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Low cost Integrated Communication Technologies for Controlling Home Appliances from Anywhere - An Outcome of IoT

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***Abstract*— Now a days entire world is moving towards the exiting new technology that is Internet of Things. Many of the organizations and industries are continuously trying to convert the theoretical aspects into practical implementations. But the implementations are very complicated and highly expensive. Automating home appliances remained like a dream for a common person. As a step towards low cost solutions for this problem we had implemented the central control system with the help of Wi-Fi, Bluetooth and Internet technologies to provide remote access from smart phone or personal computer. The status of all switches is synchronized in centralized control system.**

***Index Terms*— App Inventor, Arduino, Bluetooth, Centralized control system, Relay module, Remote Access, SSH, Wi-Fi**

I. INTRODUCTION

In this era of digitalization everyone wants to make their lives easier and convenience with the help of technology. Everything is getting digitalized and automated with the help of convergence of different technologies. IoT is one of the evolving technologies, which is playing a vital role to achieve the better solution in human lives. The continuous efforts of different organizations and industries are creating new revolution in IoT. But the implementations are very complicated and highly expensive. In the other side automating home appliances [1] remained like a dream for a common person. As a step towards low cost solutions for this problem we had developed an integrated application to connect all of our home appliances to the centralized control system. For this implementation we had developed a smart phone application to provide the interface for controlling configured home appliances. The centralized control system [2] was implemented by using an Arduino board with various communication modules like Wi-Fi and Bluetooth modules. A simple HTTP Server will be initialized in Wi-Fi module at some particular source port. Whenever we use the application to control home appliances the mobile application will create the appropriate HTTP requests and sends it to the server. The server will send the request to the arduino board where the request can be processed and operation of switching can be performed to switch on or off the electrical device. The requests can be sent to this server in the form of plain HTTP Requests. This source port can port forwarded at our internet facing system so that this server can be available in the entire Internet. A person can use his smart phone with internet connection to connect this server. Here we had integrated three technologies for the convenience of a user that is integrated technology of Bluetooth, Wi-Fi and Internet. Whenever we are at nearer distance to our home we can use Bluetooth to control the home appliances. By using these technologies we can expect low power consumption and less radiation. When it comes to Wi-Fi it can work up to a fixed range. This Wi-Fi module can be connected to Internet to make our server globalized.

II. LITERATURE REVIEW

IoT Stands for Internet of Things. It is a combination of two words [3]. The first word is “Internet” another word is “Things”. Internet means network of networks which connects billions of users and organizations worldwide. It contains millions of private, public, educational, business and government networks. There is no centralized owner for this Internet. Everyone who is using internet is a part of Internet. Today more than 150 countries are using connected together through Internet to share the information. Another word is “Things” it can represent any physical object. When it comes to the definition of IoT [4] there is no single definition available for Internet of Things. It is having different forms among different groups. But the widely accepted and well known definition is it is a comprehensive network of physical devices that connected

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to the internet. Every device has some intelligence behavior to execute the commands provided by the user. User can directly interact with their devices from anywhere through internet either by using smart phone or Personal Computer. This interaction is possible because of IPv4 addresses, where every device will be having a unique IP address. Whenever a user wants to communicate with his device he will send some commands to this IP address. The microprocessor present in that device will execute those commands and acts accordingly. When it comes to smart home every electronic device will be connected to the internet. To connect all of our home appliances we need more public IP addresses which leads to highly expensive. Because of the less address space we cannot automate every home by using IPv4. But we can create a centralized system with public IP and we can assign private IP addresses for all devices present in the home. The concept of public and private IP addresses had reduced the implementation cost for smart home.

Microcontrollers are playing a vital role in IoT. Physical devices are acting smartly because of microcontrollers [5] only. Arduino created an open-source and easy-to-use software & hardware platform; as a result microcontrollers are accessible to a wide range of audience. Along with time this platform has transformed into several forms and today many of the dedicated devices which are found in robots, 3-Dimentional printers, Drones and Media players had bloomed thanks to a vast ecosystem of the researchers and vendors. These devices are following the path for adding more networking and communication features, and becoming as a part of Internet of Things.

Many research papers are existed for home automation with individual technologies but none of them had provided the low cost and integrated applications which can be available to a common man. User has to deal with multiple interfaces or applications to control his smart home by using different communication channels like we are having Bluetooth based Android application for controlling Bluetooth controlled smart home and GSM Based Applications to control Water Motors in farmer's fields. If the user has an application to control all his appliances then it would be very comfortable and he can easily control his smart home from anywhere. In order to provide more comfort and less cost solution for user we had implemented an integrated application which controls smart home from anywhere with different communication channels.

