Leveraging Internet of Things to Revolutionize Homes for Smart Cities

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Abstract— In recent years the life style of people has been improved a lot. Now a day's there is lots of talk about smart cities but to really leave in smart city our homes should be smart also. The aim of this research work is to build such a system where we not only monitor and control home from local Wi-Fi network but we should able to do this from any corner of the world. This can be implemented by Internet of Things where things talk to things and according to conditions appropriate actions can be implemented without human interaction. In this work for security of the home premises we have added Passive Infrared (PIR) motion sensor, on detection of movement system captures the image and stores that image directly to webserver. To automate lighting control in the home, LDR base circuit is placed which controls the lighting in the house or office building according to the weather lighting condition. Temperature in this smart home is also maintained by constant monitoring of temperature. The other main benefit of all this system is that the server side of the smart home is implemented using dynamic IP which saves annual expenditure on the static IP for the server.

Key words: Leveraging Internet, PIR

I. INTRODUCTION

In today's modern computer age more and more tasks are becoming automated. Automation can make things easier & safer. What was once a science friction being today a reality. Home automation only become practical in the early 20th Century after the widespread of electricity into the home, and the rapid advancement of IT. The popularity of home automation has been increasing at a great rate recently through smart phones and tablets, due to higher affordability and simplicity of connection.

There are many home automation systems and device manufacturers. Main types of home automation system.

1) Individual Control System: These devices were introduced in the early stages of automation systems. There exists a separate control for each device.
2) Distributed Control Systems: Important features for this type of system is emergency shut down. These devices also include such equipment for better integration of hardware and software components.
3) Centrally Controlled Systems: These systems are computer programmed in order to deal with various functions. If control parameters are forgotten, people can still be safe with these control because of Computer-controlled assistance.

II. IOT & HOME AUTOMATION

The Internet of Things (IoT) is refereed as the Internet of Objects, objects can be consumer products, sensors and other things that are connected to internet. IoT is next generation of internet. IoT base system elements the need of a human for constant data monitoring and to take action on the event. In 1999 a group working at the Auto-ID centre of Massachusetts Institute of Technology(MIT) founded this technology. In 2003 there are 6.3 billion people are living on earth and 500 million devices are connected to internet [1]. And there is a prediction of more than 100 billion devices will be connected by 2025 [2]. IoT is grew from combination of wireless technologies, the internet and microelectromechanical system and micro services. Addition of sensors and actuators made the system a general class of cyber-physical system like smart grid, smart home and smart cities.

Kevin Ashton the founder of IoT explained the potential of IoT as. “Today computers and, therefore, the Internet are almost wholly dependent on human beings for information. Nearly all of the roughly 50 petabytes (a petabyte is 1,024 terabytes) of data available on the Internet were first captured and created by human beings by typing, pressing a record button, taking a digital picture or scanning a bar code. The problem is, people have limited time, attention and accuracy all of which means they are not very good at capturing data about things in the real world. If we had computers that knew everything there was to know about things using data they gathered without any help from us we would be able to track and count everything and greatly reduce waste, loss and cost. We would know when things needed replacing, repairing or recalling and whether they were fresh or past their best.”

IoT can be used to monitor and control the mechanical, electrical and electronic systems used in Homes. Systems like lighting control, heating, ventilation, air conditioning, home security devices and many more to improve convenience.

In first paper [3] authors have implemented internet based switching on and on off electronics appliance using waved cloud services. Reference paper “Towards the Implementation of IoT for Environmental Condition Monitoring in Homes. [4] created IoT base home environmental condition monitoring in homes. They used temperature sensors and measured temperature of solar water heater cylinder, lighting condition and uploaded the data via internet to server. Other paper [5] created home automation system using Raspberry Pi and controlled switching ON/OFF of electrical appliance through E-mail subject. B.Ghazal [6] created a XeeBee base remote control to control the lighting condition of the chandelier. This control can be done within the limited coverage range. Shaiju Paul paper [7] in Android Based Home Automation Using Raspberry Pi created a automation system and application which can be installed on Android smart phone to control the home system. IoT base implementation “Internet of Things in Home Automation and Energy Efficient Smart Home Technologies” [8] authors have explored the history and implementation of the IoT and how it can be used in smart home automation.

