IoT Based Home Automation Using Raspberry Pi

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IoT Based Home Automation Using Raspberry Pi

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Abstract—Availability of high speed mobile networks like 3G, 4G and Long Term Evolution coupled with cheaper and accessible smart phones, mobile industry has seen a tremendous growth in terms of providing various services and applications at the fingertips of the citizens. This paper discusses about IoT and it can be used for realizing smart home automation using Raspberry Pi.This system consists of a smart phone along with webpage which is having the home appliances details with ON and OFF conditions. Smart phone is connecting with Raspberry Pi using the IP address of Raspberry Pi through Wi-Fi. The wireless application is user friendly improves efficiency and lifestyle. The system successfully overcomes the drawbacks in Bluetooth and ZIGBEE technology.Internet of Things (IoT) is one of the promising technologies which can be used for connecting, controlling and managing intelligent objects which are connected to Internet through an IP address. Applications ranging from smart governance, smart education, smart agriculture, smart healthcare, smart home etc. can use IoT for effective delivery of services without manual intervention in a more effective manner.

Keywords — Long Term Evolution (LTE), Internet of Things (IoT),Bluetooth Low Energy (BLE), General Purpose Input / Output (GPIO),Raspberry Pi (RPI)

I. Introduction

IoT is the internetworking of physical devices, vehicles (also referred to as “connected devices” and “smart devices”), buildings, and other items-embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. In 2013 the Global Standards Initiative on Internet of Things (IoT-GSI) defined the IoT as “the infrastructure of the information society” [1-3].

IoT and the machine-to-machine (M2M) technology are bringing a kind of “super visibility” to nearly every industry. Imagine utilities and Telco’s that can predict and prevent service outages, airlines which remotely monitor and optimize plan performance, and healthcare organizations that can base treatment on real-time genome analysis [3]. The business possibilities are endless. IoT cloud solutions provide affordable to high-speed data networks- to significantly extend the reach and usability of your IoT application. They can also offer data storage, processing, analysis, and remote device management.As companies collect data beyond traditional IT boundaries, IoT security measures will be critical.

The home automation is nothing but interconnection of physical devices embedded with sensors and software. The network connectivity is used to collect and exchange the data. Home automation refers to the automatic and electronic control of household features, activity and appliances. Various control systems are utilized in this residential extension of building automation. Home automation is also known as domesticsor demoniac. Modern system generally consist of switches and sensors connected to a central “gateway” from which the system is controlled with a user interface that is interacted either with a wall-mounted terminal, mobile phone software, tablet computer or web interface, often but not always via internet cloud services[4].

Nowadays home automation system is being widely used to control devices around the home. A variety of home devices can be controlled with the help of a home automation system. All kinds of home appliances like doors, lights, fan, electric heater, surveillance systems, and consumer electronics belong to the home automation system devices. Home automation system is adopted by using the technology available for the purpose of controlling the devices as well as the systems used in the home automatically [4-5].

This paper presents an intelligent home automation to control the home appliances and electrical and electronic equipment by using smartphone. It will turn ON or OFF the home appliances and electrical equipment by using relay circuits with the concept of IoT. This is implemented by using Raspberry Pi.

The organization of this paper is as follows,Section II summarizes the background study of its benefits and problems. Section III gives the brief description about the proposed system with block diagram. Section IV

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and V describes about the Hardware and Software requirements. Section VI deals with the results and discussion of the model followed by conclusion in the Section VII.

II. BACKGROUND STUDY

A. Home automation system based on Bluetooth Technology

Automation systems are gaining IoT of popularity nowadays and are being used at various places such as shopping malls, toll gates, airport, etc. The implementation details of two schemes for home automation and control is presented in this work. The first scheme presents a prototype of Home Automation System (HAS) for remotely controlling the appliances at home through the subject of email. This system is based on ARM11 Raspberry pi microcontroller board. Python Integrated Development Environment (PIDE) is used for developing the necessary software [6-7].

The second scheme uses Bluetooth Technology for controlling the devices when we are at home. It uses a HC-05 Bluetooth module and Bluetooth controller mobile application for switching on or off the appliances. Relays and LEDs are used as load to demonstrate the working of the system [6-7].

B. Smart home based on Zigbee

Constructing the efficient, convenient and cozy home environment has become the current hot spot by using ZIGBEE wireless communication technology. This system uses ZIGBEE Wireless Technology to build home internal Network, and connect a variety of sensors and home appliance controller to ZIGBEE network node [8].

Various signals collected by a few end-nodes may be delivered by this system to the main control module, which will analyze and process them. Then the main control module transfers this information to internet through the Ethernet and GSM/GPRS network to remotely and locally monitor and control family inner environment and household appliances. Furthermore, the working condition of the system can be traced into SD Cards [8].

C. Touch screen and remote control based home automation system

Home automation needs to make use of modern technologies to reduce human efforts as well as save energy. This work focuses on the development of an embedded system for home automation system that use standard remote controller, temperature, humidity and touch screen as a user input device. The inconvenience in controlling the devices has been solved by this home automation system. In this proposed home automation system different attractive features are combined together which is not found very often in other home automation system [9]. This offers a low cost, complete and efficient system for remote operation of a room. Furthermore, this system can be applied to control all kinds of appliances automatically installed within buildings, companies, schools, hospitals etc…

D. Embedded platform for web based monitoring and control of a smart home

The architecture of a low cost embedded platform for web-based monitoring and control of a smart home is presented in this work. The platform consists of a distributed sensing and control network, devices for access control and a residential gateway with touch-screen display offering an easy to use interface to the user as well as providing remote, web based access. The key issues related to the design of the proposed platform were addressed: the problem of security and the robustness of the distributed control network to network fault [10].

One of the main advantage of this system include scalability – the multipoint network can easily be extended with new sensor/controller/actuator nodes, new embedded Ethernet gateways can be added to the local network (e.g. for monitoring and control of the greenhouse and of the garden) which can be exposed directly to the web through embedded web servers or through the residential gateway by following the restful architecture [11].

For making the home automation easy, the control of all the devices should be brought in one place. To do this several works have been done. But there are some obstacles to be overcome for making the home automation system easier and popular; these are high cost of ownership, inflexibility, poor manageability, and difficulty in achieving security. In Java based home automation system, a complex and costly installation and is needed. The requirement of a high end PC makes the system expensive. To avoid and overcome these problems, we are proposing home automation using IoT with Raspberry Pi.

III. PROPOSED SYSTEM

In this system, we are using Raspberry Pi and establish the internet connection for the purpose of automation using IoT by accessing the IP address.

Figure 1: Model view of home automation system

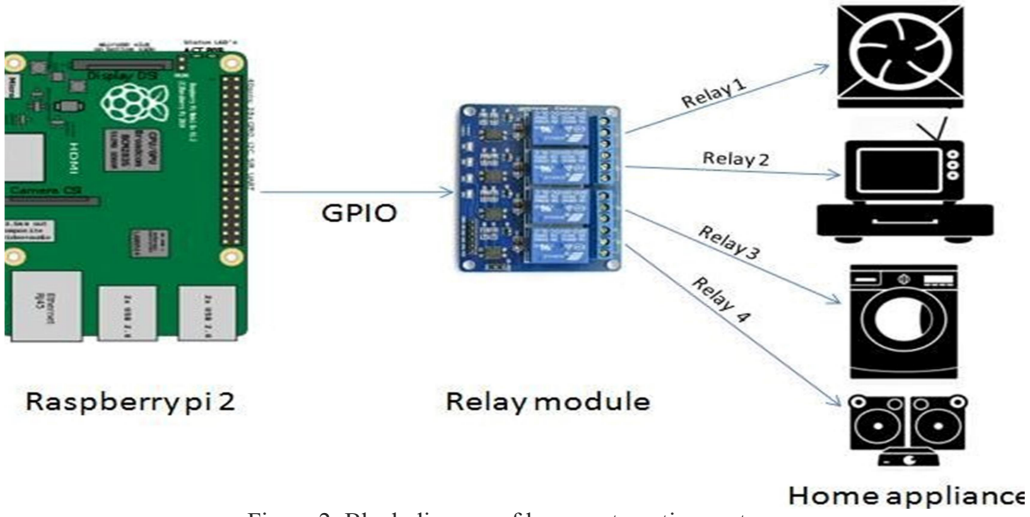

Figure 2: Block diagram of home automation system

The figure 1 represents the home automation system that allows the user to control home appliances through wireless.Figure 2 represents the block diagram of smartphone based home automation system using IoT. All the home appliances are connected with Raspberry Pi.Mobile phone and Raspberry Pi are connected through Wi-Fi. Raspberry Pi is used as the board controller to connect the appliances via input and output port. We can use cloud server for controlling and monitoring the home appliances from anywhere. PHP coding is used for controlling home appliances. Copy the saved program in SD card and inserting it in Raspberry Pi and then run the program. While the program is executing, enter the IP address in the URL to open the webpage. It establishes the connection between the smart phone and the Raspberry Pi board.