III. PROPOSED SYSTEM

In this section the entire working mechanism of the application has been described. The centralized system for performing the switching operations has implemented according to the following black diagram.

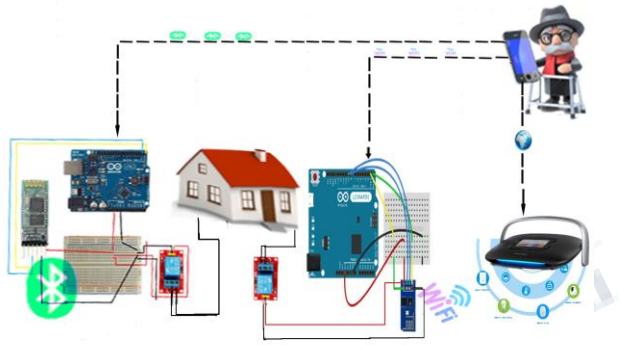

Fig 1: Top Level View of Centralized Control System

The components Used for implementing the system

A. Arduino UNO:

Arduino Uno, the ATmega328P [6] based microcontroller. It consists of 14 digital input and output pins. In this 14 pins 6 can be used as PWM outputs, 6 analog input pins, quartz crystal with 16 MHz frequency, a Universal Serial Bus connection, a power socket, an ICSP header and a RST button. It consists of everything that is completely needed to support the microcontroller; simply we can connect it to AC-to-DC adapter or to a computer's USB port or connect it with battery to get started.

Fig 2: Arduino UNO - Micro Controller

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B. ***Bluetooth module HC-05:*** The Bluetooth module HC-05 is a master or slave module. The default settings for this module are configured as slave. We can change the role of the module by using AT Commands only. We will configure this module to accept our commands.

Fig 3: Arduino Serial Bluetooth 4.0 BLE module

C. ***Wi-Fi ESP 8266 module:*** ESP-8266 is a low-cost and easy to use Wi-Fi module. It is integrated with TCP/IP protocol stack. ESP8266 is having capabilities of powerful on-board processing and storage which can be used to integrated with the sensors. Wi-Fi hotspot will be created by using this module; a client will connect to this hotspot to send commands to the Arduino board.

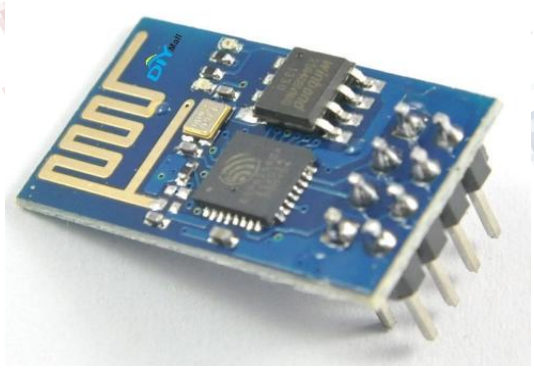

Fig 4: ESP 8266 Wi-Fi module

D. *Relay module Board*: Relay module is like a switch only but it controlled by logic pins (IN0 – IN7). The logic pins are connected with the Arduino digital pins (D2 – D9). According to these connected digital pins status the relay module will control the corresponding electrical devices.

Fig 5: Relay module

E. ***MIT APP INVENTOR***: It is an online platform for creating mobile applications. This will provide the User interface to build our own mobile applications. App inventor [8] is used to develop applications for Android phones using a web browser and either an emulator or a connected smart phone. The App Inventor server will store users project and help the user by keeping the track of his project.

The Role of key components:

***Role of the Integrated Application*:** The integrated application provides an easily operated Graphical User Interface. In this application's home page we have provided the different interfaces for controlling home appliances by using different network technologies like Bluetooth, Wi-Fi and Internet. User can choose an appropriate network type and navigate the entire home and can control the desired home appliances. We have developed an UI for each room and electrical devices in that room. The application can maintained the switching status of each electrical device. For that we have built a tiny database to maintain the switching status. We used the simple HTTP protocol (Excluding Bluetooth) to send the data from integrated application to the Arduino board by using the network selected by user.

