Cloud Based Home Automation – Adapting Greener Homes

Megha Peter
Assistant Professor
Department of Electronics and Communication Engineering
Holy Kings College of Engineering and Technology, affiliated to M.G University

Abstract

The Home automation technology is set to revolutionize the way people perceive digital devices in our homes and office environment. Now they are no longer just the individual devices, instead, with the HA technology, they form a network in which appliances can communicate with each other. This wireless technology is especially useful in home environment, where there exists hardly any infrastructure to interconnect intelligent appliances. These days convenience and easy work environment is what everyone is looking for. Home automation is one such technology which gives us Convenience, Safety and security, Fun and Enjoyable environment. In the proposed system, the user will have a GUI application in his android phone with which he can control and monitor the home devices. A master control unit placed at home receives the control messages over the internet and sends it over to the corresponding devices over zigbee network. As the control and monitoring devices being developed are battery powered, there will not be an issue of availability of power sockets. The message transactions between the smart phone and home are through a cloud server, which will manage the users and the devices to be controlled or monitored. The user authentication is done in the cloud server.

Keywords- Home Automation, Master Control Unit (MCU), Current Monitoring Unit (CMU), Remote Transmit Unit (RTU), Intelligent Plug Unit (IPU)

I. INTRODUCTION

In all the existing Home Automation technologies, the main problem is the interoperability between networks. In case where two different networks co-exist, power line communications are used, which limits the positioning for the home devices to the points where there are power sockets. In some other technology, the issue is with the user interface, that the user has to remember access codes while controlling the devices. In cases where there are many devices to be controlled, this becomes a tedious job.

In the proposed system, the user will have a GUI application in his android phone with which he can control and monitor the home devices. A master control unit placed at home receives the control messages over the internet and sends it over to the corresponding devices over zigbee network. As the control and monitoring devices being developed are battery powered, there will not be an issue of availability of power sockets. The message transactions between the smart phone and home are through a cloud server, which will manage the users and the devices to be controlled or monitored. The user authentication is done in the cloud server.

II. PROJECT ANALYSIS AND DESIGN

In the proposed Home Automation system, the user can access the home automation system for control and monitoring services, through a mobile phone with android application. The proposed system can be divided into two subsystems:

A. Digital Home Service Distribution and Management System

It provides a user interface for control and monitoring of connected home automation devices. This subsystem includes:

- An Android based phone, which provides the user interface for controlling and monitoring the devices. A menu driven application running in the smart phone will be used to send and receive commands and responses and to display status of the monitored/controlled units such as AC and Lights at the remote location.
- A cloud server, which manages the users and the devices to be controlled, through a webpage. Also the cloud server receives the commands from the mobile phone, identifies the targeted home network and routes it to the corresponding network.

B. Home Gateway (Zigbee)

It is responsible for controlling the home devices. Here the home network is formed using zigbee communication protocol. To achieve the above requirements, following units are designed

1) Master Control Unit (MCU)
2) Current Monitoring Unit (CMU)

3) Remote Transmit Unit (RTU)
4) Intelligent -Plug Unit (IPU)

The Master Control Unit (MCU) acts as the gateway between server and the home automation system. Each house requires only one MCU, and it will be placed anywhere inside the home where Ethernet interface is available through a suitable router. The MCU receives the data from server through the Ethernet interface.

MCU interacts with other units namely, RTU, CMU and IPU through Zigbee. There will be only a single MCU connected to each home automation unit and multiple slave devices can be connected to it.

III. THE PROPOSED SYSTEM

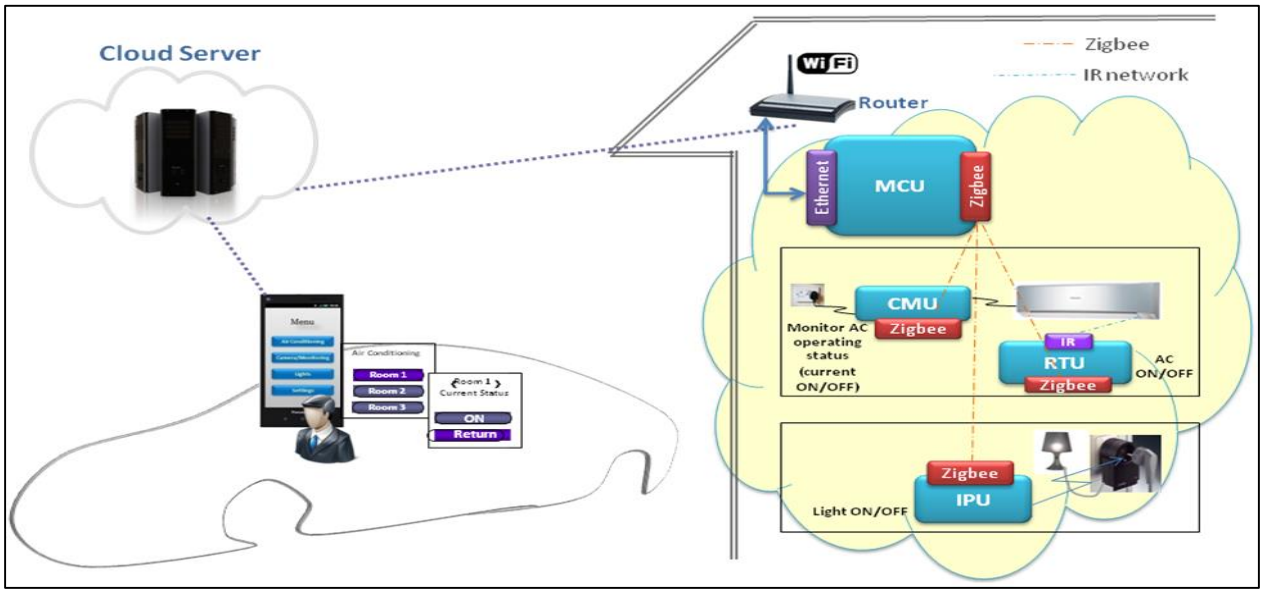

Fig. 1: The top level context diagram of the home automation system

The Master Control Unit (MCU) acts as the gateway between server and the home automation system. Each house requires only one MCU, and it will be placed anywhere inside the home where Ethernet interface is available through a suitable router. The MCU receives the data from server through the Ethernet interface.