IV. HARDWARE REQUIREMENTS

A. Raspberry Pi

Raspberry Pi is a low cost credit card size computer that plugs into a computer monitor or TV and uses a standard keyboard and mouse. Most importantly it's open source hardware. Computing Programmable Language like python and scratch under Linux platform. Raspberry Pi 2 model B has CPU 900MHZ quad-core ARM cortx-A7 processor. The Ethernet adaptor is connected to an additional USB port. In model A and A+ the USB port is connected directly to the Silicon on Chip (SoC).

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Figure 3: Schematic representation of RPI 3

Figure 3 represents the detailed diagram of Raspberry Pi3.Raspberry Pi3 is the third generation Raspberry pi. It replaced the Raspberry pi 2 model B in February 2016. Compared to the Raspberry pi 2 it has:

- A 1.2GHZ 64-bit quad-core ARMv8 CPU
- 802.11n Wireless LAN
- Bluetooth 4.1
- Bluetooth Low Energy(BLE)

B. Relay circuit

Relays are switches that open and close circuits electromechanically or electronically. Relays control one electrical circuit by opening and closing contact in another circuit. When a relay contact is Normally Closed (NC), there is a closed contact when the relay is not energized. It is an electromagnetic switch operated by relatively small electric current that can turn on or off much larger electric current the heart of a relay is an electromagnet (a coil of wire that becomes a temporary magnet when electrically flows through it).Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults, in modern electric power systems these functions are performed by digital instruments still called “protective relays”.

Figure 4: Schematic representation of two channel relay

Two channel relay diagram is shown in figure 4.This is a 5V, 10A 2-Channel Relayinterface board. It can be controlled various appliances, and other equipment with large current. It can be controlled directly with 3.3V or 5V logic signals from a microcontroller (ARM, 8051, PIC).

C. DC motor

A DC motor is any class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic; to periodically change the direction of current flow in the part of DC motor.

DC motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A DC motor’s speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. DC motor is shown in figure 5.

Figure 5: Pictorial view of DC motor

D. Buzzer

A buzzer is an audio signaling device which may be mechanical, electromechanical or piezoelectric. Typical uses of buzzers include alarm devices, timers and confirmation of user input such as a mouse click or keystroke. It is an electrical device that makes a buzzing noise and is used for signaling. Early devices were based on an electromechanical system identical to an electric bell without the metal gong. Similarly, a relay may be connected to interrupt its own actuating current, causing the contacts to buzzer. Often these units were anchored to a wall or ceiling to use it as a sounding board. The word comes from the rasping noise that electromechanical buzzers made. Buzzer is shown in figure 6.

Figure 6: Pictorial view of Buzzer

E. Motor driver circuit

L293D is a typical Motor driver or Motor driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. It means that you can control two DC motor with a single L293D IC. Motor driver board is shown in figure 7.

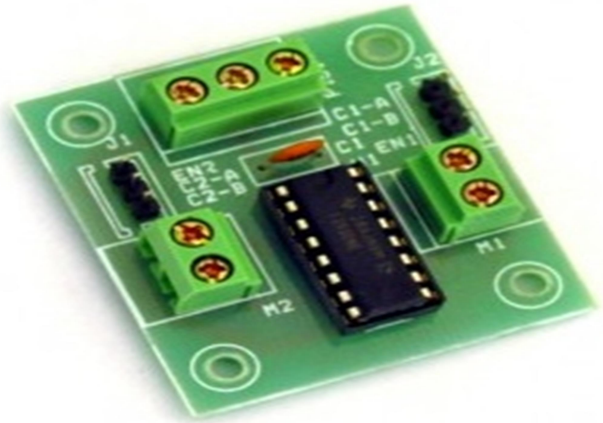

Figure 7: Schematic view of motor driver board

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V. SOFTWARE REQUIREMENTS

A. PHP

PHP (PHP: Hypertext Preprocessor)is an "HTML-embedded scripting language" primarily used for dynamic Web applications. The first part of this definition means that PHP code can be interspersed with HTML, making it simple to generate dynamic pieces of Web pages on the fly. As a scripting language, PHP code requires the presence of the PHP processor. PHP code is normally run in plain-text scripts that will only run on PHP-enabled computers. PHP takes most of its syntax from C, Java, and Perl. It is an open source technology and runs on most operating systems and with most Web servers. For this reason, PHP originally stood for "Personal Home Page".

B. Python

Python is a widely used high-level programming languagefor general-purpose programming, created by Guido Van Rossum and first released in 1991. An interpreted language, Python has a design philosophy which emphasizes code readability (notably using whitespace indentation to delimit codeblocks rather than curly braces or keywords), and a syntax which allows programmers to express concepts in fewer lines of code than possible in languages such as C++ or Java. The language provides constructs intended to enable writing clear programs on both a small and large scale.

VI. RESULTS AND DISCUSSION

Two different color bulbs are used in this system instead of connecting home appliances. Light1, light2, buzzer and motor are among the appliances that can be used in this system. Home automation system is used for controlling and monitoring the home appliances. It can perform in several ways. In this system, Wi-Fi is used in order to control the devices in small coverage area. Raspberry Pi is used as the board controller to connect the appliances via input and output port. Mobile phone and Raspberry Pi are connected through Wi-Fi. Light1, light2, buzzer and DC motor are connected with Raspberry Pi. The voltage of home appliances is 230V but the Raspberry Pi voltage is 5V. So in this system,relay circuit is used to cover the high voltage to low voltage, low voltage to high voltage which is also act as a switch. In this system, we are using two bulbs, a dc motor and a buzzer as home appliances. Here two way relay are used in order to connect zero watts bulb in 230 V. Next device is DC motor. DC motor needs the two 5 V supply. But the Raspberry Pi board has only for three 5 V pins. So the male header pins are used to connect the motor. Buzzer is connected to the Raspberry Pi in the assigned pin. Connection setup of this system is shown in figure 8.

Figure 8: Implementation of smart phone based home automation using IoT

The command “ifconfig” is given in the command window. It will show the IP address in the screen as shown in figure 9.

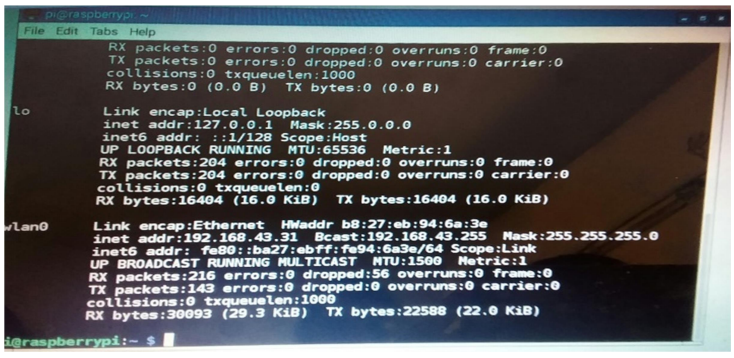

Figure 9: Schematic view of IP address page

While the program is executing, we should enter the IP address in the URL to open the webpage. It will establish the connection between the smart phone and the Raspberry Pi board and corresponding. On the webpage, we are having ON and OFF buttons in the smart phone. By using these buttons we can able to ON and OFF the home appliances which we connected with Raspberry Pi.When we touch the ALARM_ON button on the webpage correspondingly the buzzer will turn ON and it will show in the smart phone. Likewise when we touch the ALARM_OFF button the buzzer will be turn OFF and it will show in the smart phone.

