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Research Paper

A Smart Home Automation system using IoT and Open Source Hardware

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Abstract

In the era of Internet of Things, the information will be exchanged without the intervention of human. The manual systems are transforming into smart systems with the incorporation of IoT. The remote superintendence of electrical devices and sensors in the home environment with the employment of the internet is called as home automation. The electrical devices like bulb, fan and the sensors like temperature sensor, gas sensor, flame sensor, PIR sensor, current sensor are monitored and controlled by the user remotely with the employment of IoT technology. The implemented system, has both the transmitter and receiver section. In the transmitter section the information from room 1 and room 2 will be gathered at the central server. The Arduino Uno and ESP8266 plays a significant role in the transmitter section. The Raspberry Pi central server facilitates the gathered information to the user in a Graphical user interface.

Keywords: *Electrical Device ; Home Automation; IoT; Open Source hardware; Sensors*

1. Introduction

The Internet of Things and Home automation employed together lead to a predominant enhancement in the technology [1]. The electrical devices in the home environment are made smarter with the inclusion of IoT. The managing and controlling activities in a home environment comprises the Home Automation. The Home automation facilitates the users with a contended, reliable, secure life [2]. In the home automation technology the human effort is much diminished. The human life is facilitated with ease due to enhancements made in the home automation. The Internet of things with the employment of home automation made rise to control and monitor distinct devices like Bulb, Fan, Air conditioner, Television, Washing machines and it is driving the human life with comfort. Many sensors and electrical devices are manufactured by distinct vendors, there may be a rise in intercompatibility issues. The intercompatibility issues can be overridden by the IoT because all the devices and sensors are integrated via the internet [3]. The three ways to control electrical appliances in the home environment are Automatic, manual, remote control [4]. In the automatic control, a specific firmware is implemented for controlling electrical appliances automatically in the home under some power tariff conditions. The ON and OFF of the electrical appliances can be accomplished automatically without the involvement of human users. The automatic control system is a also inherits the energy management scheme. In the Manual control, an On/OFF switch directly connects to the electrical appliances. The manual control system is a traditional way of controlling devices and makes it convenient to the users for managing it. In the remote control, the electrical appliances are observed and managed via the internet. The users can remotely control the electrical appliances from any part of the globe. The remote control systems have a firmware innovatively developed for smart monitoring and controlling of electrical appliances through web. This system can detect whether the electrical appliance is in ON/OFF state and hence can make the desired decision. In the Home environment two classifications of communications are possible they are one-way communication and two-way communication [5]. In the one-way communication, the device has the ability to transfer the information in only one way that is the device is intended to work in delivering and displaying the accumulated information to the user. In the two-way communication, the user controls and monitors the devices remotely by using a dedicated path or a network. The urge for IoT in the home environment is to enable to establish connectivity between the home and the outside world.

Internet of Things is visualized from three aspects: internet, things, semantic. The Internet of Things permits individuals and things to be associated anytime, anyplace, with anything and anyone, in a perfect world utilizing any way and any network. The enhancements made in the RFID technology, communication technologies, sensors and internet protocols made the IoT an enabling technology for all domains. The primary meaning of the IoT was from a things arranged point of view, where RFID labels were considered as things. Internet of things facilitates sensor communicates without the interference or involvement of humans and leads to the implementation of advanced class of applications. In the prime phase of internet of Things there is a revolutionary act in the mobile, internet and machine to machine technologies. With the further enhancements the Internet of things is expected to provide physical objects the power of decision making. An ample

of physical objects are correlated with the Internet at an extraordinary amount accomplishing thought of the Internet of Things. There are likewise different domains and circumstances in which the IoT can assume a noteworthy part and enhance the nature of our lives. These applications incorporate transportation, automation, health care and crisis response to common and man-made calamities where human decision making is troublesome. The Internet of Things endorse physical objects to think, see, listen and accomplish occupations by making them talk together, share data and facilitate decisions. The Internet of Things commutes the physical objects from traditional to smart by employing the fundamental technologies such as embedded devices, ubiquitous, communication technologies, pervasive computing and sensor networks and applications. The smart objects intended with the specific tasks comprise the domain level applications. The independent domain services comprise the ubiquitous and analytical services. The prime goal of Internet of Things is to assist the sensors and the actuators to correspond with each other. With a specific end goal to understand this potential development, rising advancements and benefit applications need to develop relatively to coordinate promote requests and client needs. The physical objects should be produced to fit user prerequisites regarding accessibility anyplace and at anytime. By the aid of new protocols the heterogeneous physical objects can communicate with each other. For delivering quality products to customer end, the architecture standardization must take place. Security and privacy are other vital prerequisites for the IoT because of the heterogeneity of the Internet associated objects and the capacity to monitor and control physical objects. Moreover, management and monitoring of the Internet of Things ought to happen to guarantee the conveyance of high quality services to users at a low cost.