The systems created for home automation mainly focus on turning ON/OFF the electrical appliances. Which is not sufficient for smart home. In another way controlled turning ON/OFF of LED with E-mail subject. In order to do so the user has to remember the particular format for the subject otherwise the desired controlling will not be done. An IoT base system is implemented to monitor hot water cylinder of solar water heater, room temperature and temperature of outside surroundings of the home. In order to implement IoT based system a server is required which updates the data collected by various sensors. The servers cost huge amount of money. Amazon AWS charges $0.01/hour for a machine consisting of 512MB RAM and charges extra for data transfer from and to server for Asia Pacific region. [4] When the number of user increases such system becomes expensive and increase the price of overall automation system which is undesirable.

III. HARDWARE COMPONENTS

A. Raspberry Pi:

Hardware prototypes are commonly used during embedded control unit design. Within an existing model-driven design methodology, it is possible to perform real-time hardware simulation using the Raspberry Pi single-board computer to simulate planned system with less development and testing effort.

There are many handy devices available in the market today like Arduino, Beaglebone black, Intel Galileo, Raspberry Pi, Cotton Candy etc for the use and which are cost effective in comparison with the PCs and laptops and can be used with different OS for multipurpose.

1) Raspberry Pi specification

a) The Processor:

This processor used is a 32 bit, 900 MHz System on a Chip, which is built on the Quad-core ARM Cortex-A7 architecture. The Raspberry Pi 2 Model B comes with 1GB RAM on the board.

b) Secure Digital (SD) Card slot:

There's no hard drive on the Pi; everything is stored on an SD Card. It will require at least 4GB, and it should be a Class 4 card or above.

c) The USB port:

On the Raspberry Pi 2 Model B has four USB 2.0, in Model B there are two USB 2.0 ports. This model is up to full specification to the USB 2.0 spec.

d) Ethernet port (LAN):

The new versions of Raspberry Pi2 model B has a standard 10/100 Base Ethernet socket. Apart from Ethernet we can connect to the internet via using the USB Wi-Fi dongle or by USB tethering from android mobile device.

e) HDMI connector:

The Raspberry Pi 2 provides HDMI port, which is supported by many LED and at panel TV's so that we can directly connect the Raspberry Pi to the HDMI enabled display.

B. Zigbee Module:

The ZigBee RF Modules meet IEEE 802.15.4 standards. These module work on low power while providing reliable data packet delivery to the device. This module operates 2.4 GHz frequency band and are pin-for-pin compatible with each other.

C. PIR Sensor

The PIR stands for Passive Infrared Sensor. The PIR used here is HC-SR501 which works on infrared technology, it has high sensitivity, and high reliability with ultra- low power operating voltage. Because of this features it is widely used for motion detection.

D. Temperature and Humidity Sensor:

In order to monitor the temperature, the house temperature LM315 IC is used. LM35 is precise temperature sensor, with an output voltage changes proportional to centigrade temperature. There are some other modules available in the market for measuring the temperature in kelvin. But in order to convert the data to centigrade unit some additional conversation is required which requires extra computing time and power.

IV. SERVER SETUP AND HARDWARE IMPLEMENTATION

In order to implement the IoT base an internet server is required, on which webpage and database as stored. In general, the server is accessed by static IP over the internet which costs some money for maintenance and for using static IP. To overcome this pricing I have implemented the server by using the dynamic IP which doesn't cost any extra money, in this way the system is made cost effective. I have implemented a server using Ubuntu 14.04 LTS on 32-bit machine running the kernel version 3.19.0-25-genric. This server is accessed on internet through dynamic IP and dynamic DNS. The DNS combined with this server is vatsalbhavsar.ddns.net.

Image 1 below shows the system information like system load, memory usage etc.

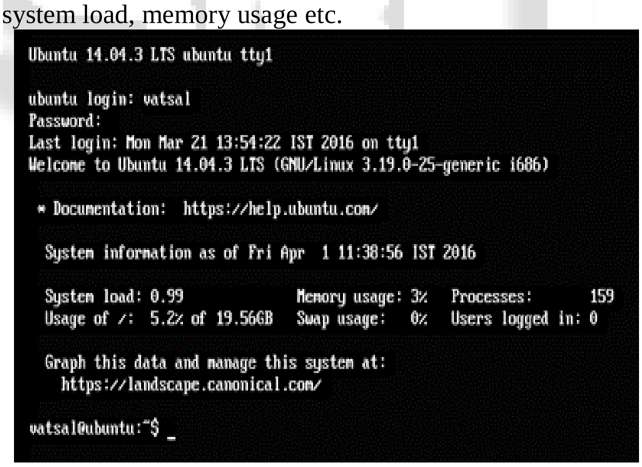


Fig. 1: Server Details

A. Linking Raspberry Pi with Server:

The interlinking of Raspberry Pi and server is done using the socket command. In this command at server side the port is opened for connection. At client end using this command the destination server address type i.e. IPv4 or IPv6 used is specified. Destination server address and on which port to connect is specified. The ow chart shows the sequence of both side, how the port is created at server side and how the connection is made from Raspberry Pi and the server.