VII. CONCLUSION

In this paper, a prototype smart home automation using IoT is presented. This work will be carried forward by integrating relays to Raspberry pi board for controlling home appliances from a remote location in a real scenario. As an extension, authors propose a generic IoT framework and use cloud computing infrastructure for connecting and managing. Expected to grow in popularity in the near future is the use of smart home products to increase family safety, specifically related to fire protection and carbon monoxide monitoring.Now we are connecting and controlling the few devices in home appliances. In future we are connecting multiple devices in order to control it from all over the world.

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Raspberry Pi based Interactive Home Automation System through E-mail

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***Abstract*— Home automation is becoming more and more popular day by day due to its numerous advantages. This can be achieved by local networking or by remote control. This paper aims at designing a basic home automation application on Raspberry Pi through reading the subject of E-mail and the algorithm for the same has been developed in python environment which is the default programming environment provided by Raspberry Pi. Results show the efficient implementation of proposed algorithm for home automation. LEDs were used to indicate the switching action.**

***Key Words* —Raspberry Pi, E-mail, Home Automation, Python.**

I. INTRODUCTION

Home automation refers to the application of computer and information technology for control of home appliances and domestic features. Its application varies from simple remote control of lighting to complex computer/micro-controller based networks involving varying degrees of intelligence and automation. Home automation results in convenience, energy efficiency, and safety benefits leading to improved quality of life.

The popularity of network enabled home automation has been increasing greatly in recent years due to simplicity and much higher affordability. Moreover, with the rapid expansion of the Internet, there is the potential for the remote control and monitoring of such network enabled appliances. However, the new and exciting opportunities to increase the connectivity of devices within the home for the purpose of home automation through internet are yet to be explored.

Several definitions are available in the literature for home Automation. Bromley *et al* (2003) describes home automation as the "introduction of technology within the home to enhance the quality of life of its occupants, through the provision of different services such as telehealth, multimedia entertainment and energy conservation". There has been significant research into the field of home automation with many other communication protocols like bluetooth, hand gestures, DTMF etc. The X10 industry standard, developed in 1975 for communication between electronic devices, is the oldest standard identified from the author's review, providing limited control over household devices through the home's power lines. Sriskanthan *et al* (2002) introduced a Bluetooth based home automation system, consisting of a primary controller and a number of Bluetooth sub-controllers. Al-Ali *et al* (2004) developed a Java based home automation system. The use of Java technology, which incorporates built-in network security features, produces a secure solution. However, the system requires an intrusive and expensive wired installation and the use of a high end PC. Baudel *et al* (1993) proposed a novel control network, using hand gestures. The controller uses a glove to relay hand gestures to the system. Ardam *et al* (1998) introduced a phone based remote controller for home and office automation. The system differs in that all communications occur over a fixed telephone line and not over the Internet. The system can be accessed using any telephone that supports dual tone multiple frequency (DTMF).

The research available into home automation in public domain lies predominantly in the academic arena, with little industrial research being available in open literature. The adoption of home automation technologies into commercial systems has been limited, and where available consumer uptake has been slow. The aforementioned systems offer little in the way of interoperability. Attempts have been made to provide network interoperability and remote access to home automation systems through the development of home gateways. Kushirio *et al* (1998) proposed a home energy management focused home gateway, which connects the home network with the Internet. The system was installed in twenty houses in the Tokyo area. Saito *et al* (2000) defined a home gateway as the point of ingress between a personal area network and a public access network. Yoon *et al* (2008) implements a home gateway that accepts mobile phone signals and activates or deactivates an LED representing a home device. Ok *et al* (2006) proposed a home gateway based on the OSGI (Open Service Gateway Initiative), which allows service providers to access home automation systems for administration and maintenance services. These systems have made a significant contribution to the development of a home gateway. However, the existing network infrastructure within the home environment has not been taken into consideration when selecting the networks for integration with the respective home gateways.

The paper proposes a Raspberry Pi based home automation system through e-mails.

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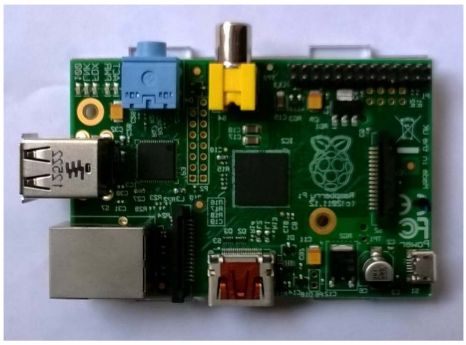

Fig. 1. Raspberry Pi board.

Raspberry Pi (shown in Fig. 1) is a credit-card-sized single-board computer developed in the UK by Raspberry Pi foundation with the intention of stimulating the teaching of basic computer science in schools. It has two models; Model A has 256Mb RAM, one USB port and no network connection. Model B has 512Mb RAM, 2 USB ports and an Ethernet port. It has a Broadcom BCM2835 system on a chip which includes an ARM1176JZF-S 700 MHz processor, Video Core IV GPU, and an SD card. The GPU is capable of Blu-ray quality playback, using H.264 at 40MBits/s. It has a fast 3D core accessed using the supplied OpenGL ES2.0 and OpenVG libraries. The chip specifically provides HDMI and there is no VGA support.

The foundation provides Debian and Arch Linux ARM distributions and also Python as the main programming language, with the support for BBC BASIC, C and Perl, detailed description of Raspberry Pi board has been given in Fig. 2 (Raspberry Pi user guide). Python was chosen as the main programming language, as it is generally accepted to be both easy to learn and a fully fledged , programming language suitable for real world applications. With the addition of NumPy, SciPy, Matplotlib, IPython, and PyLab, Python can be used for computational mathematics as well as for the analysis of experimental data or control systems (Ali *et al* -2013).

Also, the recent development of the Raspberry Pi mini-computer has unlocked great potential for computing to be applied in a vast number of areas. Due to the unique advantages of the Raspberry Pi system, this technology holds great promise for providing solutions within the developing world. This includes but is not limited to education tools, especially the use of GPIO (General Purpose Input/Output) which allows automated data acquisition and producing simple digital control systems in a school laboratory setting. The most distinctive feature of the Raspberry Pi when used for educational purposes is the GPIO module, which allows interfacing with general purpose electronics (Ali *et al* -2013).

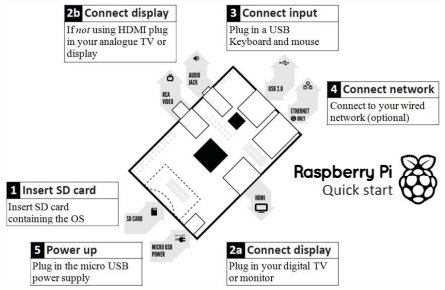

Fig. 2. Description of raspberry Pi Board.

This paper presents a basic application of Raspberry Pi in home automation control through internet (E-mail) where subject of the received e-mail is read by the developed algorithm fed into raspberry Pi and system responds to the corresponding instructions. The presented system is interactive, efficient and flexible according to the consumer needs. It immediately replies the status of work done by raspberry Pi to the consumer. The proposed system has been tested practically using LEDs as switching signal indicators, which can be seen in the presented results. The project can be extended for more applications apart from switching of home devices like surveillance, power monitoring, fault monitoring, power control, security etc.

II. SYSTEM CONFIGURATION

Fig. 3 describes the configuration of the proposed system. Raspberry Pi has been chosen as the processing unit for the system because of its user friendly features and economical benefits. Further, python coded algorithm has been fed into the raspberry Pi and is connected to the internet through Modulator-Demodulator (MODEM) interface to access and send e-mails to the consumer. The Devices to be controlled have been interfaced with raspberry Pi using relay driver circuit due to different power ratings of devices and raspberry Pi. A display (optional) may also be connected to view the instantaneous status and processing of raspberry Pi.