MCU interacts with other units namely, RTU, CMU and IPU through Zigbee. There will be only a single MCU connected to each home automation unit and multiple slave devices can be connected to it.

A. ON/OFF Control of Air Conditioner

A user should be able to ON/OFF the AC, remotely using a smart phone with proper application running on it. The MCU receives the ON/OFF command from server through Ethernet interface. The MCU sent this command to RTU through Zigbee interface. The AC is made ON/OFF by RTU using IR transmitters.

The ON /OFF of AC is done using three communication stages

- Cloud Server –MCU
- MCU-RTU
- RTU – AC

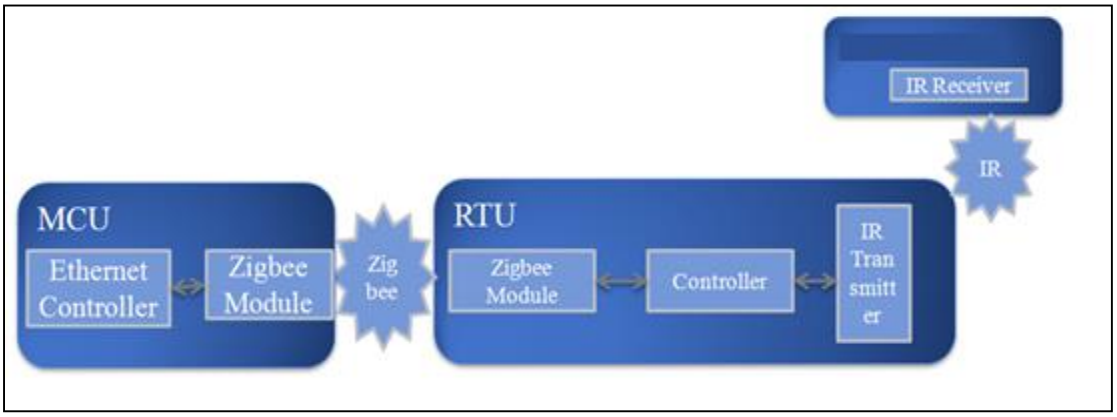

Fig. 2: ON/OFF Control of Air Conditioner

B. Remote Learning of AC Code

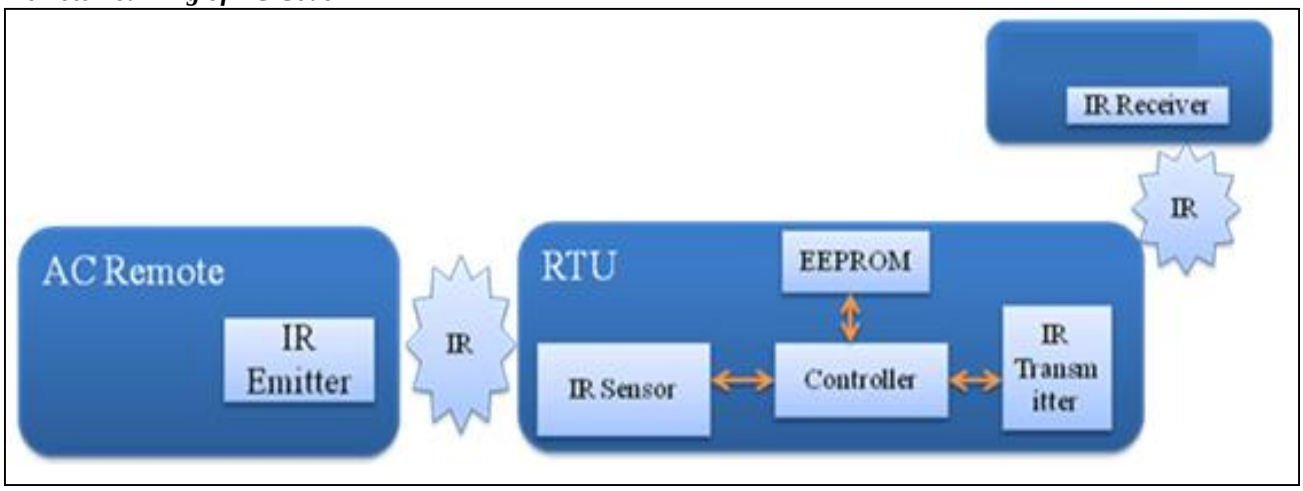

Fig. 3: Remote Learning of AC Code

This feature is included to make the RTU universal, for using it for ACs of all makes. 'Learning method' of universal remote is being used in RTU. Here the bit pattern for AC_ON command and AC_OFF command is learned by the RTU and is stored in its memory. The stored bit patterns of each command is played back when the corresponding switch is pressed.

C. Status Monitoring of Air Conditioner (CMU)

A user should be able to know the ON/OFF status of the AC remotely using a smart phone with proper application running on it. The MCU on request from server sends the request to CMU using zigbee to monitor the current consumed by the AC. Based on the current measured, CMU will sent the on/off status to MCU. MCU will sent this status to sever through Ethernet, which will then be displayed in the mobile phone.

