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Automatic/Manual Controlling and Monitoring of Appliances

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***Abstract*— The Internet of things (IoT) has a huge number of applications such as: Healthcare, Fire detection, Agriculture, Smart Home, Smart Cities, Industrial Automation and Transportation. One among them is Smart Home system, which clearly stands out, ranking as highest Internet of Things application. The proposed prototype is focused mainly on low-cost solution for automation of legacy appliances so that to automate the home environment without replacing the existing equipment's. The proposed model mainly consists of 2 modules namely Sensing module, Controller module and one interface that is user interface. In the sensing module, we use different sensors such as gas, temperature, and PIR motion sensor which will sense the data from the environment which act as an input to the controller. The Controller or Relay module consist of several appliances like light and fan that are controlled & monitored based on the data sensed by the different sensors that is stored in the database or it can be done manually by the commands that are given by the end user. A web based user interface provides highly interactive design to interact with the home automation system. It also provides an interface by which user can automatically and manually monitor and control appliances connected to the system. The Automatic/Manual Controlling and Monitoring of Appliances using Raspberry pi board has been experimentally proven to work satisfactorily by connecting simple appliances to it and the appliances were successfully controlled remotely through internet. The designed system not only monitors the sensor data like, temperature, gas, PIR motion sensors, but also actuates a process according to the user requirement, for example switching on the light or fan, when temperature exceeds threshold value.**

Keywords—Internet of Things; Automatic Monitoring and Control; Sensors; Home Automation; Smart Homes;

I. Introduction

The Internet of things (IoT) can be defined as connecting the various types of objects like smart phones, personal computer and tablets to internet, which brings in very new angled type of communication between things and people and also between things. IoT has a huge number of applications such as: Healthcare, Fire detection, Agriculture, Smart Home, Smart Cities, Industrial Automation and Transportation. One among them is Smart Home system, which clearly stands out, ranking as highest Internet of Things application.

The major challenges or issues of IoT are: Sharing data, Backend connectivity, Interoperability, Lack of privacy and security. Security is an essential pillar of the Internet and the most significant challenge for the IoT. The IoT creates unique challenges to privacy, many that go beyond the data privacy issues that currently exist. Much of this stems from integrating devices into our environments without us consciously using them. The use of wireless technologies gives several advantages that could not be achieved using a wired network only. Some of the advantages are: reduced installation costs, system scalability and easy extension, aesthetical benefits, integration of mobile devices.

Homes of the 21st century will become more and more self-controlled and automated due to the comfort it provides, especially when employed in a private home. A home automation system is a means that allow users to control electric appliances of varying kind. Home automation is the emerging field that has attracted the attention in both the commercial and research field. Nowadays the house can be easily transformed in an advanced and integrated domotics (house automation) environment, where everything is evolving as smarter and smarter. Today, people all over the world are putting their faith in IoT and employ it in almost every aspect of daily life. Be it smart homes, fit-bits, indoor mapping or vehicle tracking, at the end of the day, it's all IoT.

When you enter your house, pleasant lighting comes on, the roller blinds and curtains go up. The system selects your favourite music, movie, or TV

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channel. You don't need to nervously set the light level in the living room, surprised by guests - just press a button to change the scene (the feel) e. g. 'a party' or 'guest visit'.

When you leave your house, after you've turned your key the alarm system goes on, temperature is reduced, and all lamps and appliances switch off automatically. Nobody is at home, so why use up costly energy. And what would happen if water from an open tap flooded the house? The system will automatically turn it off and calls you on your mobile phone. That is a home automation!