2. Literature Survey

The resource constrained and the resource rich modules are the two categories in the scope of IoT. In the resource rich scheme, the devices have the support that a smart system desires. In the resource constrained scheme, the devices lack the support that a smart system desires. In the home automation the technologies like X 10, Z-Wave, INSTEON, EnOCEAN, ZigBee are some of the conventional and promising technologies.

The X 10 is the traditional and significant home automation technology. Both the wired and wireless scheme can achieve with this X 10 technology. The X 10 technology was innovated by Glenrothes in the midst of 1975 in the era of Pico Electronics. The prime goal of this technology is to ensure remote control of home appliances and devices. It remains most broadly accessible and despite has its own significance with large number of entities being used around the world and economically accessible to a wide range of new components. The X 10 uses one way and two way communication [6]. In the one-way X 10 communication, all the X 10 devices only receive commands and don't give any acknowledgement to the network. In the two-way X 10 communication, all the X 10 devices getting the commands and in return acknowledgment to the network. The X 10 technology is more expensive in terms of two-way communication. The X 10 technology has the facility in providing lower transfer rate for slower devices.

The Z-Wave technology operates wirelessly. In the home environments all the devices irrespective of their size and complexity can be monitored and controlled by the Z-Wave technology [7]. The Z-wave technology eliminates the throughput and noise. The Z-wave technology employed with the RF technology can provide extraordinary results and enhances effective transmission of information. Every device in the Z-Wave technology implements a unique ID for the purpose of security and also to uniquely distinguish the devices. The Z-Wave at a time can govern 232 devices for the desired operations. It has the feature of cross compatibility with different devices and can function effectively up to a range of 30 meters.

The INSTEON technology enables the electrical appliances in the home environment to become smarter. It employs a dual network in which all the devices can freely send and receive messages. The INSTEON technology enhances reliability in such a way that it goes through error detection and correction while transferring the information. The INSTEON technology can work even without any controllers. A Personal computer can be utilized for performing the required functionalities. In the INSTEON all the devices transfer the similar messages at the same time so as to ensure effective communication.

The EnOCEAN technology is the significant automation technology and aims at zero energy consumption. All the innovative systems can be developed by using this EnOCEAN technology and has the capability called as energy harvesting technology. In the scheme of energy harvesting, the energy is collected from sources like solar, wind, thermal energy. Efficient communication can be established with the integration of wireless sensor modules, gateways, controllers [8]. In the EnOCEAN technology three packets are transmitted at three variable interval of times.

The ZigBee resembles the standards similar to Bluetooth and Wi-Fi standards. The mesh protocol is the protocol which is implemented by ZigBee for effective transmission of information. The ZigBee has its own significance in the effective monitoring of devices. The XBee module is integrated with the devices so as to transfer the accumulated information to the central controlling element [9]. The XBee module has the capability to transfer the information remotely. The distance of 10 meters is encouraged so as to establish an effective communication. The XBee modules information is collected by the ZigBee coordinator. The ZigBee device has the capability to transfer information and accumulate in the database.

3. Architecture of Internet of Things

Among a group of proposed architectures, the five-layered architecture drafted in the figure 1 is considered to be the basic architecture.

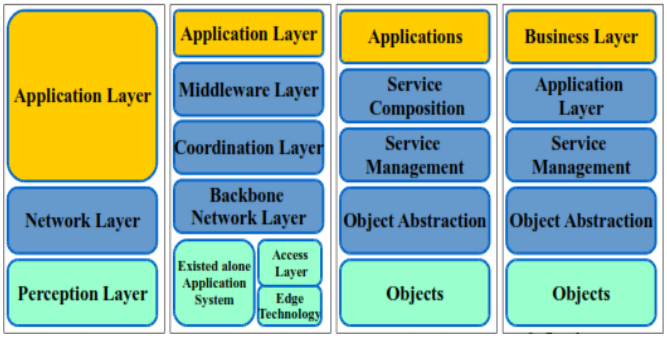


Fig. 1: Framework of the IoT.