The monitoring of ON /OFF status of AC is done using four communication stages

- Cloud Server –MCU
- MCU-CMU
- CMU-MCU
- MCU-Cloud Server

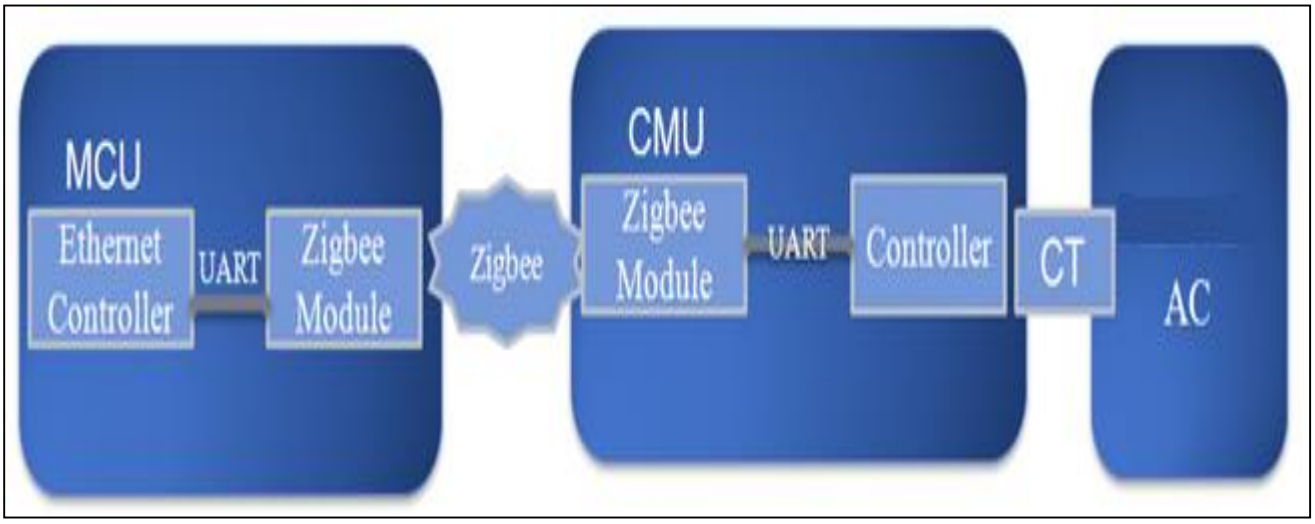

Fig. 4: Status Monitoring of Air Conditioner

D. ON/OFF Control of Light (IPU)

A user should able to remotely ON/OFF the light connected to a intelligent plug using a smart phone with proper application running on it. The MCU and IPU together controls the ON/OFF of the appliance. IPU is a plug that can receive commands remotely to ON/OFF the appliances connected to it. ON/OFF of appliance is achieved by closing or opening a relay system in the IPU.

The ON /OFF of IPU is done using two communication stages

- Cloud Server –MCU
- MCU-IPU

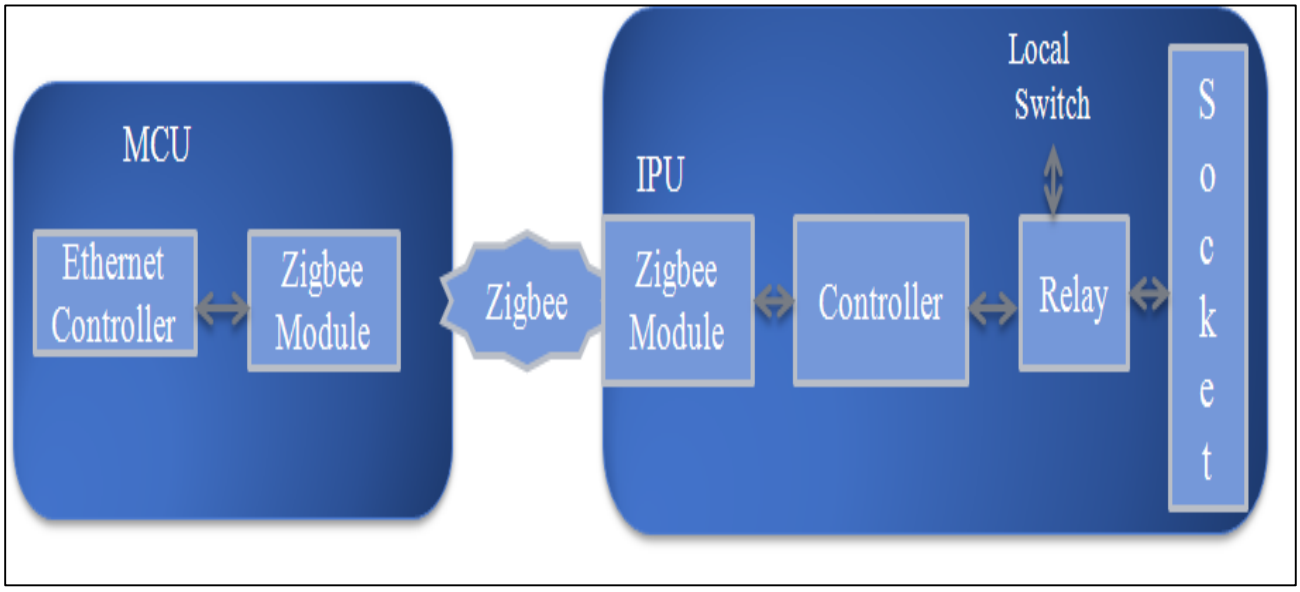

Fig. 5: ON/OFF control of Light Stands

E. Status Monitoring of Light Stands(IPU)

A user should be able to know the ON/OFF status of the light stands remotely using a smart phone with proper application running on it. Status request message is recieved at Home automation system using a wired LAN connection .The monitoring of Light stands will be done on basis of this message. The MCU and IPU together finds the status of light stands.