Smart Homes sometimes called Automated Homes because they help the home owners to automate the tasks. Anything in your home that uses electricity can be put on the home network and at your finger. Whether you give that command by voice, remote control or smart phone, the home reacts. Each device on the network, such as a lamp, TV, thermostat, garage door opener, pool control and others have an individual code, selected from more than 86000trillion options. When you program one of the controller options, it automatically identifies what those codes are. Then when you press the appropriate button, the controller sends a signal to the device saying it what to do. Smart Homes enables effective communication between adhoc nodes and connected devices through Internet of Things Technologies. In order to exchange the information between them, first of all they will use authentication technologies like RFID (Radio Frequency Identification) - using for personal as well as object identification, EPC (Electronic Product Code) - Products, IPv6 which can even include all the atoms address on the earth and so that all our home appliances can be connected through Home Area Network (HAN).

ZigBee (IEEE 802.15.4) is the one of the latest IoT technology in which, when all the devices connected to the Internet reduce the power consumption and reduce the power loses and smooth flow of power in all things and save the energy. Wi-Fi and Bluetooth are the knowing Technologies, can be found in all smart mobiles these are helpful for transfer the data from the objects - mobile –HAN – internet. Motion sensors are helpful in detection of objects and citizens in the home for both security automatic lighting. In addition, for the security purpose surveillance technologies like CCTV and IP camera are in depth use in Smart Homes.

Actuators, performs a physical action. Controllers, makes choices based on programmed rules and occurrences. Central unit renders possible programming of units in the system. Networks, allows communication between the units and possibly to the surroundings. Interface, is the user's communication with the system. The Smart Home technology can be used to monitor, warn and carry out functions according to selected criteria. Smart Home technology also makes the automatic communication with the surroundings possible, via the internet, ordinary fixed telephones or mobile phones. Smart home technology gives a totally different flexibility and functionality than does conventional installations and environmental control systems, because of the programming, the integration and the units reacting on messages submitted through network.

Fig. 1.1 Basic Architecture of Smart Home

Motivation for developing smart home systems comes from many reasons, but most prominent are convenience, security, energy management, connectivity and luxury. Smart Home systems are one of the newer areas of research that have not been fully integrated into our society. Technology is becoming better and cheaper, and this will help to make smart home systems an expense worth having when new homes are being. The biggest motivation behind smart home systems is the convenience. Convenience is really another way of saying "time saver", and into day's world where everything is moving faster, every second has value. Most of the technology we use today is based of convenience, for example cars get us where we need to go faster, phones get us information from other people faster, and computer's get work done faster. Smaller conveniences in the home will be desirable because they allow the home to save the user time as well.

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There are so many ways of bad habits of using electricity such as running space heaters under desks while air conditioning is on because buildings are over cooled, propping doors or windows open in retail stores or office buildings to mitigate over-cooling or to draw in shoppers, running heating and cooling systems at the same time due to improperly maintained, keeping lights on all day even though sunlight could be used, utilizing all of the lighting in a space when task-specific lighting would easily cover the area, leaving lighting, heating or cooling systems on during the night at levels that would be appropriate only for daytime occupancy when more people present, keeping computers, printers and computers on all night or over the weekend when they are not being used. Therefore, group feels the need to do something to change these habits. This smart home project comes up.

The rest of the paper is organized in the following sections. The proposed methodology for automatic monitoring and controlling of appliances is presented in section 2. Section 3 is divided into four sections. Section 3.1 outlines the high level design of the system. Section 3.2 narrates technical description, Section 3.3 describes the design of tables and Section 3.4 sketches out the flowcharts. Section 4 includes results and its description. Section 5 presents the concluding remarks and future scope.

II. PROPOSED METHODOLOGY

The proposed prototype is focused mainly on low-cost solution for automation of legacy appliances so that to automate the home environment without replacing the existing equipment's. The goal is to keep replacement of equipment's to minimum and thus to reduce the overall implementation cost, thereby making the reach of the technological advancement to a larger section of the society. Keeping this in mind the approach is to use a gateway that can act as a mediator between the user and the end devices. Any smart-phone with an internet connection can access the home environment through the gateway. The gateway in the proposed prototype provides data transfer between the client and the multiple home appliances through internet.

