of the Device Detector

Figure 9 Exhibits the Internet of Things Platform. Ubidots is an IoT Platform that empowers innovators and industries to prototype IoT projects and to scale them into production. It can submit data from any connected internet system to the cloud through the Ubidots framework. It can also customize activities and warnings based on real-time data and activate data value through visual tools. Ubidots offers a REST API that enables it to read and write data to the available resources: data sources, variables, benefits, events, and insights. The API supports HTTP and HTTPS and requires an API key. Two additional replication, encrypted storage, and optional TLS / SSL support will protect your data. It can also customize permission groups to each platform module, ensuring the right user is shown the correct information.

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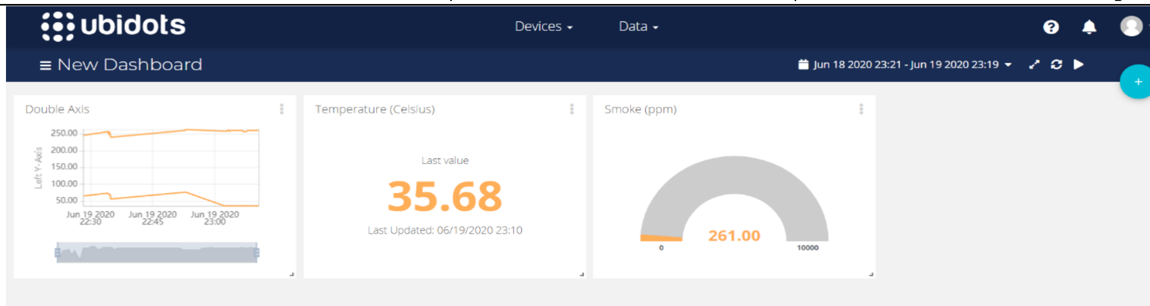

Fig. 9 Internet of Things Platform

Evaluation of the Fire Alarm System Using Internet of Things (IoT) with Cloud Storage to Detect and Prevent Fire Occurrences

After constructing the model, documentation and testing phase was performed to correct the errors and adjusting the mathematical formula. During the operation of Fire Alarm System Using Internet of Things (IoT), recommendations were noted and implemented to enhance the best performance and functionality of the model. Based on the evaluation given by the team of five (5): Two (2) IT Experts, two (2) fire personnel, and one (1) Homeowner using the Prototype/Model Demonstration and Evaluation Form from Rochester Institute of Technology. In getting the Interpretation of the Accumulated Grade per attribute, the researcher used the modal, which was the most frequently occurring score or value.

Table 3. Evaluation of the developed Fire Alarm System

Attribute Being Evaluated	Grade (MODE)	Interpretation	Remarks
Functionality?: Does the prototype/model have all the functionality required to meet the team's deliverables	A	93-96	Superior
Performance?: Does the performance of the prototype/model meet the team's deliverables	A	93-96	Superior
Robustness?: Can the prototype/model operate repeatedly without adjustments or repair	A	93-96	Superior
Workmanship?: Does the prototype/model fabrication show quality workmanship	A -	90-93	Superior
Overall?: Grade Recommendation	A	93-96	Superior

Legend: F <60 D- 60-<63 D 63-<66 D+ 66-<69 C- 70-<73 C 73-<76 C+ 76-<79 B- 80- <83 B 83-<86 B+ 86-<89 A- 90-<93 A 93-<96 A+ >96

Results shows that majority of the evaluators responded to the functionality of the proposed system to be Superior and provide all the functionality required for the system to detect and prevent fire occurrences are compiled and well executed. [14] software functionality service quality reflects how well it complies with or conforms to a given design, based on functional requirements or specification and can also be described as the fitness for purpose of a piece of software or system. In addition, that majority of the evaluators responded to the performance of the proposed system to be Superior and perform all the useful work of the proposed technology and achieved its system objectives. Also, most of the evaluators responded to the proposed system to be Superior in terms of robustness where the system still provides accurate and trustworthy information of the location of the fire when met with software and hardware failures. And lastly, that majority of the evaluators responded to the performance of the proposed system to be Superior, the proposed system shows quality workmanship is imparted and the proposed system is not defective for the purposes for which it was made. [6] the dependability of fire equipment components and system should be high, and the performance parameters should obey the requirements of design. In general, result shows that the proposed fire alarm system overall grade was Superior and with the proper implementation and integration of the current technologies, the proposed fire alarm system will help in cases of emergency that would provide real-time information to prevent or mitigate the loss of lives and properties.