The ON /OFF status of IPU is monitored using four communication stages

- Cloud Server –MCU
- MCU-IPU
- IPU-MCU
- MCU-Cloud Server

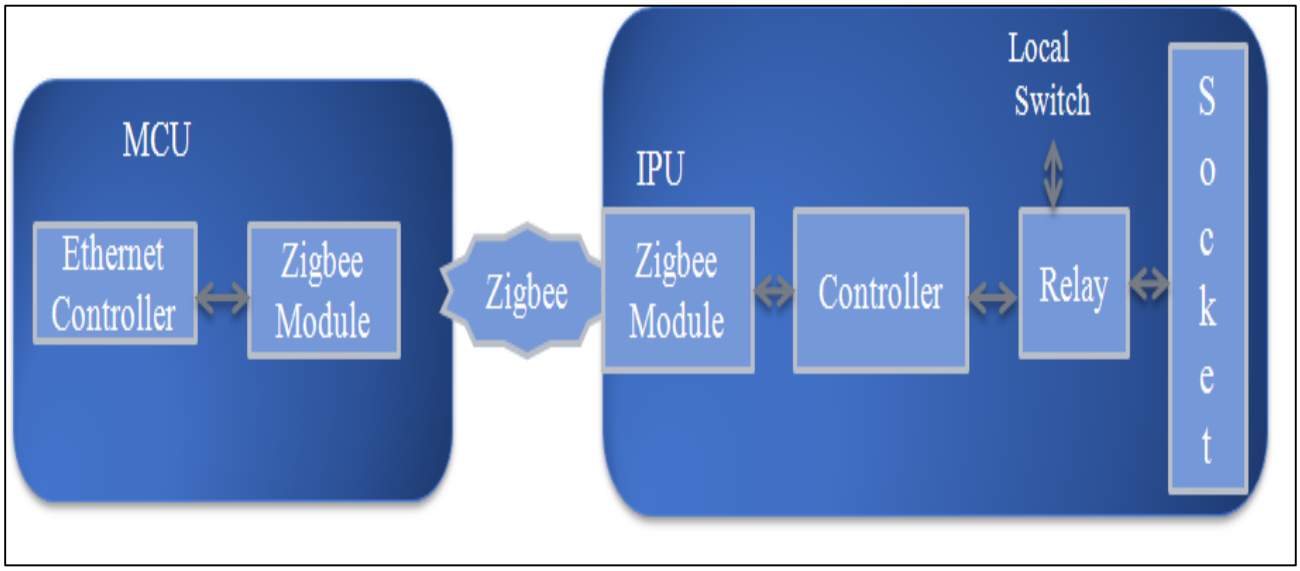

Fig. 6: Status Monitoring of Light Stands

IV. SYSTEM ARCHITECTURE

Cloud based Home automation is a Home Monitoring and controlling system, which is used to control/monitor the home devices through a smart phone. The control commands and status from the smart phone is passed to the system through a cloud server. The cloud server manages the control request and status information from smart phone to HA system and vice versa.