The proposed model mainly consists of 2 modules namely Sensing module, Controller module and one interface that is user interface. In the sensing module, we use different sensors such as gas, temperature, and PIR motion sensor which will sense the data from the environment which act as an input to the controller. This input data is stored in the database of the system. The Controller or Relay module consist of several appliances like light and fan that are controlled & monitored based on the data sensed by the different sensors that is stored in the database or it can be done manually by the commands that are given by the end user. A web based user interface provides highly interactive design to interact with the home automation system. It also provides an interface by which user can automatically and manually monitor and control appliances connected to the system.

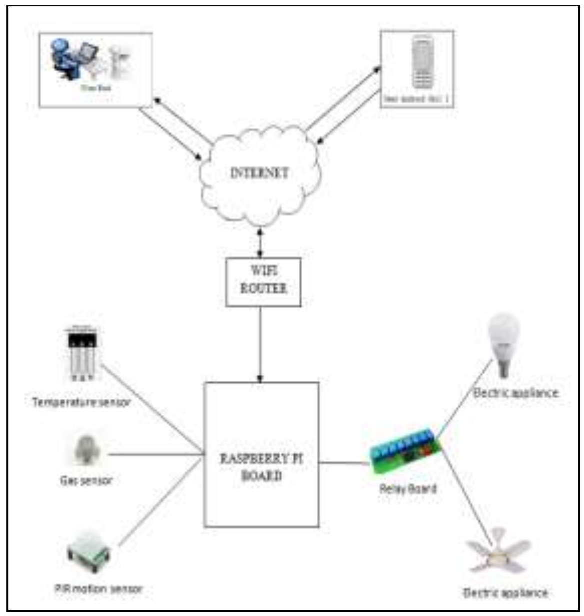

Fig. 2.1 Proposed Model of Automatic/Manual Monitoring and Controlling of Appliances.

III. IMPLEMENTATION

3.1 High Level Design of System

High-Level Design or A Data Flow Diagram (DFD) is a graphical representation of the "flow" of data in a system.

A login page asks the user to provide credentials in order to view certain protected pages on a website. These protected pages usually include secure and individualized information, like a Configuring System, View Appliance Status or Control Appliance Status. Building an effective login page is essential for many types of websites. The diagram demonstrates how the login page works in a login system. Here both Admin and User will have different permissions. Admin will be having the options like Configuring System, Automatic Control

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and Manual Control. Whereas in configuring system, Admin can add and delete the sensors and appliances. Users will be having the options like Automatic Control and Manual Control. In Automatic Control, Admin and user can only view the appliance status. In Manual Control, both Admin and User can View and control the appliance status like Turning ON/OFF. The various objects in the system—user, login page, login checker, main page, and login failure page—interact over the course of the sequence, and certain results are displayed depending on user's credentials.

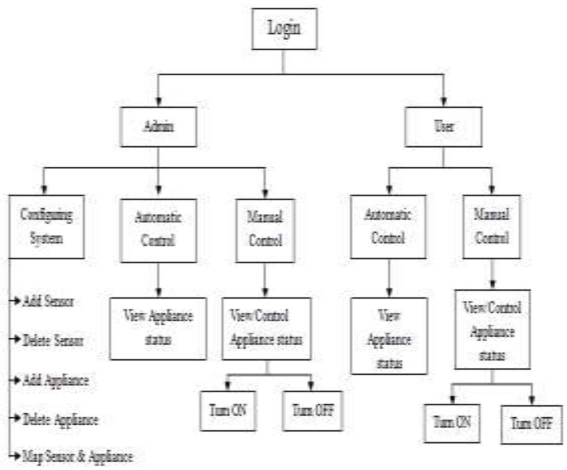

Fig 3.1 High Level Design of System

3.2 Technical Specification

Technical Specification specifies in depth description of the various sensors that are used and also about the relay. The sensors that are used are temperature sensor, gas sensor and PIR motion sensor. The details of each of these sensors are given below.