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GUI of Integrated Application

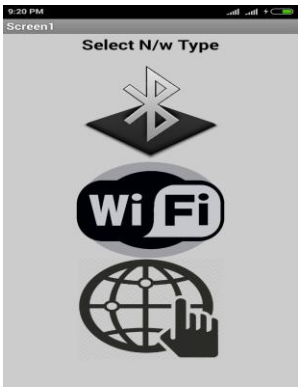

Fig 6: Integrated Application Home Screen

Fig 7: Interface of Rooms in a Home

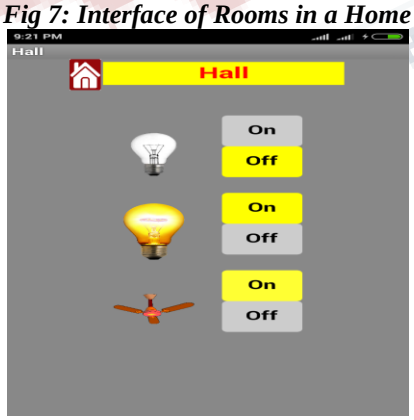

Fig 8: Interface of Existing Devices in a Room

***Role of Bluetooth*:** We have used HC-05 Bluetooth module. We will supply 3.3Volts to Vcc and ground to enable Bluetooth module. We configured the Bluetooth module as slave. The Bluetooth module will be blinking with a delay of one second when it gets power. Now it is enabled to connect with any smart device. The integrated application which installed on a smart phone should be paired with the Bluetooth device to send the data. The Bluetooth module will get the data from connected smart phone and the data will be sent to Arduino for further process.

***Role of Wi-Fi module**:* we will supply 3.3Volts to Vcc and ground to enable Wi-Fi module. It has transmitter and receiver pins for communication between android application and Wi-Fi module. Wi-Fi module has three modes
1. Client mode 2. Server mode 3. Both. Here we had used server mode. So it acted as a hotspot.

Role of Arduino: It has digital and analog pins. (We used digital pins). By using the Arduino program, we had enabled the pins. Later Arduino board received the data from Wi-Fi module and turned on the switch when the android application sent the **'on'** instruction to Wi-Fi module. Arduino processed the data of Wi-Fi module according to programming logic it had enabled the corresponding digital pin of Arduino that power enables the led. In place of led we can use relay and can connect home appliances

Implementation of Centralized Control System by using Bluetooth:

We had connected the Bluetooth module to the Arduino board according to the following table.

Table 1: Bluetooth Connections with Arduino

HC-05 (Digital Pin)	Arduino UNO (Digital Pin)
Vcc	5V
GND	GND
TX	RX
RX	TX

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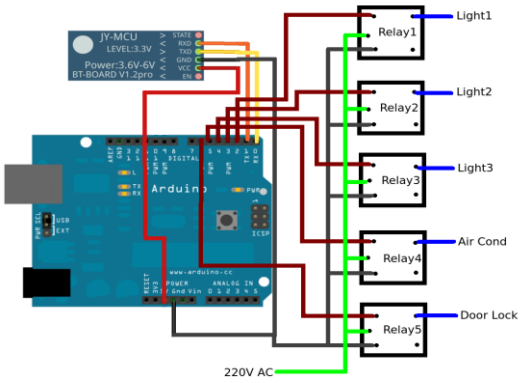

Fig 9: [9]Connecting Bluetooth module and Relay module with Arduino

We cannot directly connect the home appliances to the Arduino board so a relay module is connected with Arduino board and home appliances are connected to the relay board. After completing all connections just switch on the power supply for Arduino board then use the smart phone with integrated application installed and navigate to the Bluetooth interface. Then search for the available Bluetooth devices from the smart phone and there should be a device named HC-05. Pair with it and the default passcode is 1234(You can change it later from AT commands). If HC-05 is paired it blinks it with a delay of 2 seconds.

Now we can send instructions from android app to this HC-05 module. In Arduino we are going to dump the program with instructions to configure home appliances. Depending upon received instructions from app Arduino will make corresponding digital pins to high logic. Now these digital pins from Arduino are going to connect relay module and switch on/off the desired appliances. Here we are providing the code snippet for reading instructions sent from integrated application to Arduino using Bluetooth.

```
Void setup()
{
BT.begin(9600);
Serial.begin(9600);
pinMode(2, OUTPUT);
}
Void loop()
{
        delay(10);
        char c=BT.read();
        device += c;
If(device==”B1ON”)
                digitalWrite(2, HIGH);
else if(device==”B1OFF”)
                digitalWrite(2, LOW);
}
```

Implementation of Centralized Control System by using Wi-Fi:

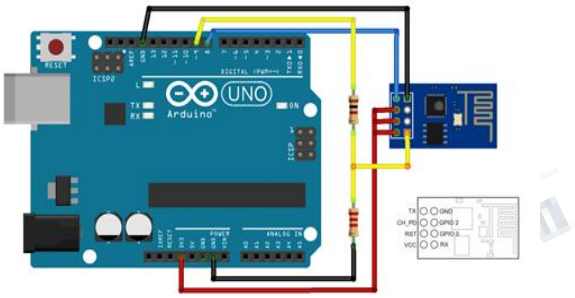

Fig 10: [10] Connecting Wi-Fi module to the Arduino

We had connected the Wi-Fi module to the Arduino board according to the following table.