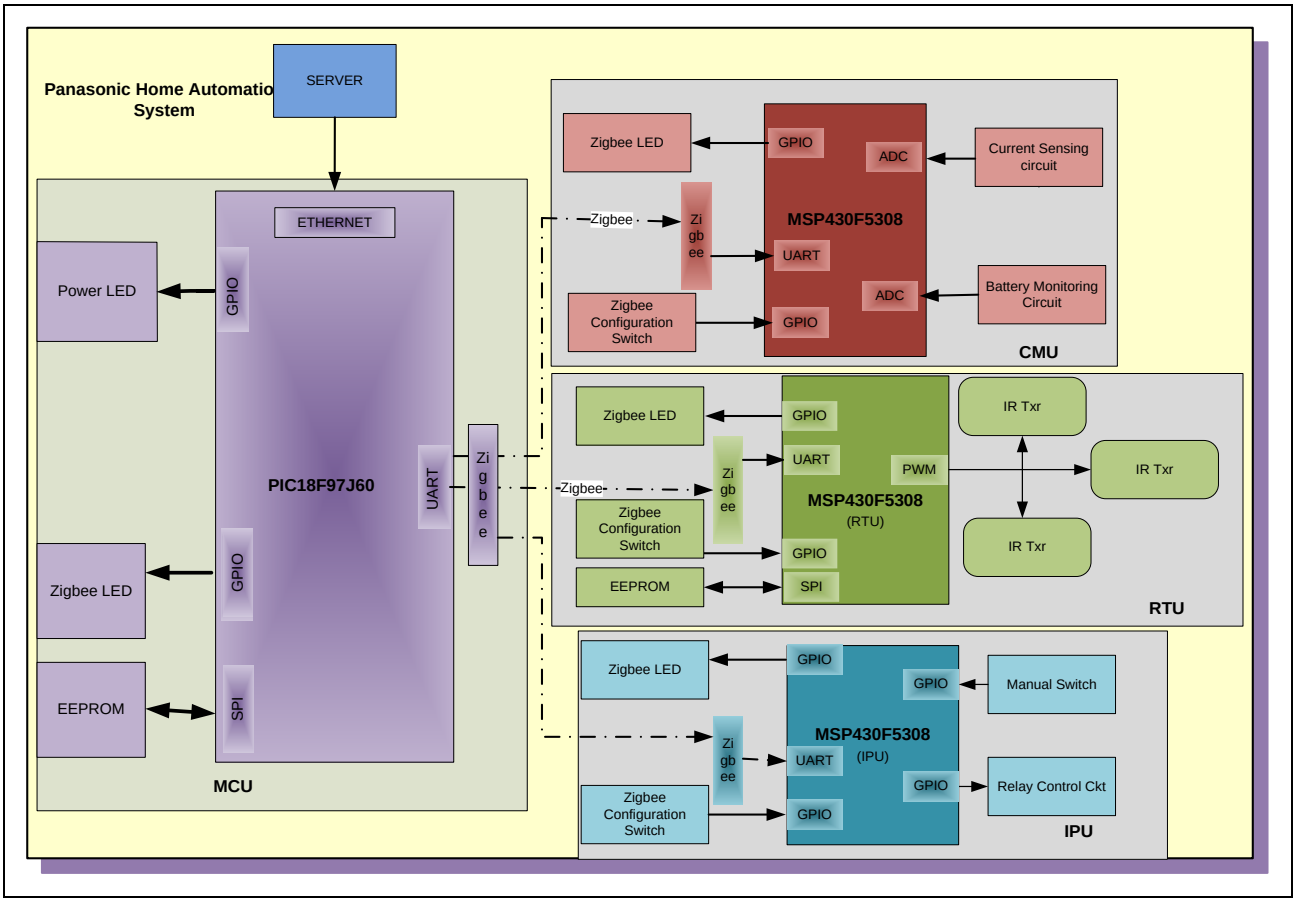

Fig. 7: System Architecture

A. Master Control Unit (MCU)

This is the module that initiates and establishes connection with the cloud server, through Ethernet. The message transactions occur between the server and MCU using TCP/IP protocol. The controller being used in MCU is PIC 18F97J60. To request a connection, the client sends a 'connect request' to the server, along with the MCU id. The server either accepts or rejects this request with an acknowledgement 'connect confirm' along with the appropriate status code. In case the connection been accepted, the connection Startup protocol is successfully completed.

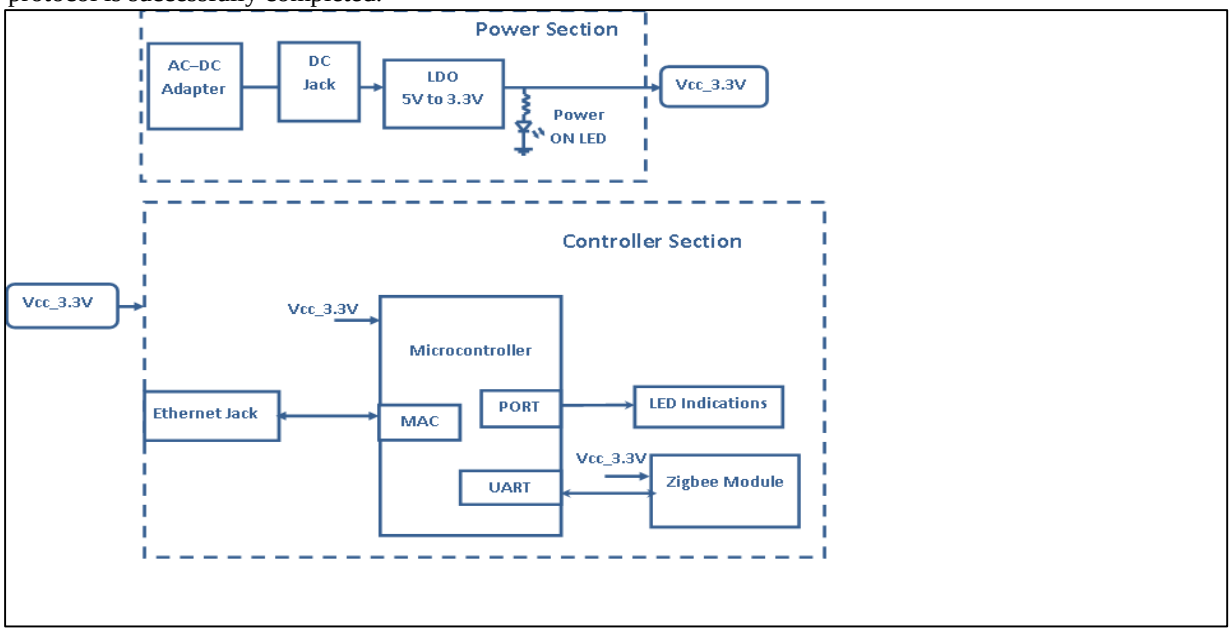

Fig. 8: Master Control Unit Block Diagram

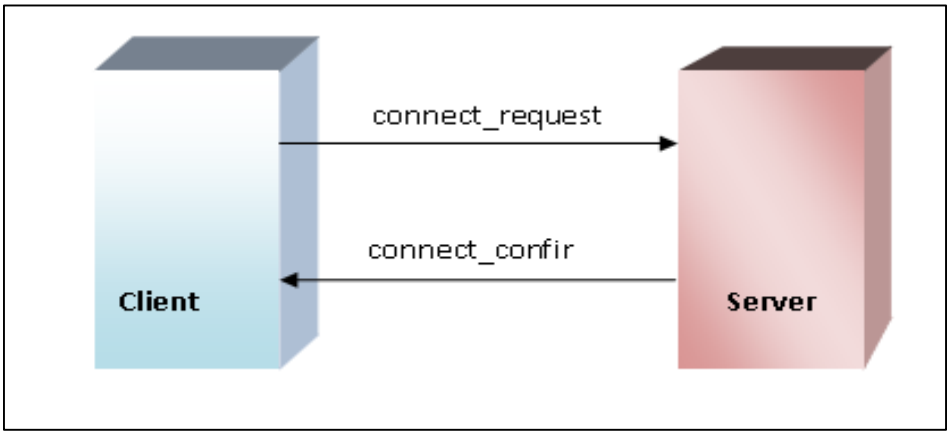

Fig. 9: Startup Communication protocol between MCU and Server

The connection request will be sent to the cloud server using a host name. There will be a DNS client running on MCU, which will resolve the IP address with the help of DNS server and MCU will connect to this IP address. Once the connection has been established, the device control commands will be sent to the system, by the smart phone through the cloud server and the device status will be returned back to the smart phone, on status request from the user.