3.2.1 Temperature Sensor

The DS18B20 digital thermometer provides 9-bit to 12-bit Celsius temperature measurements and has an alarm function with nonvolatile user-programmable upper and lower trigger points. The DS18B20 communicates over a 1-Wire bus that by definition requires only one data line (and ground) for communication with a central microprocessor.

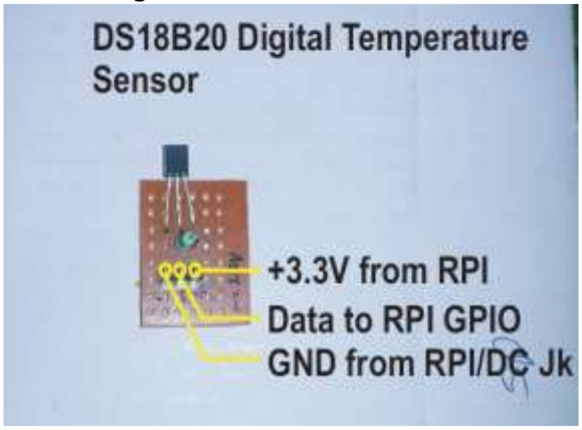

Fig 3.2 Temperature Sensor with PIN Configurations

3.2.2 Gas Sensor

Sensitive material of MQ-6 gas sensor is SnO2, which with lower conductivity in clean air. When the target flammable gas exist, the sensor's conductivity gets higher along with the gas concentration rising. Users can convert the change of conductivity to correspond output signal of gas concentration through a simple circuit. MQ-6 gas sensor can detect kinds of flammable gases, especially has high sensitivity to LPG (propane). It is a kind of low-cost sensor for many applications. It has good sensitivity to flammable gas(especially propane) in wide range, and has advantages such as long lifespan, low cost and simple drive circuit &etc. Its Main Applications is widely used in domestic gas leakage alarm, industrial flammable gas alarm and portable gas detector.

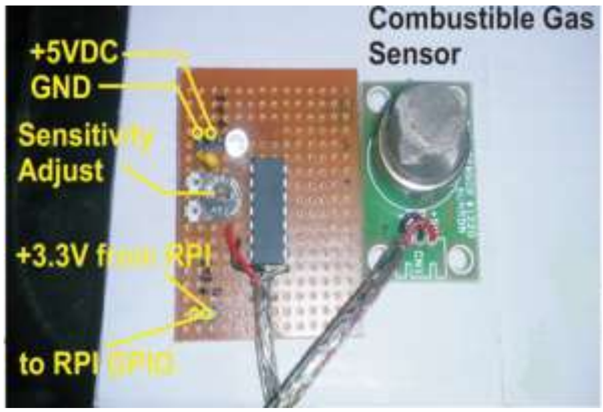

Fig 3.3 Gas Sensor with PIN Configurations

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3.2.3 Buzzer Alarm

A buzzer or beeper is an audio signalling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke.

Fig 3.4 Buzzer with Driver

3.2.4 PIR Motion Sensor

A passive infrared sensor (PIR sensor) shown in Fig. 3.5 is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. PIR sensor detects a human being moving around within approximately 10m from the sensor. This is an average value, as the actual detection range is between 5m and 12m. PIR are fundamentally made of a pyro electric sensor, which can detect levels of infrared radiation.

3.2.5 Relay

Relays shown in Fig. 3.6 are switches that open and close circuits electromechanically or electronically. Relays control one electrical circuit by opening and closing contacts in another circuit. As relay diagrams show, when a relay contact is normally open (NO), there is an open contact when the relay is not energized. When a relay contact is Normally Closed (NC), there is a closed contact when the relay is not energized. In either case, applying electrical current to the contacts will change their state. Relays are generally used to switch smaller currents in a control circuit and do not usually control power consuming devices except for small motors and Solenoids that draw low amps.