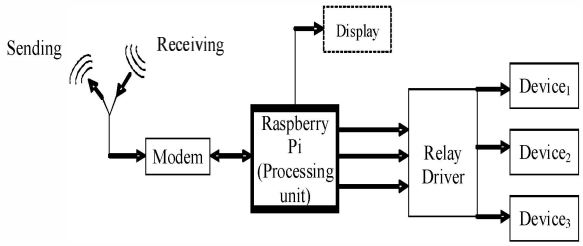

Fig. 3. Layout of the proposed system configuration

III. CONTROL ALGORITHM

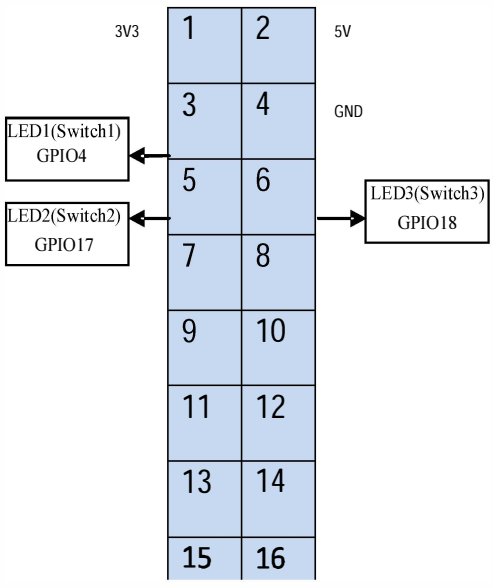

Fig. 4. Pin layout of raspberry Pi GPIO used in system.

The GPIO pins for input and output have been defined to control different devices. The Raspberry Pi board has GPIO pin layout as shown in fig. 4. Out of the 26 pins, 3 pins have been used to control three devices in this project which have been represented by 3 LEDs for testing the switching signal. For practical purposes a relay driver circuit and relays can be interfaced with Raspberry Pi and appliances, respectively, for their controlling.

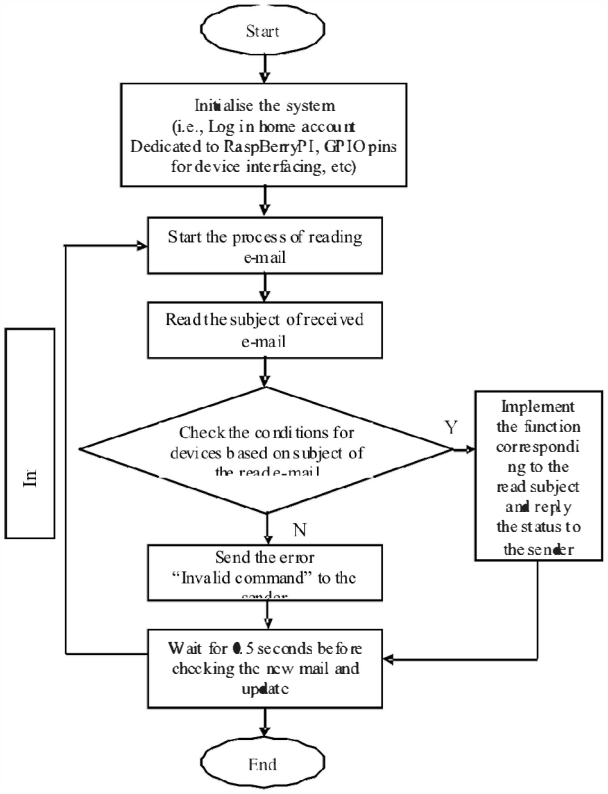

Fig. 5. Flowchart of the control algorithm used.

The pins used in this project were: pin7(GPIO4), pin11(GPIO17) and pin12(GPIO18). The code for implementing the control strategy for home automation was written in python environment on Raspberry Pi. Firstly, the code was set to initialize and log in into home g-mail account (g-mail-imap) using the e-mail library of pythonIDE. After successful initialization, Raspberry Pi starts reading the subjects of e-mails from the account specified in the code. The subject of these e-mails is then compared from the initializing commands of the interfaced devices and the control signal is generated according to it on the corresponding GPIO pin. This process is repeated continuously at an interval of 0.5 seconds. Fig. 5 represents the algorithm of the used code in the form of flowchart. Fig. 6 shows the controlling module of the proposed algorithm, coded in pythonIDE. Here, the subject read from the e-mail is stored in an array x[], and the 'if' structure was defined as per the elements of that array, i.e. if subject is 'ON1', raspberry Pi replies 'Turning On switch 1' to the sender and simultaneously the switch at pin.7 is turned ON and the structure is looped for checking new mail after every 0.5 seconds.

```
if(len(x)<>0):
    GPIO.setmode(GPIO.BOARD)
    #Signal to devices
    if(x[0] == 'ON1'):
      Reply('Turning ON swithch 1' , y[0])
      GPIO.setup(7,GPIO.OUT)
      GPIO.output(7,GPIO.HIGH)          #Turn ON LED1
    if(x[0] == 'ON2'):
      Reply('Turning ON switch 2', y[0])
      GPIO.setup(11,GPIO.OUT)
      GPIO.output(11,GPIO.HIGH)         #Turn ON LED2
    if(x[0] == 'ON3'):
      Reply('Turning ON swithch 3', y[0])
      GPIO.setup(12,GPIO.OUT)
      GPIO.output(12,GPIO.HIGH)         #Turn ON LED3
    if(x[0] == 'OFF1'):
      Reply('Turning OFF swithch 1', y[0])
      GPIO.setup(7,GPIO.OUT)
      GPIO.output(7,GPIO.LOW)           #Turn OFF LED1
    if(x[0] == 'OFF2'):
      Reply('Turning OFF swithch 2', y[0])
      GPIO.setup(11,GPIO.OUT)
      GPIO.output(11,GPIO.LOW)          #Turn OFF LED2
    if(x[0] == 'OFF3'):
      Reply('Turning OFF swithch 3', y[0])
      GPIO.setup(12,GPIO.OUT)
      GPIO.output(12,GPIO.LOW)          #Turn OFF LED3
  time.sleep(0.5)  #call delay
```

Fig. 6. Control Structure of proposed algorithm coded in pythonIDE

IV. PERFORMANCE EVALUATION

For verification of the practicality of the proposed algorithm, LEDs were used to indicate the switching signal of the interfaced devices. The experimental setup is shown in Fig. 7. Results were generated by a series of E-mails sent to the G-mail account of raspberry pi and the corresponding inbox and sent mails of raspberry G-mail account are shown in Fig. 8 and Fig. 9, respectively. For example, an E-mail with the subject

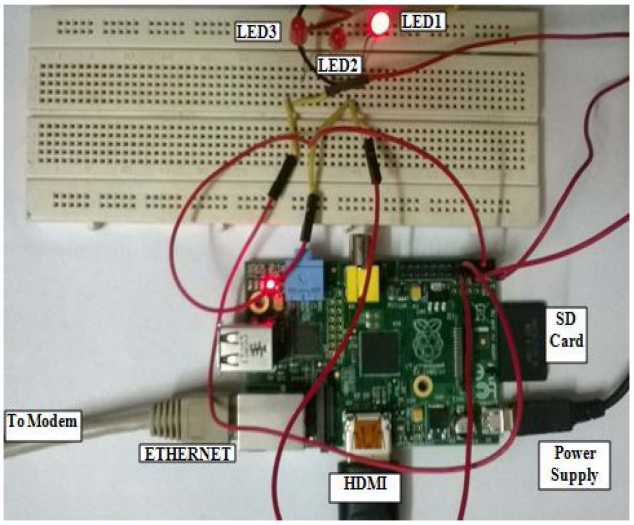

Fig. 7. Working Experimental setup, responding to email with subject 'On1" i.e. LED1 is glowing, representing the switching signal for switch1.

'ON1' was sent to raspberry Pi account ('raspanantsarthak@gmail.com' in this case) from the consumer account ('anant.vaib@gmail.com' in this case). The algorithm, read the subject 'ON1' and turned ON the device 1 represented by LED1 and instantly replied to sender by an email – 'Turning ON switch 1' under the subject- 'Home automation activated'. The code also includes exception handling in case of invalid e-mail from the consumer.