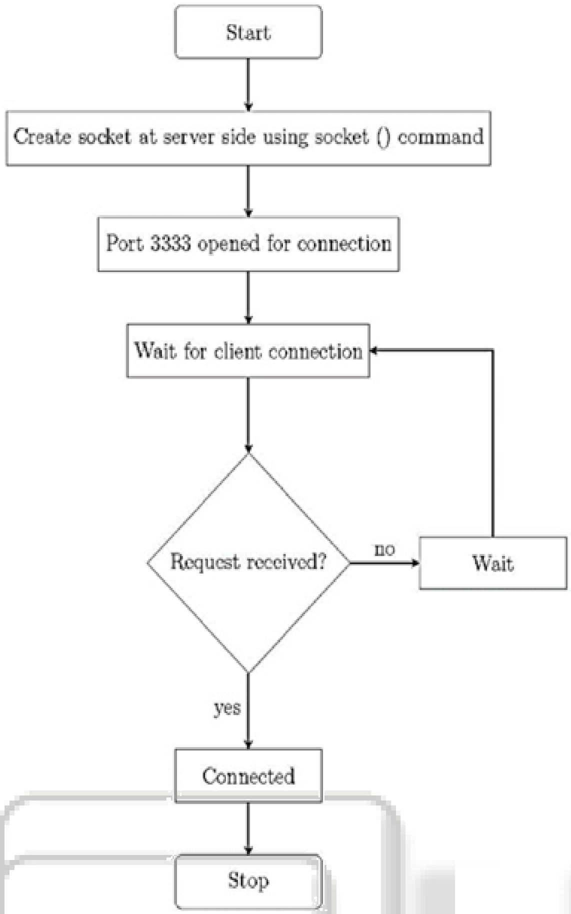


Fig. 2: Flowchart of Process at server side

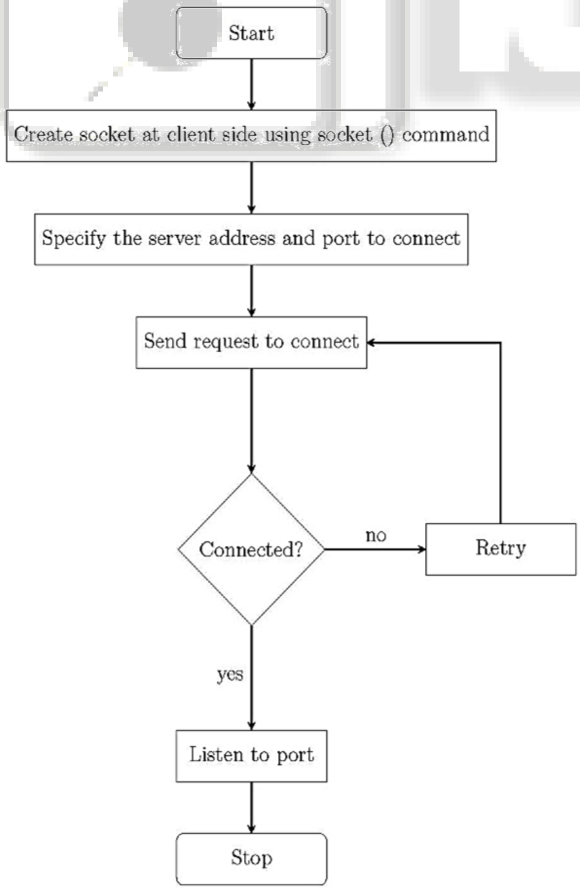


Fig. 3: Flowchart of Process at RPi

Fig 2 and 3 shows the flowchart of how the connection between Webserver and Raspberry pi

B. GPIO Control of Raspberry Pi from The Server:

Through the GPIO control different system in this work is controlled. At server side a form is created to acquired GPIO information from user. This data taken from the user via form is stored in the text file as string in the format of gpiono_direction_value this text file is transmitted to the Raspberry Pi which earlier connected to the server using the socket command. Upon receiving this text file from the server gpio pin number, direction and value for that GPIO pin is stored in three different files and from these values command is executed in Raspberry Pi accordingly, the values passed through the text file. Flow chart below explains the step by step process of controlling the GPIO from the Internet.