The controller in the MCU module will have a local web server running on it, for local customization of the module. The customization includes details such as: MCU ID, the port address and host name of the cloud server. MCU local configuration is done as explained in the next section. When the control command reaches the MCU, it will transmit the message to the target device in the PAN, based on the MAC ID in the message, using Zigbee communication protocol. The Zigbee communication occurs through the UART of the zigbee module connected to each of the system modules. The zigbee communication is configured at a baud rate of 19200 bits/sec, 8 data bits and no parity bit.

B. MCU Local Configuration

The MCU will be connected to the router using Ethernet cable. The IP address will be assigned by router DHCP Server. The IP address of MCU will be noted and used to configure the MCU, from any computer connected to the router, take http://a.b.c.d/ (where a.b.c.d is the IP-address of MCU). If the router has WLAN, we can use a tablet or smart phone connected to the Wi-Fi for this purpose. A web-server is hosted in MCU, which can be used to input the details during installation.
The webpage will have a login page which is used for configuring - MCU ID, Host name, AND Port number
The User will have a login name and password in cloud server with which he can enter the device details, such as device name and MAC ID of each module.

C. Remote Transmit Unit (RTU)

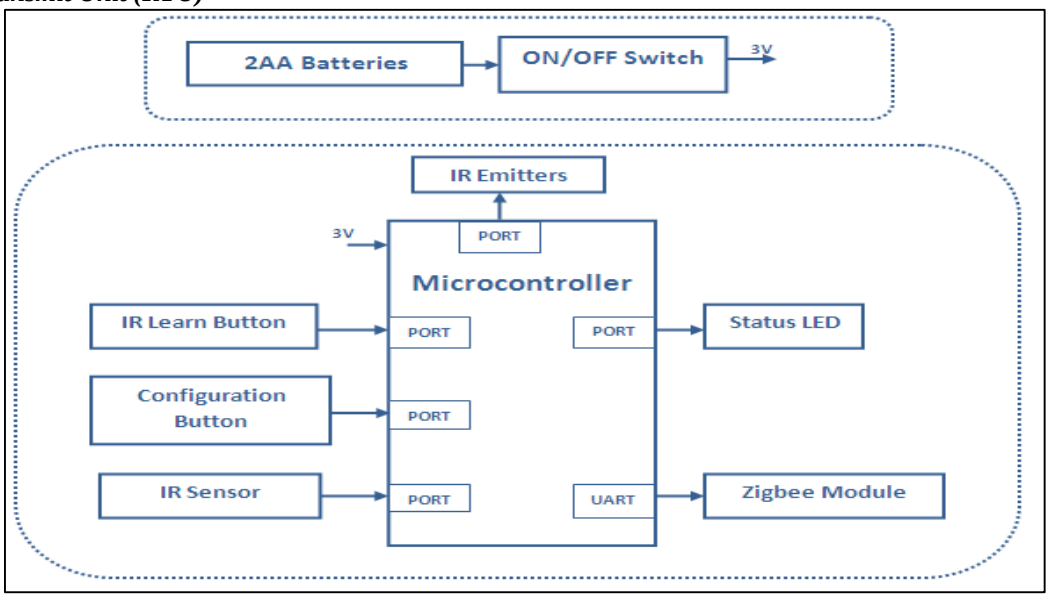

Fig. 10: Remote Transmit Unit Block Diagram

This module is used to control the Air-conditioning unit based on the control command sent by the user. This module can either be mounted on the wall or the roof, but Line Of Sight from the AC unit must be assured. MSP430F5308 is the micro controller

being used for the module. The message sent by the MCU will be received by the UART of the Zigbee module of RTU. The module receives the command in zigbee protocol, converts it to IR and transmits the command to the air conditioning unit using IR transmitters.