Similarly the same switch can be turned OFF by sending an e-mail with subject 'OFF1' to the raspberry Pi account. Further, This work consists of two more switches which can be controlled by sending e-mails under the subject – 'ON2' & 'ON3' to turn ON the switch2 & Switch3 and correspondingly – 'OFF2' & 'OFF3" to turn them OFF. So, the results show that home automation has been successfully implemented with efficiency and reliability.

V. CONCLUSION & FUTURE SCOPE

In this highly developing era, where directly or indirectly, everything is dependent on computation and information technology, Raspberry Pi proves to be a smart, economic and efficient platform for implementing the home automation. This paper provides a basic application of home automation using Raspberry Pi which can be easily implemented and used efficiently. The code provided is generic and flexible in a user friendly manner and can be extended for any future applications like power control, surveillance, etc, easily. Moreover, this technique is better than other home automation methods is several ways. For example, in home automation through DTMF, the call tariff is a huge disadvantage, which is not the case in proposed method. Also, in Web server based home automation, the design of web server and the space required is eliminated by this method, because it simply uses the already existing web server provided by G-mail.

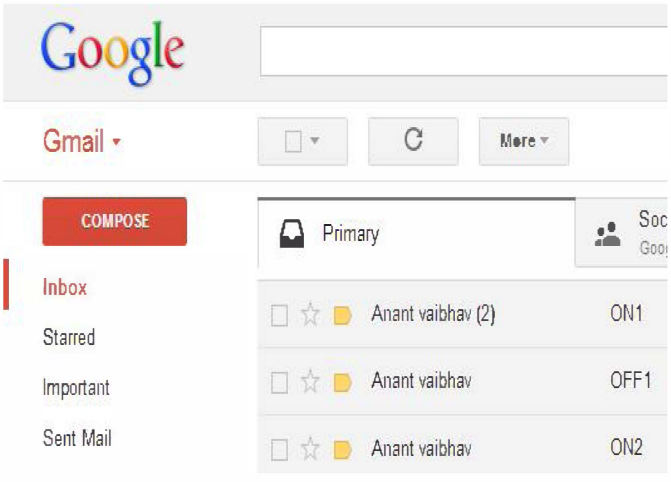

Fig. 8. Screen shot of "INBOX" received on raspberry Pi

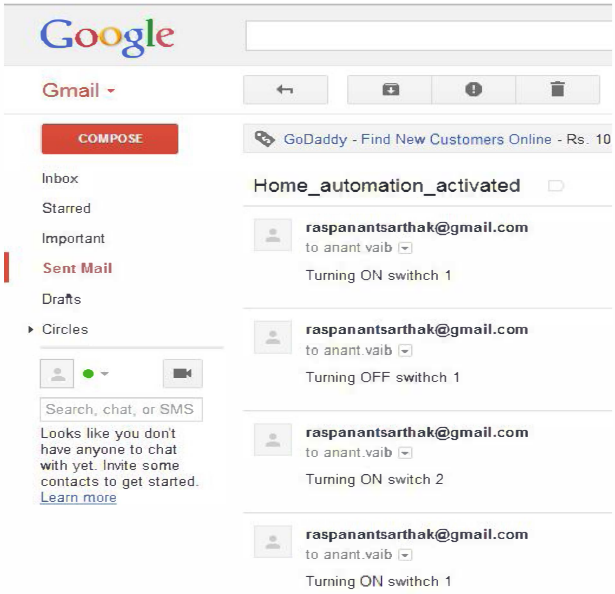

Fig. 9. Screen shot of "SENT MAIL" from raspberry Pi

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A Smart Home Automation Technique with Raspberry Pi using IoT

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***Abstract* - In this paper, we are presenting a proposed system for Smart Home Automation technique with Raspberry Pi using IoT and it is done by integrating cameras and motion sensors into a web application. To design this system, we are using a Raspberry Pi module with Computer Vision techniques. Using this, we can control home appliances connected through a monitor based internet. Raspberry Pi operates and controls motion sensors and video cameras for sensing and surveillance. For instance, it captures intruder's identity and detects its presence using simple Computer Vision Technique (CVT). Whenever motion is detected, the cameras will start recording and Raspberry Pi device alerts the owner through an SMS and alarm call.**

Keywords* - *Raspberry Pi, IoT, Computer Vision, Simple CVT, M- JPG Streamer.

I. INTRODUCTION

Now a days, automation plays a crucial role in all work places and living homes. Presently automation [2, 4] techniques are implemented either using microcontroller or computer. Microcontroller cannot run multiple programs at a time. With the use of Microcontroller it is difficult to control both the appliances and surveillance at a time i.e., it is very complex to perform the multiple functions simultaneously. We can achieve this with the computer, but using the computer is very expensive for this purpose and consumes more power. The Raspberry Pi [1, 5] is a single board computer and it can be used to overcome these problems. Simply, the Raspberry Pi system functions like a computer with small setup as shown in Fig- 2.1. It contains GPIO and USB ports. Using these ports we can control the appliances with the sensors as well as interface the camera for surveillance. Raspberry Pi can be used for multiple purposes based on our requirement.

The rest of the paper is structured as follows. Section II explains the functional description of all the components. Section III explains the system design. Section IV, deals with algorithm of the proposed system. Section V shows the results. Section VI discusses the conclusion and future work.

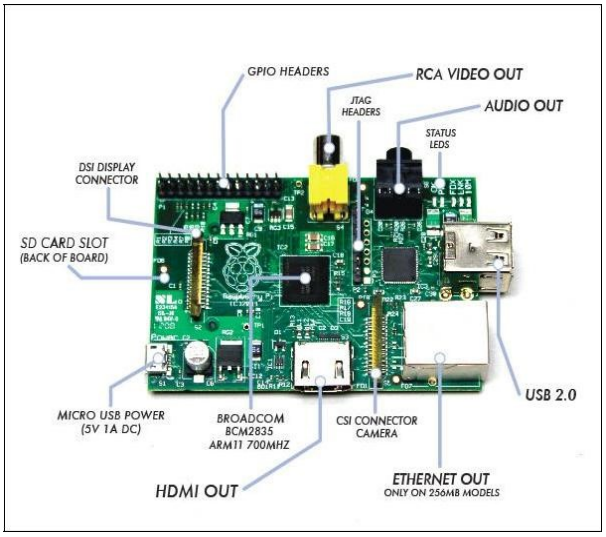

FIG2.1: RASPBERRY PI B+ BOARD

II. FUNCTIONAL DESCRIPTION

The functions of the various working components are given below:

A. Raspberry Pi:

Raspberry Pi is using the Advanced Reduced Instruction Set Computing Machine (ARM) technology. ARM technology is used on the board which reduces cost, heat and power consumption. It is energy effective multi core CPU implemented as System-On-Chip (SoC) weighing 50gm and operates on 5V, 700mA power rating. This board is available in three models named A, B, B+. The B+ Raspberry Pi board is the latest version among them, and it runs on ARM11 processor with 512MB RAM operating at 700 MHz frequency. It has SD card slot, which is used for booting the operating systems like Raspbian, Pidora, Raspbm. It has four USB2.0 ports to connect to the peripherals like mouse, keyboard and Wi-Fi adapter etc,

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making it as a full sized portable pocket computer. It also has an Ethernet port to connect to the network. GPIO ports are used to interface and control the LED's, switches, sensors and other devices. With the help of HDMI port, all kinds of monitors like LCD screens, projectors, TVs can be connected. In this board, some additional features like camera connector is available to interface camera and an audio jack. With all these features, Raspberry Pi is not just limited to single use, it can be used in many applications.

B. Simple Computer Vision Technique(CVT):

Simple Computer Vision Technique has a wide range of applications on face detection, robotics, video phone systems, intelligent human machine interface, biometrics, diagnosis of skin cancer and so on. We utilize Simple computer vision based system that allows users to interact with the virtual world by means of augmented reality along with movement recognition in the specified zone. Simple CV is an open source system for building PC vision applications and it allows the users to get more personal with their devices. It gathers the libraries for programming and that can be utilized to create vision applications. It gives the possibility to work with the images or feature streams that originate from USB & IP cameras, webcams, kinects, firewire and cell phones. Simple CV is composed in Python and it runs on Mac, Windows, and Ubuntu Linux.