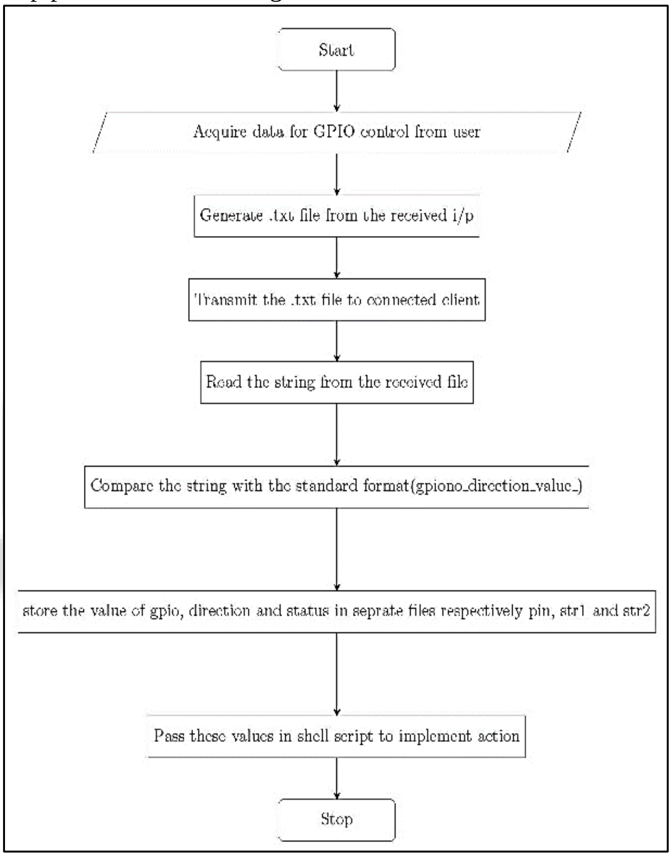


Fig. 4: GPIO control flow chart

C. Security System Implementation:

The security system consists of PIR motion detector, ZigBee and camera. Fig 5 shows the security module which is placed at outside home and can be turned ON or OFF remotely. The PIR motion sensor transmits data to ZigBee. The PIR motion sensor is connected to DI0 pin of the ZigBee. This ZigBee and PIR motion sensor are powered by a separate power source. This ZigBee transmits the data to another ZigBee which is connected to the GPIO21 of the Raspberry Pi. GPIO21 on the Raspberry Pi is configured as input pin which accepts the data from the DI0 of the ZigBee. The data received from the PIR sensor is further used to detect motion and also it plays important part in the controlling of the camera to capture the image.

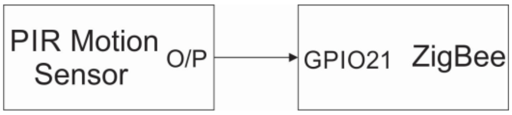


Fig. 5: Security System outdoor part

Figure 6 shows the other end of the security system. The data collected at GPIO21 from PIR sensor is analysed and if motion is detected Raspberry Pi initiates camera module and sends command to capture the image. On capturing the image that image is uploaded on the server. Figure 8 Shows the complete flow process of the system.

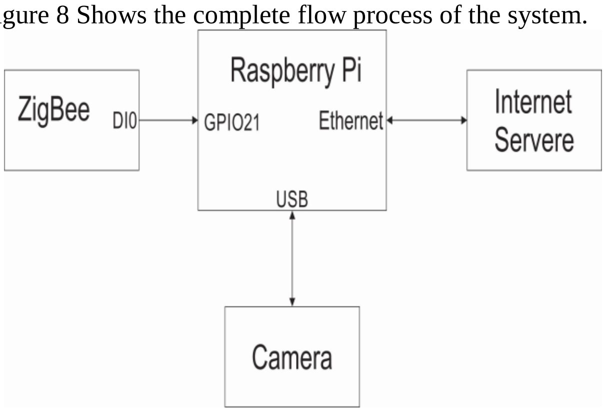
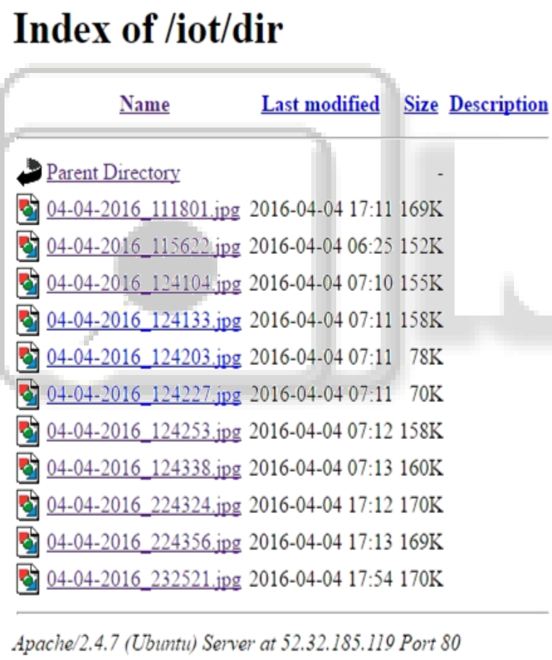