The Internet of Things must be enabled for integrating trillions of distinct entities through the Internet, so the adaptable layered Architecture is a fundamental requirement. The elaborated propound architectures not united to an extracted model. In the interim, there are a few projects in IoT which attempt to outline a typical architecture in view of the necessities of researchers and users.

The object layer is the primary layer also called as the perception layer. The entities of the IoT plan to accumulate and process the data. This layer accustom sensors and actuators to perform distinctive functionalities, for example querying data, temperature, weight, movement, vibration, increasing pace, humidity [10]. For the configuration of distinct physical objects in the perception layer aims for the standardization mechanisms. By the utilization secure channels the data from the perception layer computes and transfers the gathered information to the object abstraction layer. The object abstraction layer computes the information and transfers it to the service management layer with the aid of secure channels. The RFID, Wi-Fi, GSM, Bluetooth low energy, ZigBee, 3G is some of the enabling technologies for transferring data. The Object abstraction layer provides the services like cloud computing and processing the data. Based on the Addresses and names, the service management layer combines with the service requester. This layer eliminates the need of specific desired hardware platform while working with Internet of Things applications. The service management layer computes the received data, decision making capability is provided and delivers the requests over the networks. The services that are requested by the users are provided by the application layer. The data from the physical objects is sent to the user for visualization. This layer enhances the importance of Internet of Things by providing high-quality services to the users. The applications such as smart home, smart health care, Warehouse inventory management, smart transportation. The overall services, system activities of IoT systems are managed by this business layer. Based on the received information and data the business layer is capable of business flowcharts, graphs. It is moreover expected to configuration, investigate, execute, assess, screen, furthermore, create IoT framework related components. The Big-data analysis is also possible with the involvement in decision making. All the monitoring and management of the above layers is accomplished at this layer. This layer has the facility to enhance services and users.

4. Implementation of the system

In this implemented system, there are two transmitter section and one receiver section. The Fig.2 shows the functional block diagram of the implemented system. In the transmitter section, the Arduino Uno and ESP8266-01 and in the receiver section the Raspberry Pi 3 and ESP8266-01 plays a predominant role. The Arduino Uno and ESP8266-01 are arranged in two different rooms named as room 1 and room 2 as arranged in the block diagram. The sensors like DHT11, current sensor, PIR sensor, Flame sensor, MQ-2 gas sensor are arranged in both rooms 1 and 2. The bulb and fan are the two electrical appliances arranged in both room 1 and 2. The receiver section also exhibits as a central server Raspberry Pi 3.

The room 1 is a transmitter section which consists of Arduino Uno, DHT11, PIR sensor, Flame sensor, MQ-2 Gas sensor, current sensor, Relay, Bulb, Fan, ESP8266-01. The room 2 is also equipped with the same modules, sensors that are arranged in room 1. The DHT11 also called as digital humidity and temperature sensor interfaced to Arduino Uno which is used to measure the humidity and temperature in the room 1 and 2. The MQ-2 gas sensor is also arranged at both the room 1 and 2 which is interfaced with Arduino Uno used to detect are there any gas leakages in the room 1 and 2. The flame sensor is interfaced to Arduino Uno and arranged in room 1 and 2 used to detect if there is any fire detected within the home environments. The Current sensor is interfaced to Arduino Uno and is arranged in both the rooms and is used to detect whether the current is flowing through the bulb. The PIR sensor is interfaced with Arduino Uno and is arranged in both the rooms. The Fan and PIR sensor both work together in coordination.