C. M-JPG Streamer:

There are couple of cutting edge gushing conventions for web programs like HLS for Apple items, Fragmented MP4 and so forth. Divided MP4 is supported by Adobe and Microsoft, however obliges program plugins from these organizations on the player PC. The windows and Mac PCs can do it, but not versatile with the Linux based systems.

MJPG-streamer is a command line tool to stream JPEG files over an IP-based network from the webcam to a viewer like Firefox, Video LAN or even to a Windows Mobile gadget using the TCPMP-Player. MJPG-streamer relies on input- and output-plug-in, e.g. an input-plug-in to copy JPEG images to a globally accessible memory location, while an output-plug-in, like output http//, processes the images. For example serve a single JPEG file (provided by the input plug-in), or streams it converts existing MPEG standards. MJPG-streamer summons up a line application that duplicates JPG-outline from a solitary information module to different yield module. MJPG Streamer is a simple and straight forward video streamer, but it is faster than most streamers, so this makes it ideal for remote control projects in which real-time video feed is crucial for navigation and orientation purposes.

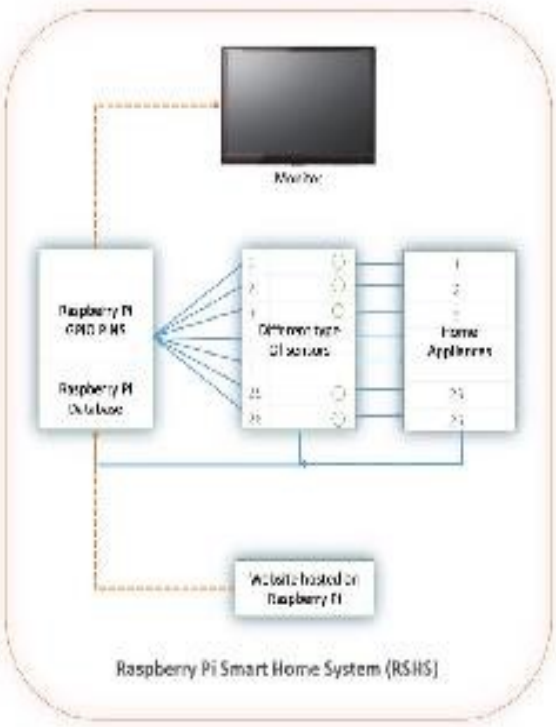

FIG3.1: SYSTEM DESIGN FOR SURVEILLANCE SYSTEM

III. IMPLEMENTATION

System Design:

The main aim of the system design is that the user can control the home appliances through mobile or laptop having internet facility using Raspberry Pi. A program is written to control home appliances and to get the current status (i.e, OFF or ON) of the appliances and to get the live streaming from camera connected to Raspberry Pi. It uses this program to get the status of appliances and to store the status on the database of website and it displays the current status of appliances and live streaming on monitor connected through HDMI port.

It is also used to stream video online i.e, we can see the live streaming anywhere through internet. We can connect it to several monitors at a time using HDMI extension switch. Thus Raspberry Pi will act as the central authority for controlling the home appliances and website database as well. Refer fig 3.1.

IV. ALGORITHM

In Raspberry Pi, Raspian operating system [7] is installed. This Operating System is a Linux based one and it supports all programming languages like Python, C, C++etc.

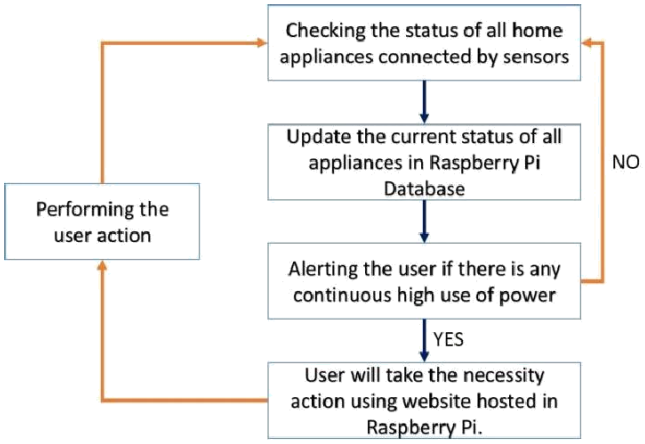

FIG4.1: ALGORITHM FOR SURVEILLANCE SYSTEM

Out of those, Python programming language is used in this system to communicate with General Purpose Input Output Ports and simple connection is made with databases using MYSQLDB [6] and Simple CV [8] modules. Refer the flowchart (Fig 4.1). For sending SMS to alert the user Serial module is used.

The proposed system can be demonstrated with the help of following steps:

- Import all the required modules i.e, Simple CV, MYSQLDB, Serial Module;
- Check the status (ON/OFF) of all home appliances connected to Raspberry Pi;
- Update the website database of appliances with the current status;
- Check whether the Raspberry Pi captures the surroundings using the camera;
- Using Simple CV, find whether the motion is present;
- If there is motion alert the user about the motion through SMS using GSM connected Raspberry Pi;
- If there is no motion Surveillance, check it continues the process from the beginning;

Whenever there is change in status of appliances then the changes are updated in website database.

V. RESULTS

The system allows the user to control the appliances from anywhere in the world using an internet connection. The proposed home automation system is practically implemented and thus the results are obtained.

Results of the proposed automation system are as follows:

Fig 5.1 shows the website containing the status of all the home appliances and live status from the camera connected to Raspberry Pi.

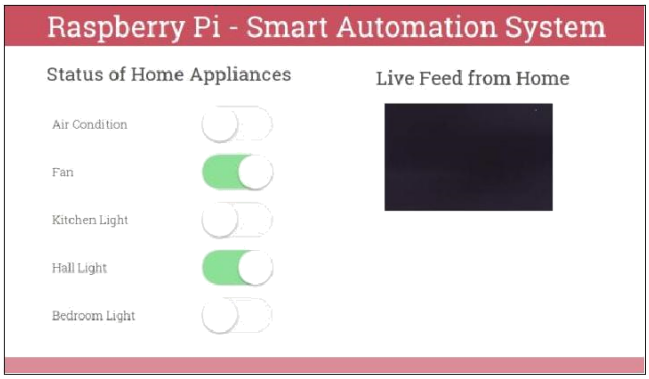

FIG5.1: WEBSITE SHOWING THE STATUS OF APPLIANCES AND LIVE STATUS FROM CAMERA

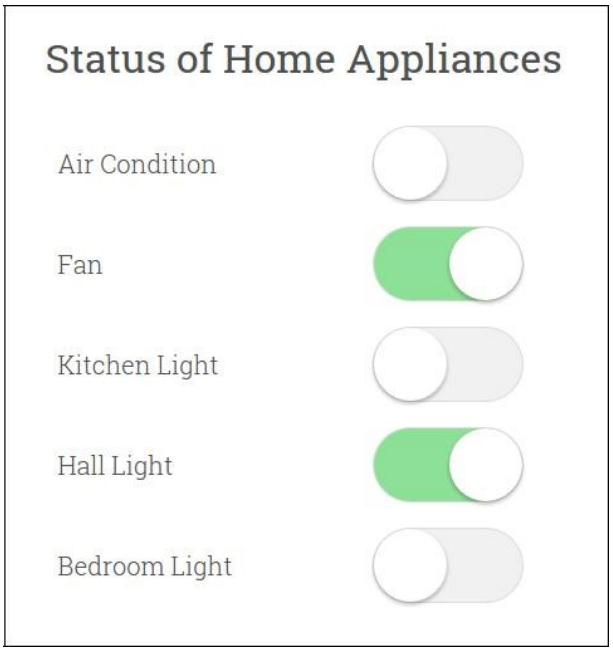

FIG5.1.1: STATUS OF HOME APPLIANCES

FIG5.1.2: LIVE STATUS FROM CAMERA

After detecting the motion Fig 5.2, Shows the process of cautioning the user.