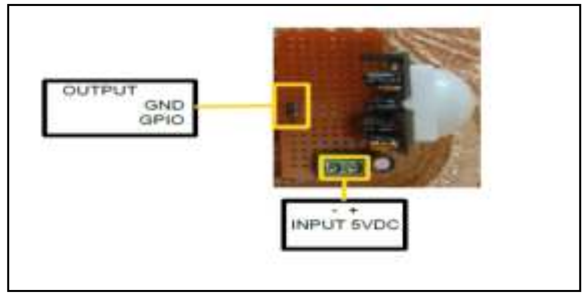

Fig 3.5 PIR Motion Sensor Board – Optically Isolated Output

The circuit figure shows the circuit diagram of relay. There is a coil connected to it which may range from 5V to 24V. The input circuit (black loop) is switched off and no current flows through it until something (either a sensor or a switch closing) turns it on.

3.3 Design of Tables

Before implementation we created a schema which is the structure described in a formal language supported by the database management system (DBMS).

Sensor_list Table

This table is designed to maintain a list of sensors and its type deployed at different locations in the house.

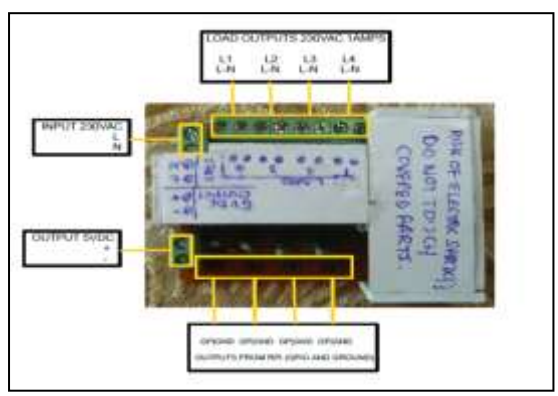

Fig 3.6 Channel Optically-Isolated Solid State Relay Board

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Sensor_ID	Sensor_type	Location

Fig 3.7 Schema of Sensor_list

In Sensor_list schema, it has three fields, namely, Sensor_id, Sensor_type and Location. Sensor_id is the unique id given to a sensor in the table. Sensor_type field describes the type of the sensor such as temperature, gas and PIR motion sensor. Location field tells us about where the sensor is located. There may be more than one sensor of same type in different location, to distinguish it we use sensor id and location field.

Appliance_list Table

This table is designed to maintain a list of appliances deployed at different locations in the house that are automatically and manually controlled and monitored.

Appliance_ID	Appliance_name	Location

Fig 3.8: Schema of Appliance_list

Appliance_list schema has three fields, namely, Appliance_id, Appliance_name and Location. Appliance_id is the unique id given to appliance. Appliance_name describes the name of the appliance such as light and fan. Location tells us about where the appliance is located.

Appliance_data Table

This table is designed to maintain a status of each of the appliances based on last modification date and time.

Record_no	Appliance_id	Appliance_name	Date_Time	Appliance_status

Fig 3.9 Schema of Appliance_data

Appliance_data schema has five fields, namely, Record_no, Appliance_id, Appliance_name, Date_Time and Appliance_status. Record_no is uniquely identified each record in the table. Appliance_id is the unique id given to appliance. In this table Appliance_id is a *foreign key*, in one table that uniquely identifies a row of another table or the same table. Appliance_name describes the name of the appliance such as light and fan. Date_Time field stores the date and time of last modification and Appliance_status field is used to store status of appliance.

Sensor_Appliance_mapping Table

This table is designed to keep track of sensors mapped to various appliances.

Sensor_Appliance_mapping schema has two fields, namely, Sensor_id and Appliance_id. Sensor_id and Appliance_id are the unique id given to sensor and appliances. Here Sensor_id and Appliance_id act as a *foreign key*, whereas the same keys are used as primary key in other tables.