D. Intelligent Plug Unit (IPU)

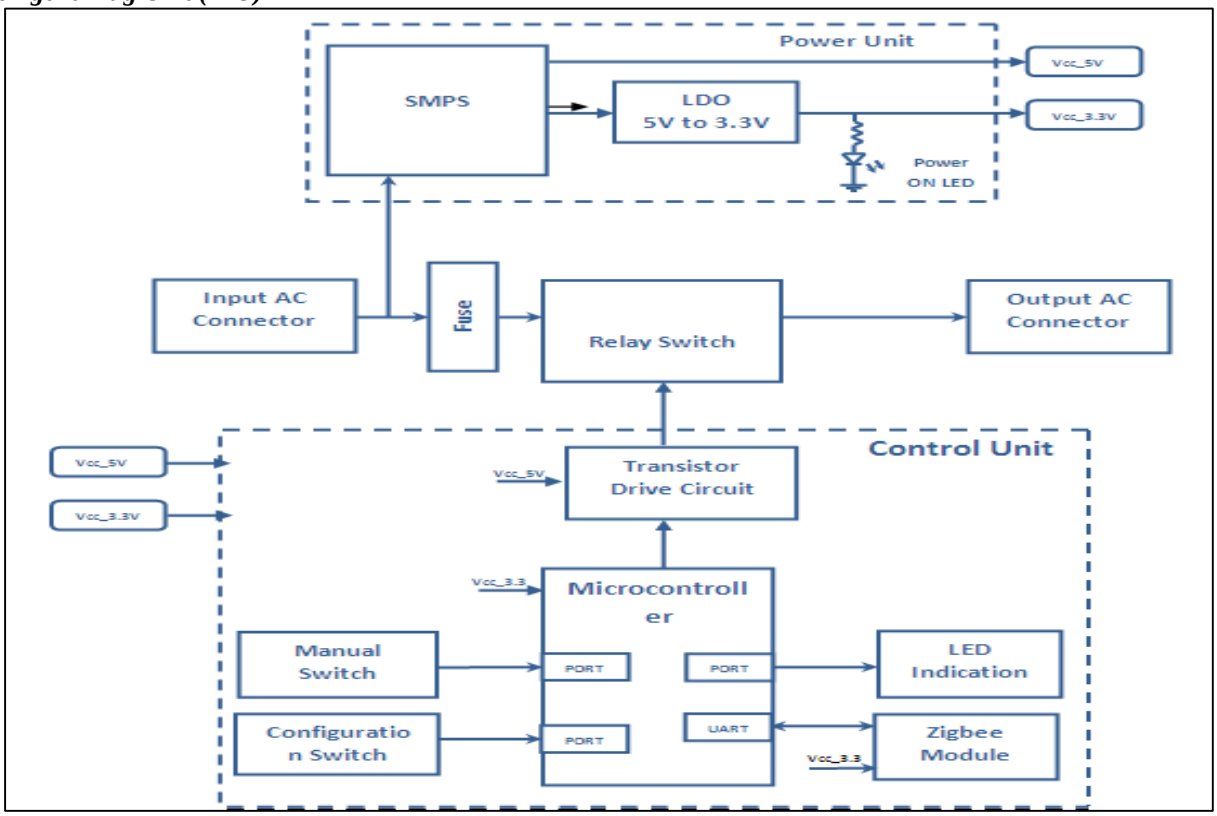

Fig. 11: Intelligent Plug Unit

The purpose of this module is to control and monitor the ON and OFF status of lighting unit. This is mounted to the current socket. MSP430F5308 is the micro controller being used for the module. The module processes the message once it receives the message through the UART of the Zigbee module. Based on the command received, LIGHT_ON or LIGHT_OFF, the module will open or close a relay circuit and it will also return the status of light on request. Light on and light off can also be controlled manually using a manual control switch. On reception of the control command or on manual switch action, the relay status will be stored in memory, so that in case of a power failure the previous IPU status can be retrieved.

E. IR learning Mechanism for RTU

This type of universal remote controllers has the ability to learn IR codes. Corresponding to each of the command from the original remote controller there will be a bit pattern. The universal remote controller recognizes the bit pattern and learns each of the patterns for various commands. Later the universal remote controller stores them in its memory. Then it can play back the learned patterns when we press the command keys on the universal remote controller. One of the biggest advantages of this approach is that the universal remote controller can learn codes of brand new remote controllers, which does not exist when the universal remote controller was created. RTU comes with a pushbutton switch to enable learning feature. At learning state RTU records the IR code for On/Off air conditioner from the original remote control. This recorded IR code is played back from RTU to turn air conditioner ON/OFF.

1) IR Learning Algorithm

1) Press the remote learning button, IR indication LED will glow to indicate RTU is ready to accept air conditioner turn ON code.
2) Hold the air conditioner remote above the RTU (LED of AC remote facing the RTU) and Press the ON button of AC remote. IR indication LED will turn off to indicate that the remote learning for ON command is complete.
3) Press the remote learning switch again and repeat the same procedure for OFF Button/command in AC remote.
4) To confirm, remote learning is successful, press the learning switch again maintaining a line of sight between the AC and the RTU, for which the AC will be turned ON for two seconds initially and then it will be turned OFF.
5) Now Place the RTU in Line of sight with the AC and it is ready for controlling the ON/OFF of the AC from mobile phone.

F. Zigbee Communication

The MCU communicates with the slave devices using zigbee communication network. The Zigbee module being used in the project is 'ETRX357HR'. Zigbee commands are executed using Attention Commands (AT Commands). Each zigbee module (hence each device in HA network) has a unique MACID with which each device is identified in a network. A custom protocol is developed for the communication between MCU and slave devices which is detailed in the next section.