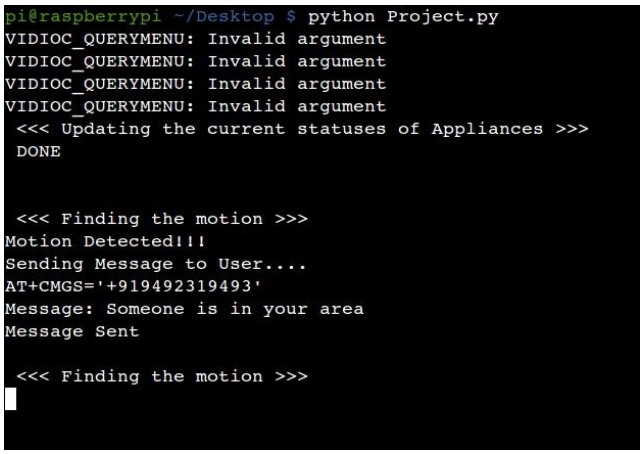

FIG5.2: RASPBERRY PI TERMINAL SHOWING THE RESULTS

VI. CONCLUSION AND FUTURE WORK

In this paper, we are designing an advanced automation system which has surveillance system and which in turn reduces most of the human interactions, by supporting this system using Internet of Things (IoT). Finally, it is absolutely an affordable system. It can be associated with various other options like energy monitoring systems etc., soon, as an extension to this project a system may be developed which warns the user about the excess usage of energy.

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Smart Home Automation: A Literature Review

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ABSTRACT
Home automation is becoming popular due to its numerous benefits. Home automation refers to the control of home appliances and domestic features by local networking or by remote control. Artificial Intelligence provides us the framework to go real-time decision and automation for Internet of Things (IoT).The work deals with discussion about different intelligent home automation systems and technologies from a various features standpoint. The work focuses on concept of home automation where the monitoring and control operations are facilitating through smart devices installed in residential buildings. Heterogeneous home-automation systems and technologies considered in review with central controller based (Arduino or Raspberry pi), web based, email based, Bluetooth-based, mobile-based, SMS based, ZigBee based, Dual Tone Multi Frequency-based, cloud-based and the Internet with performance.

Keywords
Home-Automation, Intelligence, Microcontroller, Sensor System, User-friendly Interface

1. INTRODUCTION
Automation is a technique, method, or system of operating or controlling a process by electronic devices with reducing human involvement to a minimum. The fundamental of building an automation system for an office or home is increasing day-by-day with numerous benefits. Industrialist and researchers are working to build efficient and affordability automatic systems to monitor and control different machines like lights, fans, AC based on the requirement. Automation makes not only an efficient but also an economical use of the electricity and water and reduces much of the wastage [5].

IoT grant to people and things to be connected Any-time, anyplace, with anyone, ideally using any network and any service [10]. Automation is another important application of IoT technologies. It is the monitoring of the energy consumption and the Controlling the environment in buildings, schools, offices and museums by using different types of sensors and actuators that control lights, temperature, and humidity.

2. HOME AUTOMATION
The Smart home known as House automation, with the use of new technology, to make the domestic activities more convenient, comfortable, secure and economical. The home automation system includes main components which are:

User interface: as a monitor, computer, or Phone, for example, that can give orders to control System.

Mode of transmission: wired connections (example Ethernet) or Wireless (radio waves, infrared, Bluetooth, GSM) etc.

Central Controller: It is hardware interface that communicates with user interface by controlling domestic services

Electronic devices, a lamp, an AC or a heater, which is compatible with the transmission mode, and connected to the Central control system.

The "Figure 1" shows projected trends in the smart home market in the coming year [10].

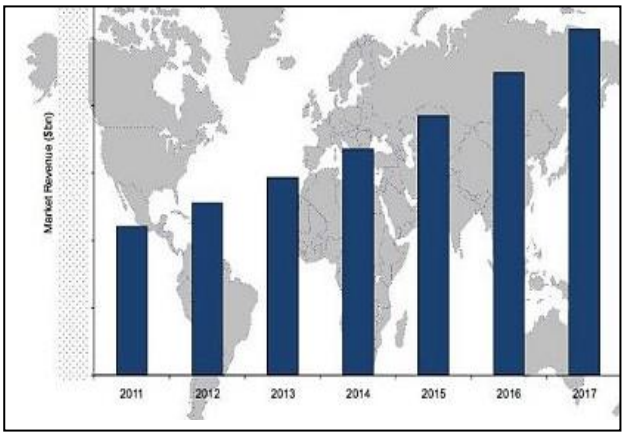

Figure 1: Popularity of Smart home in market

2.1 Features of Home Automation System
In recent years, wireless systems like Remote Control have become more popular in home networking. Also in automation systems, the use of wireless technologies provide several advantages that could not be achieved with the use of a wired network only.

2.1.1 Reduced Installation costs
Installation costs are significantly reduced since no cabling is necessary.

2.1.2 Internet Connectivity
Control devices from anywhere in the world with use mobile phones to control smart home.

2.1.3 Scalable and Expandable
With the Compare of Wireless network is especially useful when, due to New or changed requirements, an extension of the network is necessary.

2.1.4 Security
Easily add devices to create an integrated smart home security system and built-in security ensures integrity of smart home.

2.2 Challenges of Home Automation System
The work of John J. Greichen [12] discussed some of the early challenges faced by home automation systems. These include high manufacturing costs, high development costs, high installation costs, additional service and support costs, lack of home automation standards, consumer unfamiliarity with

technology, and complex user interfaces. With the advancement of time, rapid development in technology and processing power which leads to a considerable reduction in device cost and size. All of these factors have contributed to the popularity of electronic devices today, so people are no longer confused or unsure about the use of the computer, mobiles, or tablets. Moreover, a lot of home automation protocols, communication and interface standards.

3. LITERATURE REVIEW

In this section, discussed different Home Automation System with their technology with features, benefit and limitations they have. "The Figure 2" shows Basic Architecture of Remote Home Automation.

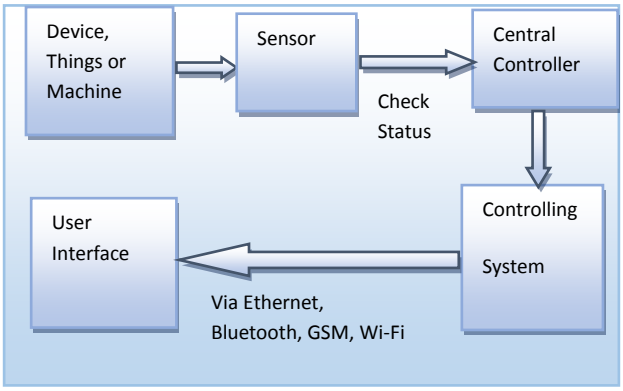

Figure 2: Basic Block Diagram of Home Automation

The Home automation system that uses Wi-Fi technology [1]. System consists of three main components; web server, which presents system core that controls, and monitors users' home and hardware interface module(Arduino PCB (ready-made), Wi-Fi shield PCB, 3 input alarms PCB, and 3 output actuators PCB.), which provides appropriate interface to sensors and actuator of home automation system. The System is better from the scalability and flexibility point of view than the commercially available home automation systems. The User may use the same technology to login to the server web based application. .If server is connected to the internet, so remote users can access server web based application through the internet using compatible web browser.

The application has been developed based on the android system [2]. An interface card has been developed to assure communication between the remote user, server, raspberry pi card and the home Appliances. The application has been installed on an android Smartphone, a web server, and a raspberry pi card to control the shutter of windows. Android application on a smartphone issue command to raspberry pi card. An interface card has been realized to update signals between the actuator sensors and the raspberry pi card.

Cloud-based home appliance monitoring and controlling System. Design and implement a home gateway to collect metadata from home appliances and send to the cloud-based data server to store on HDFS (Hadoop Distributed File System), process them using MapReduce and use to provide a monitoring function to Remote user [3].