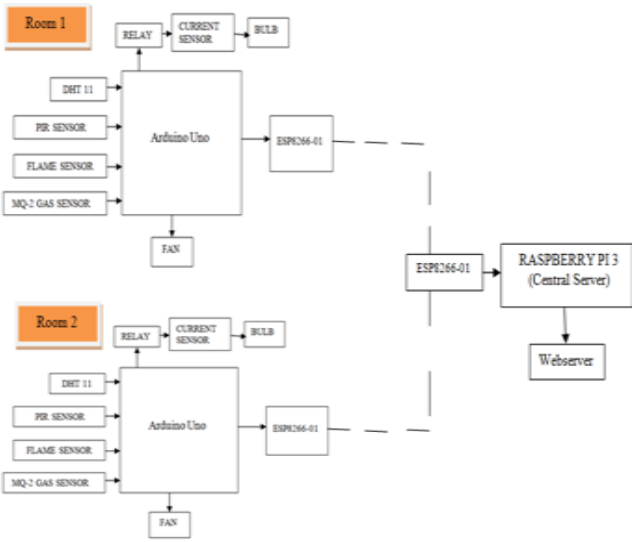


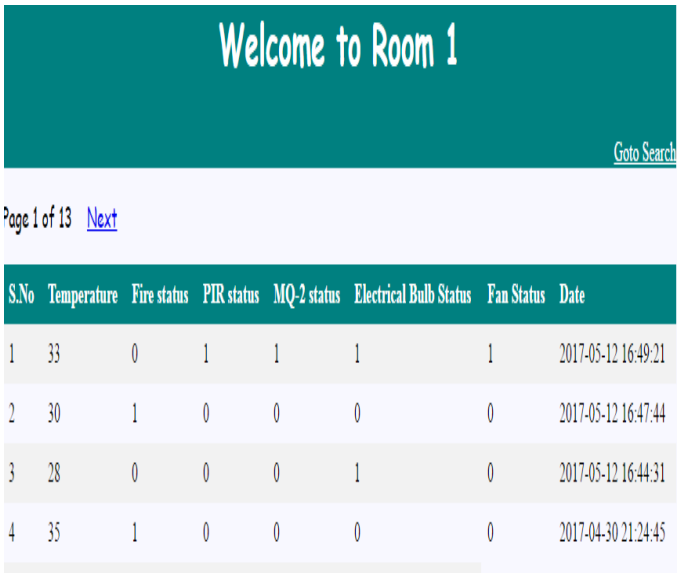
Fig. 2: Block Diagram of the implemented system.

The DHT 11 measure the temperature and humidity in the room environment, if the sensed values are not in the threshold range, then the user will be notified through SMS and also the values get updated into the web server. The MQ-2 gas sensor in both the rooms 1 and 2 are to detect any poisonous gases or is there any leakage. If there are any gases detected, then the user will be notified through SMS and the values also get updated on the web server. The Flame sensor detects whether there is any fire detected in the rooms 1 and 2. Whenever the flame sensor gets activated, then the user will be notified through SMS and also the status is also updated on the web server. The Passive infrared sensor used to detect is there any change in the field of the environment. If there is any change in the field, then the PIR sensor gets activated and make the fan ON indicating that there are people in the rooms 1 and 2. The relay is interfaced to the current sensor and the current sensor is interfaced to bulb. The current sensor is used to detect whether the current is flowing through the bulb or not. The relay is used to make the bulb switch on and off.

The information from the room 1 and 2 is transmitted wirelessly to the receiver section via the internet link. The ESP8266-01arranged at room 1 and room 2 is used to transfer the accumulated information from the Arduino Uno to the Raspberry Pi 3 central server via the internet. The ESP8266-01interfaced with Raspberry Pi 3 is used to act as Access point and provide internet to the ESP8266-01 arranged at room 1 and 2. Based upon the accumulated data in the central server the information is uploaded into the webserver and in case of emergency situations the user will be receiving an SMS. The user can view the accumulated data in the web page and take the necessary actions.