1) Zigbee PAN Creation for Slave Devices Flowchart

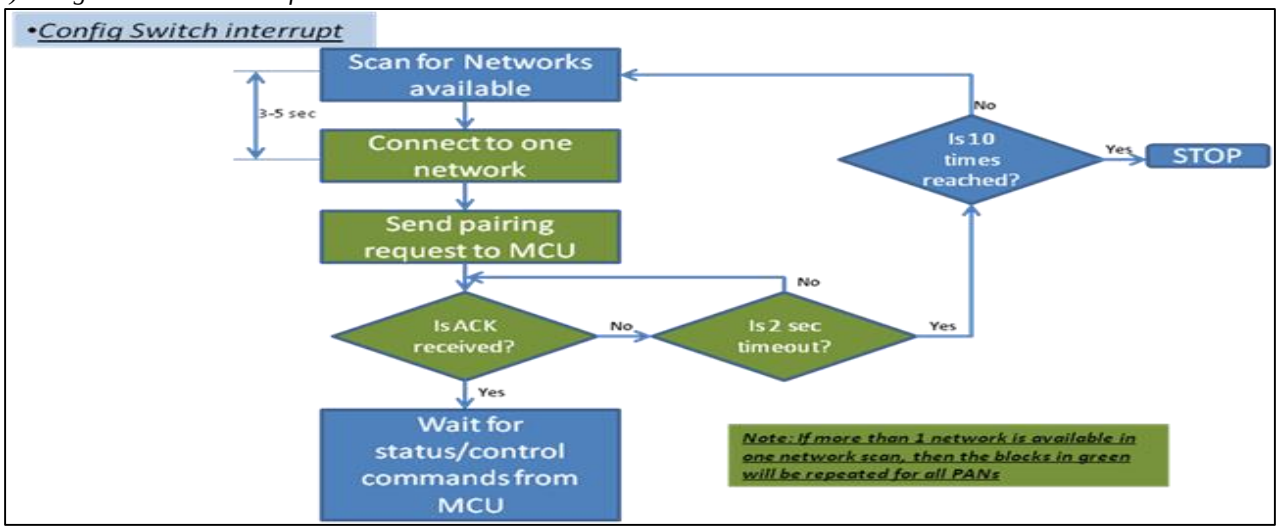

Fig. 12: Zigbee slave pairing mechanism

2) Zigbee Command Processing Workflow for MCU

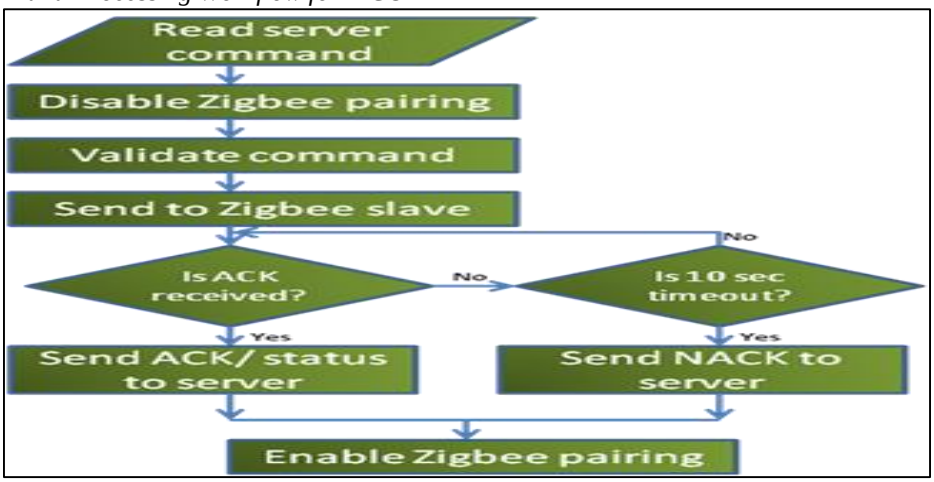

Fig. 13: MCU Command Processing Workflow

V. CONCLUSION

A Home Automation system to control home devices using an android based mobile phone is developed. The mobile user will have a menu driven application running in the phone with which he can send the commands and view the device status. The message transactions between the mobile phone user and the home network occur through a cloud server, which has administrative functionality of managing the home devices and managing the users. In addition to this cloud server identifies the targeted home MCU, using the MCU ID and directs the messages.

At home, we'll have an MCU connected to the internet through a router. The MCU receives the commands from the mobile phone in TCP/IP, decodes it and sends it over to the targeted slave device, using its Mac ID. The received commands are processed by the corresponding slave device and the status is returned back to the MCU and from there over to the cloud and then the user's mobile phone.

The system is a sort of easy and economic, home automation system. The functionalities of which can be extended to various other devices such as TV, geysers, iron box etc., which helps in reducing power consumption to a great extent. Also incorporating a power meter in the system may help us to monitor the power consumption and thus control the same.
If needed then appear before the acknowledgment and references.

ACKNOWLEDGMENT

I would like to express my special gratitude to Dr. Justus Rabi, Principal of Toc H Institute of Science and Technology for his support for completion of my project. Also I would like to express my sincere thanks to R&D division of NeST Technologies which have given me a platform in carrying out my project.

REFERENCES AND FOOTNOTES

[1] 'A ZigBee-Based Home Automation System' by Khusvinder Gill, Shuang-Hua Yang, Fang Yao, and Xin Lu,2009.
[2] http://en.wikipedia.org/wiki/X10_(industry_standard)
[3] "Java-based home automation system", IEEE Transactions on Consumer Electronics, vol. 50, no. 2.
[4] H. Ardam and I. Coskun, "A remote controller for home and office appliances by telephone", IEEE Transactions on Consumer Electronics, vol. 44, no. 4, pp. 1291-1297, 1998.
[5] "Bluetooth based home automation system", Microprocessors and Microsystems, Vol. 26, no. 6,pp. 281-289, 2002.
[6] "Charade: remote control of objects using free-hand gestures", Communications of the ACM, vol. 36, no. 7
[7] "Home Gateway Architecture And Its Implementation", IEEE International Conference on Consumer Electronics
[8] IEEE Editorial - 'Home Automation as a Means of Independent Living'
[9] 'Wireless Home Automation Networks- A Survey of Architectures and Technologies' by Carles Gomez and Josep Paradells, Technical University of Catalonia
[10] 'A PRESENTATION ON ZIGBEE'- Department of Electronics & Communication Jaipur Engineering College.
[11] http://www.authorstream.com/Presentation/Bina-60652-ZigBee-Market-Application-Landscape-Why-Target-Markets-Technology-as-Education-ppt-powerpoint/
[12] http://www.maxim-ic.com/app-notes/index.mvp/id/4017
[13] http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=2664&param=en546143
[14] MSP430x5xx MSP430x6xx Family users guide
[15] MSP430F5308_DT
[16] AN3174Application note - Implementing receivers for infrared remote control protocols using STM32F10xxx microcontrollers
[17] Microchip 24AA00/24LC00/24C00 128-Bit I2C Bus Serial EEPROM
[18] ETRX35x ZIGBEE MODULES PRODUCT MANUAL
[19] ETRX2 and ETRX3 Series Zigbee Modules AT-Command Dictionary
[20] Microchip TCP/IP Stack Help