IV. Conclusions

Running the technology immediately after turning it on and immediately detecting the heat and smoke to trigger the alarm. The capability of the proposed technology provides accurate and trustworthy information on the exact location of the fire to the fire station personnel when meeting with software and hardware failures. The users can easily understand the functionalities of the application, and the ease-of-use can be achieved in terms of human interaction. The new fire management system would assist in

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the useful application and incorporation of emerging technology in emergency circumstances. It will include real-time intelligence to deter or minimize the loss of lives and assets. Fire hazards can be fatal and denigrating for industrial and household security, also minatory for human life. The best way to reduce these losses is to respond to the emergency situation as quick as possible [12]. By implementing the new System, the firefighters would be supplied with the appropriate and accurate details on the fire's site and will be able to respond quickly to the public's needs. Preventing fire damage, death, and destruction of property. The centralized installation of the new mechanism in various households and establishments throughout the city will enable these stations to communicate effectively and to inform the occurrence and location of the fire, thus providing an efficient service to society that adheres to the doctrine of life preservation of the BFP in emergencies, disasters and calamities.

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References

1. Al-Ali, Abdul-Rahman, and Mohammad Al-Rousan. "Java-based home automation system." Consumer Electronics, IEEE Transactions on 50.2 (2004): 498-504.
2. Asif, O., Hossain, M. B., Hasan, M., Rahman, M. T., & Chowdhury, M. E. H. (2014). Fire-Detectors Review and Design of an Automated, Quick Responsive Fire-Alarm System Based on SMS. International Journal of Communications, Network and System Sciences, 07(09), 386–395. doi:10.4236/ijcns.2014.79040
3. Atzori, Luigi, Antonio Iera, and Giacomo Morabito. "The internet of things: A survey." Computer networks 54.15 (2010): 2787-2805.
4. Azmil, M. S. A., Ya'acob, N., Tahar, K. N., & Sarnin, S. S. (2015). Wireless fire detection monitoring system for fire and rescue applications. 2015 IEEE 11th International Colloquium on Signal Processing & Its Applications (CSPA). doi:10.1109/cspa.2015.7225623
5. Cong, H., Wang, X., Kong, X., & Xu, H. (2019). Effects of fire source position on smoke extraction efficiency by natural ventilation through a board-coupled shaft during tunnel fires. Proceedings of the Combustion Institute, 37(3), 3975-3984.
6. Du, Y., Mao, X., Xu, D., & Ren, F. (2012). Analyzing the Effects of Failure on Fire Equipment in Building by FAST. Procedia Engineering, 45, 655–662. doi:10.1016/j.proeng.2012.08.218
7. Gutmacher, D., Hoefer, U., & Wöllenstein, J. (2012). Gas sensor technologies for fire detection. Sensors and Actuators B: Chemical, 175, 40–45. doi:10.1016/j.snb.2011.11.053
8. Lian, C. (2011). Design of intelligent fire alarm system based on the GSM network. Proceedings of 2011 International Conference on Electronics and Optoelectronics. doi:10.1109/iceoe.2011.6013128
9. Lu Tan & Neng, Wang. (2010). Future Internet: The Internet of Things. 2010 3rd International Conference on Advanced Computer Theory and Engineering (ICACTE). doi:10.1109/icacte.2010.5579543
10. Mahzan, N. N., Enzai, N. I. M., Zin, N. M., & Noh, K. S. S. K. M. (2018). Design of an Arduino-based home fire alarm system with GSM module. Journal of Physics: Conference Series, 1019, 012079. doi:10.1088/1742-6596/1019/1/012079
11. Myint, Htay, and May Zaw Tun. Arduino based Fire Detection and Alarm System Using Smoke Sensor. Diss. MERAL Portal, 2020.
12. Omar, E. R., Zohra, M. B., Amine, R. I. A. D., & Alhamany, A. (2023). New smart actuator based on shape memory alloys for avoiding overheating and preventing fire in electronic devices. Metallurgical and Materials Engineering, 29(1), 129-141.
13. Poonam, Prof. (Dr.) Yusuf, M. (2013). Remote Temperature Monitoring Using LM35 sensor and Intimate Android user via C2DM Service. IJCSMC, Vol. 2, Issue. 6, June 2013, pg.32 – 36. ISSN 2320–088X
14. Salleh, M. A., Bahari, M., & Zakaria, N. H. (2017). An Overview of Software Functionality Service: A Systematic Literature Review. Procedia Computer Science, 124, 337–344. doi: 10.1016/j.procs.2017.12.163
15. Suresh S., Yuthika S., & Vardhini, G. A. (2016). Home-based Fire Monitoring and warning system. 2016 International Conference on ICT in Business Industry & Government (ICTBIG). doi:10.1109/ictbig.2016.7892664
16. Wei, L., Zhu, H., Cao, Z., Dong, X., Jia, W., Chen, Y., & Vasilakos, A. V. (2014). Security and privacy for storage and computation in cloud computing. Information Sciences, 258, 371–386. doi: 10.1016/j.ins.2013.04.028
17. Agoylo Jr, J. C., Bacalla, A. C., & Agoylo, S. T. (2024). Modeling and Simulation of Solar Irradiance Conversion Using the Pyranometer App. International Journal of Latest Technology in Engineering, Management & Applied Science, 13(5), 17-27. DOI: 10.51583/ijltemas.2024.130503