Fig. 6: Security system interfacing with RPi



Index of /iot/dir

Name	Last modified	Size	Description
Parent Directory		-	
04-04-2016_111801.jpg	2016-04-04 17:11	169K	
04-04-2016_115622.jpg	2016-04-04 06:25	152K	
04-04-2016_124104.jpg	2016-04-04 07:10	155K	
04-04-2016_124133.jpg	2016-04-04 07:11	158K	
04-04-2016_124203.jpg	2016-04-04 07:11	78K	
04-04-2016_124227.jpg	2016-04-04 07:11	70K	
04-04-2016_124253.jpg	2016-04-04 07:12	158K	
04-04-2016_124338.jpg	2016-04-04 07:13	160K	
04-04-2016_224324.jpg	2016-04-04 17:12	170K	
04-04-2016_224356.jpg	2016-04-04 17:13	169K	
04-04-2016_232521.jpg	2016-04-04 17:54	170K	

Apache/2.4.7 (Ubuntu) Server at 52.32.185.119 Port 80

Fig. 7: Images stored to server

The above figure 7 shows the images stored on the server the name to the images are given according to dd-mm-yyyy_hhmmss.jpg

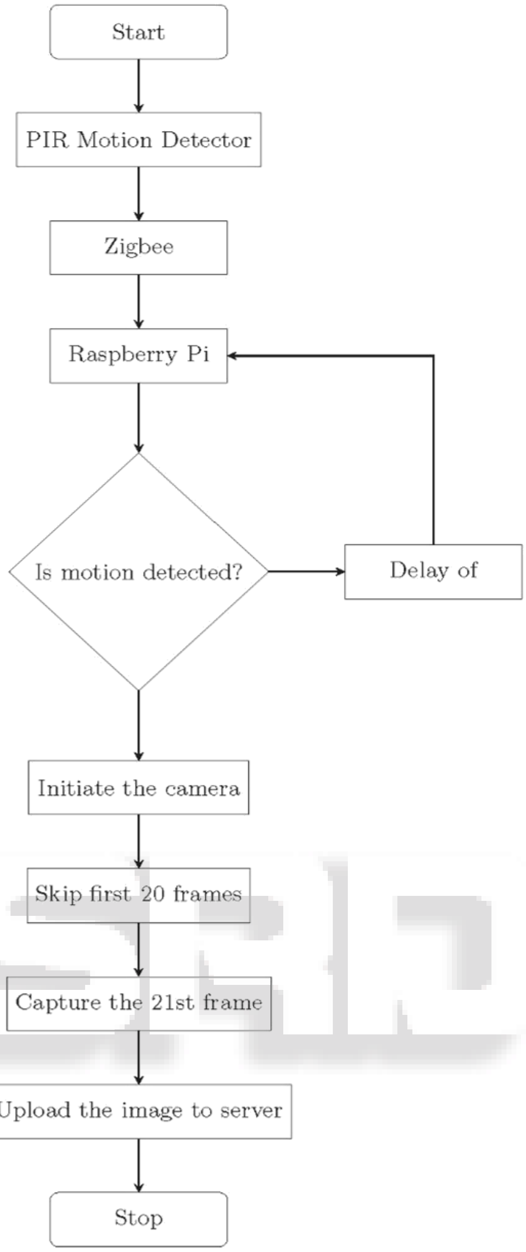


Fig. 8: Security system flowchart

V. CONCLUSION

In this work the system implemented works on IoT and through control of GPIO supply to electrical appliance is turned ON/OFF. The security system successfully detects the motion and triggers the camera module and uploads the images to the server.

VI. FUTURE SCOPE

As a part of smart city with this system a database can be created to accommodate number of user to this IoT based system. Main benefit of this IoT base system is that user can set certain parameters through web from any place on the earth. As technology advances more number of devices can be included in this IoT network to make human life more secure, comfortable and the sever side programming can also be developed to make it more user friendly and easy to operate.

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