Table 2: Wi-Fi connections with Arduino

ESP 8266 (Digital Pin)	Arduino UNO (Digital Pin)
Vcc	3.3V
GND	GND
TX	RX
RX	TX
CHPD (Chip Enable)	3.3V

Relay module is connecting in the same manner as we had done in Bluetooth. For the purpose of integrating we had connected same relay board. After completing all connections just switch on the power supply for Arduino board then use the smart phone with integrated application installed and navigate to the Wi-Fi interface. Then search for the available Wi-Fi devices from Smart Phone and there should be open networks named AI-THINKER (We can change it using AT Commands) connects to it.

Now we can send instructions from android app to this Wi-Fi module. In Arduino we are going to dump the

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program with instructions to configure home appliances. Depending upon received instructions from app, Arduino will make corresponding digital pins to high logic. Now these digital pins from Arduino are going to connect relay module and switch on/off the desired appliances. Here we are providing the code snippet for reading instructions sent from integrated application to Arduino using Wi-Fi

```
void setup()
{
Serial.begin(115200);
esp8266.begin(115200);
pinMode(4, OUTPUT);
}
void loop()
{
        delay(10);
        char c=esp8266.read();
        device += c;
If(device==”H1ON”)
                digitalWrite(4, HIGH);
else if(device==”H1OFF”)
                digitalWrite(4, LOW);
}
```

Connecting Wi-Fi module with the Arduino board to the Internet

An Internet facing system or router is used to connect the Wi-Fi network (AI-THINKER). A private IP will be allocated for the Internet facing system (192.168.4.X). Now we can use port forwarding software SSH (Secure Shell) on this internet facing system. A SSH Client software is also initialized at server side. SSH Client will be configured with remote host as AI-Thinker IP(192.168.4.1) a port as the same as port used for creating server in Wi-Fi module and SSH server details will be the client details itself. Then use local port as Internet public IP address and local port as user defined. Now just connect the smart phone to the internet and navigate to the internet page and use Public IP as server and use the application in the same manner as we had done in case of Wi-Fi module.

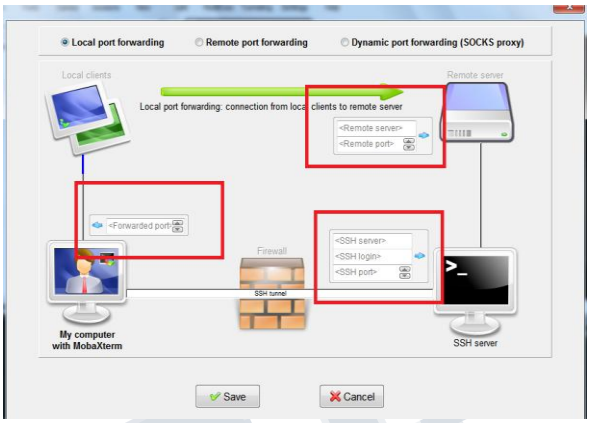

Fig 11: Port-Forwarding Client

IV. COST ESTIMATION FOR WORKING SYSTEM

Table 3: Total Cost Estimations

COMPONENT	QUANTITY	COST in Rs.
Arduino UNO	2	900
HC-05 Bluetooth Module	1	359
ESP8266 Serial WIFI Wireless Transceiver Module for IOT	1	215
MatLogix 5V 8-Channel Relay Module Board for Arduino	1	350
Jumper wires	1 set (40 wires)	50
Additional equipment (Bread board, hookup wires and etc…)		300
Total Amount		Rs. 2174/-

V. CONCLUSION

Internet of Things is gradually bringing an ocean of technological changes in the current world, which in turn helps in making human’s life comfortable and simpler, though integration of various technologies and innovating new applications. The proposed working system for home automation using IoT had implemented with low cost to work satisfactorily by connecting simple home appliances

to it and the home appliances had successfully controlled remotely by using Bluetooth, Wi-Fi and Internet.

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