Sensor_id	Appliance_id

Fig 3.10 Schema of Sensor_Appliance_mapping

3.4 Flowchart

The Fig. 3.11 illustrates the flowchart for Automatic Control of appliance using Temperature sensor and PIR Motion sensor. Once all the connections are made to the raspberry pi board, we will initialize the sensor id for the temperature sensor and PIR motion sensor. We will retrieve the appliance id corresponding to the sensor id of temperature sensor.

By using appliance id of the appliance, we will read the current appliance status from the database that is Sensor data Table. Now, we will read the temperature value using the temperature sensor which is connected to the GPIO pin number 4 of the Raspberry pi board. The temperature value along with date and time of sensed will be written to the database that is sensor data table where Record no, Sensor id, Sensor value and date and time will be recorded in the respective fields of the table. Now to turn ON or turn OFF the fan, first we will check the sensed value of temperature.

If the temperature value is greater than 30 degree, we will detect the motion by using PIR motion sensor. When the motion is detected, the information is written to the database and then the current appliance status checked otherwise, no action is taken and the data is been ignored. When we check the appliance status and if the current appliance status is OFF then we will send the turn ON signal to the appliance and if it is not in OFF status then no action is taken.

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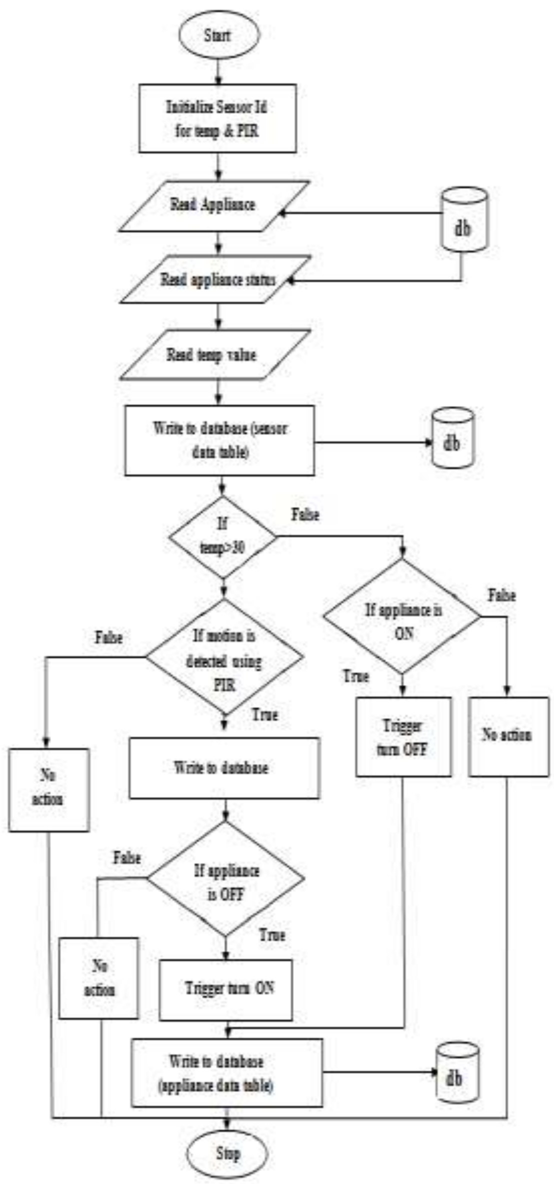

Fig 3.11 Flowchart for Automatic/Manual Control of Appliance Using Temperature Sensor

Now if the temperature value is not greater than 30 degree, then the appliance status is checked again to know the fan is turned ON or not. If the appliance status is ON, then we will send a turn OFF signal which will be given to the appliance, and the fan will be turned OFF, otherwise, no action is taken. When some action is taken and the appliance status is modified, then the updated information is written to the database that is Appliance data Table.

Fig. 3.12 illustrates the flowchart for Automatic Control of appliance using Gas sensor. Like the temperature sensor, here also we will initialize the sensor id for gas sensor and retrieve the appliance id corresponding to the sensor id of gas sensor.