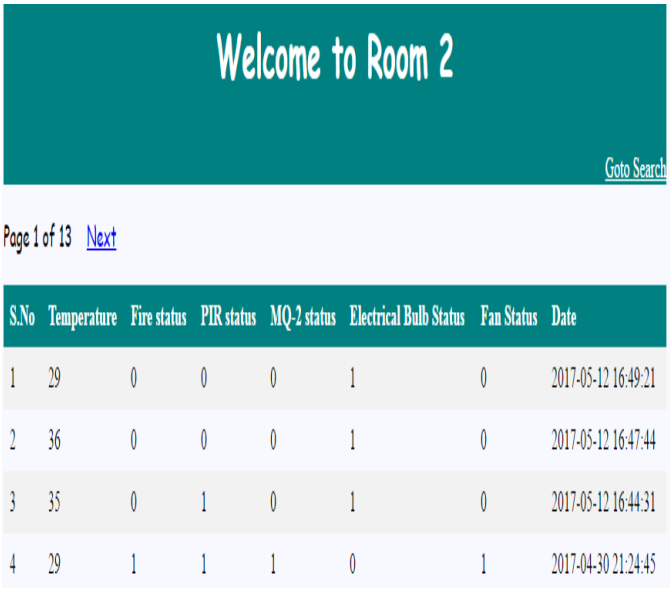
5. Results

The Fig.3 and Fig.4 illustrates the gathered data from room 1 and room 2 with the aid of Raspberry Pi 3and displayed on the web page. The temperature, Fire status, PIR status, MQ-2 status, electrical bulb and fan status and respective time details from room 1 and 2 are arranged in the form of rows and columns and displayed to the user in the form of web page. The 1's and 0's in the Fig.3 and Fig.4 depicts the ON/OFF state of the device and the sensors.



S.No	Temperature	Fire status	PIR status	MQ-2 status	Electrical Bulb Status	Fan Status	Date
1	33	0	1	1	1	1	2017-05-12 16:49:21
2	30	1	0	0	0	0	2017-05-12 16:47:44
3	28	0	0	0	1	0	2017-05-12 16:44:31
4	35	1	0	0	0	0	2017-04-30 21:24:45

Fig. 3: Information from room 1 is displayed on the web page.



S.No	Temperature	Fire status	PIR status	MQ-2 status	Electrical Bulb Status	Fan Status	Date
1	29	0	0	0	1	0	2017-05-12 16:49:21
2	36	0	0	0	1	0	2017-05-12 16:47:44
3	35	0	1	0	1	0	2017-05-12 16:44:31
4	29	1	1	1	0	1	2017-04-30 21:24:45

Fig. 4: Information from room 2 is displayed on the web page.

The Fig.5 depicts the message received by the user from the room 1 when the conditions are not in threshold range. The Fig.6 depicts the message received by the user from the room 2 when the conditions are not in threshold range. The messages like temperature is abnormal is received to the user whenever the sensed temperature is not in the threshold range. The message Flame detected is received to the user whenever a fire is detected in the threshold range. The message gas sensor is activated whenever any leakage gases are detected by the MQ-2 sensor whenever the sensor is not in threshold range.

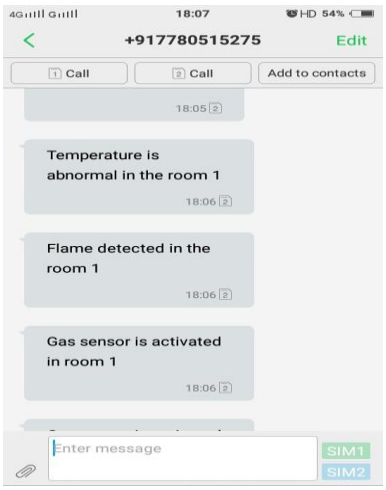


Fig. 5: SMS received by the user when there is an abnormal condition in room 1.

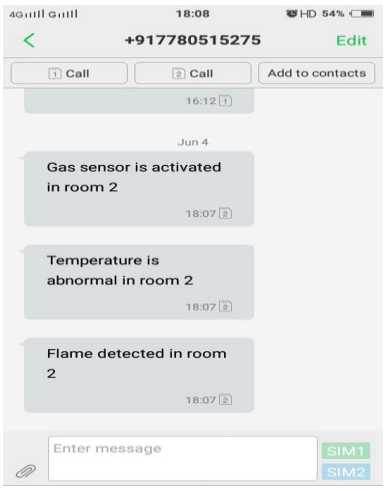


Fig. 5: SMS received by the user when there is an abnormal condition in room 2.

6. Conclusion

The implemented system can efficiently monitor and control the electrical appliances in the home environment. The developed system is of low cost and can work efficiently. The gathered information from room 1 and room 2 is accumulated in the Raspberry Pi 3 and hence the information is displayed in the web page and in case of emergency situation the user will receive an SMS so as to take the desired action. The developed system is not only for laboratory setup, but can also perform in real-time situations.

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