It has been implemented with Raspberry Pi through reading the subject of E-mail and the algorithm. Raspberry Pi proves to be a powerful, economic and efficient platform for implementing the smart home automation [4].Raspberry pi based home automation is better than other home automation methods is several ways. For example, in home automation through DTMF (dual tone multi-frequency) [11], the call tariff is a huge disadvantage, which is not the case in their proposed method. Also, in Web server based home automation, the design of web server and the memory space required is ejected by this method, because it simply uses the already existing web server service provided by G-mail. LEDs were used to indicate the switching action. System is interactive, efficient and flexible.

Shih-Pang Tseng et al. [5] proposed Smart House Monitor & Manager (SHMM), based on the ZigBee, all sensors and actuators are connected by a ZigBee wireless network. They designed a simple smart socket, which can remote control via ZigBee. PC host is used as a data collector and the motion sensing, all sensing data are transferred to the VM in the cloud. The user can use the PC or Android phone to monitor or control through the Internet to power-saving of the house.

Arduino microcontroller to receive user commands to execute through an Ethernet shield. Our house network used together both wireless ZigBee and wired X10 technologies [6]. This system followed smart task scheduling with a heuristic for the Resource-constrained-scheduling problem (RCPSP). The mobile device can be either wired to the central controller through USB cable or communicates with it wirelessly, within the scope of the home. Arduino contains the web server application that communicates through the HTTP protocol with Web-based Android application. The system is highly flexible and scalable and expandable.

The home network which monitors the appliances and sensors and transmits data to the cloud-based data server which manages the information and provides services for users by transmitting data and receiving user commands from mobile application [7]. The proposed system has good modularity and configurability characteristics with very low power consumption in cost efficient way.

Application developed using the Android platform controlled and monitored from a remote location using the smart home app and an Arduino Ethernet based micro web-server [8]. The sensors and actuators/relays are directly interfaced to the main controller. Proposed design offers are the control of energy management systems such as lightings, heating, air conditioning, security, fire detection and intrusion detection with siren and email notifications.

Embedded system Raspberry Pi to serve as a communication gateway between mobile devices and Konnex-Bus (KNX) home automation systems [9]. Store the information of all actors and sensors within a Smart Home, instead of using separate profiles. Ensures energy-consumption could be reduced, compared to a standard desktop computer.

Dual tone multi frequency (DTMF) used in telephone lines [13]. There are three components in the system DTMF receiver and ring detector, IO interface unit, PC. The PC detects the ringing of the line and then authenticates the user and use the keypad tones to control the devices as required. An example of stepper motor control is taken up. This system has the advantage of being secure and allowing international standardization. This is because the DTMF tones are the same all over the world. But it suffers from the drawback that the number of appliances is limited by the number of keys in the keypad.

PIC16F887 microcontroller for home appliances controls with GSM for control of the appliances. [14]. It has high availability, coverage and security but the cost of SMS. AT commands can be sent through the GSM network to controls the home devices. The system does not does not have any

state information related to the devices and expects the user to keep track of it.

Arduino board is the controller used to control the appliances by using GSM technology. It uses certain peripheral drivers and relays to achieve this interfacing. The application on smartphone generates SMS messages based on the user commands and sends it to the GSM modem attached to the Arduino and control the home appliances [15]. The system has drawbacks of cost and reliability of SMS. An interface cannot be customized based on devices.

It has been designed Arduino board with Bluetooth board were developed for home automation [16]. Python program is used on the cell phone to provide the user interface. The Bluetooth board has I/O ports and relays are used for interfacing with the devices which are to be controlled and monitor. The Bluetooth is password protected to ensure that the system is secure from intruders. The Bluetooth has a range of 10 to 100.

3.1 Compassion of System

Discussed Comparison of Different Home Automation Systems by considering its Central Microcontroller, Communication interface, User interface, provided features and their benefits as shown in "Table 1".

3.2 Evolution of System

3.2.1 Raspberry Pi

It is a credit-card-sized single microcontroller computer. Python as the main programming language. It is easy to learn and suitable for real world applications [4]. There are two main types of pi first one is Model A has 25 6Mb RAM, one USB port and no network connection and Model B has 5 12Mb RAM, 2 USB ports and an Ethernet port. It has a Broadcom BCM2835 system on a chip which includes an ARMl176JZF -S 700 MHz processor, Video Core IV GPU, and an SD card. The chip specifically provides HDMI and there is no VGA support. Arduino can successfully work with Raspberry Pi Computers.

3.2.2 Arduino

It is a microcontroller board, not fully computers. In this, written codes are simply executed without any obstacle. It is an 8 bit Atmel AVR Microcontroller which comprises of 32K and 512K of onboard flash memory, 2K of RAM, runs at 8-84MHz clock speeds with voltages of 2.7V-12V.programming is done using C and carries no operating system. The code is written in the computer and then sent through USB cable for execution. Its construction simply covers digital input-output pins that are between 9-54 AND 6-12 analog input pins. Its power consumption is less than 0.5 watt.

4. CONCLUSIONS

Based on surveyed study the comparison of home automation systems are presented. Microcontroller, user interface, a communication interface and their performance factor are compared. There are a number of do-it-yourself (DIY) platforms available that allow to create Home Automation system quickly and easily with low cost and high performance e.g. Raspberry pi, Arduino, other microcontrollers, etc. In this review explained different home automation system e.g. Web based, email based, Bluetooth-based, mobile-based, SMS based, ZigBee-based, Dual Tone Multi Frequency-based, cloud-based and Internet based. In future home automation will more smart and fast. It would be extended to the large-scale environment such as colleges, offices and factories etc.

Table 1. Comparison

Sr No.	System	Communication Interface	Controller	User Interface	Applications	Benefits
1.	Wi-Fi based using Arduino Microcontroller	Wireless LAN and Wi-Fi shield	Hardware interface module	web based Application.	Temperature and humidity, Motion detection, Fire detection, Door status, Light level ,Video monitoring, Controlling appliances	Low cost, Secure, Ubiquitously accessible, Auto-configurable, Remotely controlled
2.	Web service and android app Based using Raspberry pi	Web server and interface card	Raspberry pi	Android application	Controlling shutter of window	Autonomous, and Quite scalable
3.	Cloud Based Using Hadoop System	Cloud based data server uses Hadoop Technology	Home gateway and Router	Smart device	Monitoring and Controlling Home Appliances	Effectively manage Semi structured and unstructured data, Reduce computational burden of smart devices
4.	Email Based using Raspberry pi	Internet Modem	Raspberry pi	E-mail	Switching LED	Smart, Economic and Efficient

5.	Cloud Based Using Zig Bee Microcontroller	Zig bee wireless Network	Smart Socket	PC or Android Phone	entrance control management, monitoring the power consumption, temperature and humidity	Convenience, safety, and Power-saving
6.	Smart Task Scheduling Based using Arduino and Android	Wired X10 and Wireless Zig bee	Arduino	Android Application	Energy Management and task scheduling with power and cost	Energy-efficient and Highly scalable
7.	Wireless Sensors Based with mobile Technology	cloud-based data server	PCB circuits	Mobile Application	monitor the home conditions and power consumption of appliance	Low power consumption And system cost efficiency.
8.	Android based using Arduino	Micro Web Server	Arduino Mega 2560 and the Arduino Ethernet shield	Android App	Light switches, Temperature ,Humidity sensors, Intrusion detection,, Smoke/Gas sensor	Feasibility and Effectiveness
9.	Konnex-Bus based using raspberry pi	SIP Provider	Raspberry pi and Konnex Bus	Mobile App	Lights Control, Temperature Monitoring	Performance improved ,energy-consumption could be Reduced.
10.	By Using DTMF	DTMF Receiver	Logical Controller with I/O interface	Computer	Authentication of user by ringing line	Secure and allow International Standard
11.	GSM Based Using PIC Microcontroller	SMS	PIC16F887 microcontroller	Mobile phone	Control appliances	High availability, coverage and Security but costs for the SMS.
12.	GSM Based Using Arduino	SMS	Arduino	Smartphone App	Control appliances	Simplicity
13.	Bluetooth Based using Arduino	Bluetooth	Arduino	Python supported mobile	controlling	Secured and Low cost

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