The smoke is sensed using the gas sensor that is MQ6 sensor. When the smoke is detected, then the output is 0(active low) and it generate the buzzer. And when the output is 1 that is smoke is not detected, and then no action is taken.

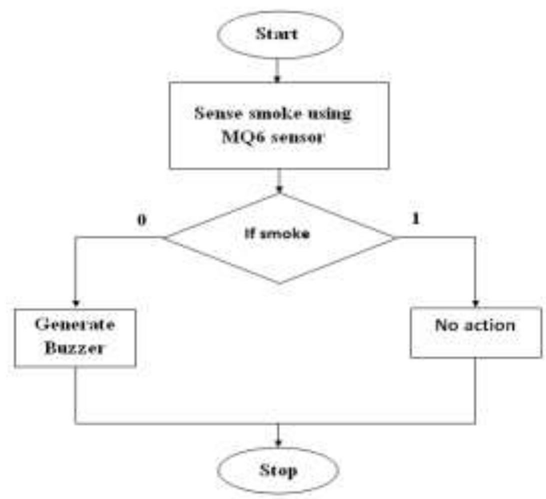

Fig 3.12 Flowchart for Automatic/Manual Control of Appliance Using Gas Sensor

IV. RESULTS AND DISCUSSION

In this section, the hardware setup and the results of the proposed methodology have been presented. Several web pages are created for providing user interface. The snapshots of these web pages are shown below.

The user is also provided an option to control and view the status of appliances by issuing manual commands. When a user clicks on turn on button then it checks the current status of appliance if it is OFF then it issues ON signal to the appliance otherwise no action is taken.

Similarly, when a user clicks on turn off button, then if the appliance is ON a turn off signal is issued otherwise no action is taken.

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Fig 4.1 Manual Control of Appliances

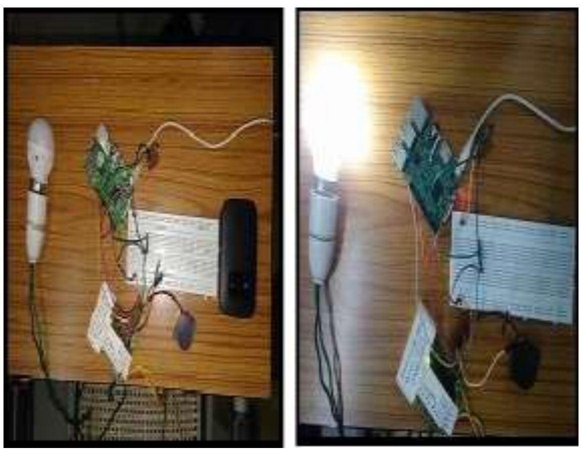

Fig 4.2 Hardware Setup for Turning On/Off the Light

The hardware setup for gas detection using MQ6 gas sensor is given in Fig 4.3. The first figure shows that there is no gas in the room and hence the led is off. When the gas is detected by the gas sensor the led glows specifying that gas is present and necessary action needs to be taken. As this module is wireless, our web page automatically displays a message for gas detection which is shown in below figure.

V. CONCLUSION AND FUTURE SCOPE

The Automatic/Manual Controlling and Monitoring of Appliances using Raspberry pi board has been experimentally proven to work satisfactorily by connecting simple appliances to it and the appliances were successfully controlled remotely through internet. The designed system not only monitors the sensor data like, temperature, gas, PIR motion sensors, but also actuates a process according to the user requirement, for example switching on the light or fan, when temperature exceeds threshold value. It also stores the sensor parameters in the database in a timely manner. This will help the user to analyze the condition of various appliances in the home anytime and also for energy efficiency.

Fig 4.3 Hardware Setup for Detecting Gas

Household environment for gas leaks or detection of smoke is possible by the MQ6 sensor, the system automatically displays and glows led specifying that gas is present and necessary action needs to be taken. All of these act accordingly to minimize risk.

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