Android based Home Automation System with Power Optimization Modes

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Abstract: This paper is based on project which developed for controlling home appliances through internet in real time and also to operate them in different modes from any remote places. Our main focus is to operate the home appliances in our desired modes and control them in an easy way. We have developed an android based application for controlling appliances and operate them in different modes like optimum, sleeping, auto etc. also all the appliances can be controlled individually. Different sensors have been used for analyzing lights, temperature and motion. Based on sensor values our algorithm will operate all the appliances according to modes. So by operating them in different modes it will save power as well as make our life easier and comfortable.

Introduction

Home automation makes a home smarter. Smart home is the term which has huge demand in present world and huge possibilities in near future. A home automation system may control lights, temperature, climate, entertainment and many other appliances. Home security is also a part of automation which includes security control and alarm system. Security control means controlling entries based on facial recognition and let recognized people in. On the other hand security alarms could be for fire or security breach in the home and notifying the owners. Home automation typically controls all the appliances from a central hub. The end user interface may vary based on application. The control system could be wall mounted, computers, a mobile phone application or web interface. It actually depends on the developers and the users. In our proposed system we have used mobile phone android application based control system.

Internet of Things allows us to control connected devices from anywhere and exchange data over the devices. Home automation system controls home appliances automatically and when this system is connected to internet it becomes a part of IoT. There are three main generations of home automation. First is, different wireless technology with proxy servers, second is Artificial Intelligence (AI) controlled home automation and lastly robots which directly communicate with humans [2]. This system is first generation automation. For implementing the first generation of the home automation appliances needs to connect with internet so users can control the system from any remote place. That's why IoT has become a need for automation. This system provide a real life home automation solution which can be implemented at home and need not to be tensed about controlling. This system also provide Android based control system which is more user friendly than web pages. Also this system provide different modes which reduce power consumption

Hardware:

I) Arduino Mega 2560

The Arduino Mega 2560 is a microcontroller board and the core of the board is ATmega2560 microcontroller chip. As shown in Fig 3.1 which we have used has 54 inputs/outputs pins among them 14 can be used as PWM (pulse with modulation) to level the voltage, some pins are used for communication also like Serial pin: 0 (RX) and 1 (TX); Serial pin 1: 19 (RX) and 18 (TX); Serial pin 2: 17 (RX) and 16 (TX); Serial pin 3: 15(RX) and 14 (TX). Used to receive (RX) and transmit (TX) TTL serial data and rest of the pins are used as digital inputs/outputs. Another 16 pins are used as analog inputs form the environment. It also has 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header and a reset button. Arduino Mega runs with 5V of DC voltage which can be a battery or an AC to DC Adapter. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. Normally, 6V-12V as input voltage is recommended. Each pins gives 40mA DC current for 5V operation and for 3.3V operation it provides 50mA DC Current and also has an internal pull-up resistor (disconnected by default) of 20-50 kohms. It also provides 256 KB flash memory for code storage among them 8KB used for boot loader. As well as 8KB Static Read Only Ram (SRAM) and 4 KB Electrically Erasable Programmable Read Only Memory (EEPRAM).

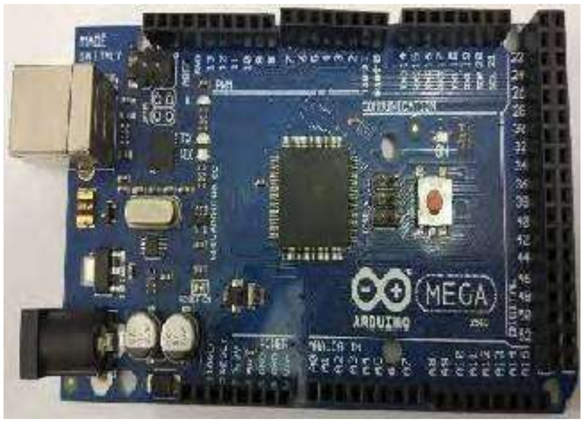


Figure 1 Arduino Mega 2560

The ATmega2560 provides four hardware UARTs for TTL (5V) serial communication. The channel creates through USB and a virtual com port to Arduino IDE on the computer. To run the code operating system like Windows need an .inf file and for other operating system machine will recognize the board as a COM port automatically. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will flash when data is being transmitted via the ATmega8U2 chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

II) NodeMCU

There are various platforms for IoT system one of them is NodeMCU. It provides lower level control on devices which is known as firmware. These control runs on ESP8266 Wi-Fi SoC, which hardware is based on ESP-12 module.Esp8266 is a Wi-Fi based communication system's microchip. It uses TCP/IP protocol for communicating with internet through router. It uses 802.11b/g/n slandered technology for Wi-Fi communication. It is a Tensilica L106 32-bit RISC instruction unite microprocessor with 32 KB instruction RAM, 32KB instruction Cache RAM, 80KB Data memory.ESP8266 (Pin) and Arduino Mega's (Pin) common pins are GND TX (0)-3.3V, RX (0), 3.3V. For running the ESP8266 on Arduino platform we need to install ESP8266 package in Arduino IDE. As a board is using, we need to give the additional board manager.

As shown in Fig 2 it has 12 GPIO pins. One ADC pin. For this project 7 GPIO pins have been used. They are D0 to D6 which delivers digital outputs.

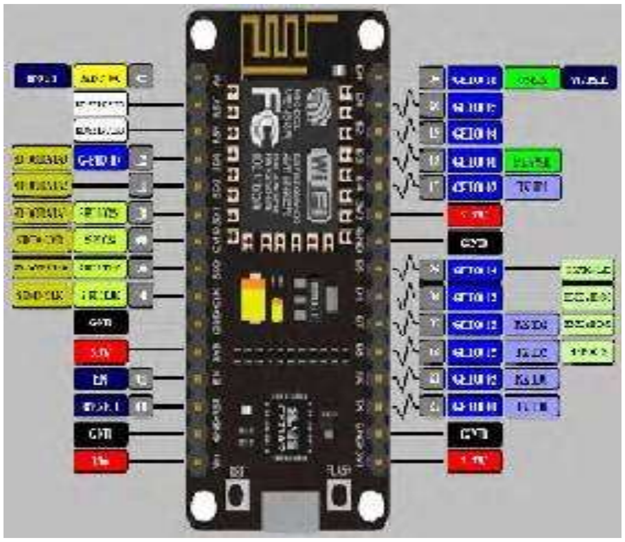


Figure 2 NodeMCU

III) Channel Relay Board

Relays are electromechanical devices which takes a relatively small amount of power like 5V(15-20mA) to operate the relay coil and then it is used to control a lot more electrical power. Normally A relay is used as switch circuit which is constructed by n-p-n transistors as shown in Fig 3.3. For low base voltage or negative voltage transistor goes to cut off region and stops the flow of collector to base directed current, If a large enough positive current is now driven into the Base to saturate the NPN transistor, the current flowing from Base to Emitter (B to E) controls the larger relay coil current flowing through the transistor from the Collector to Emitter.

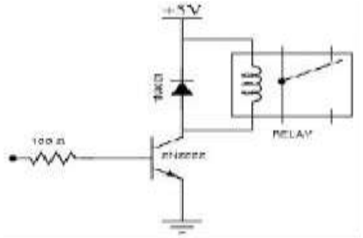


Figure 3 Circuit Design of a relay

Maximum range of 4 channel relay board is for DC level 30V and 10A and AC level 250V and 10A. It uses opto-coupler for high voltage safety and prevents ground loop with microcontroller. VCC and RY - VCC are also the power supply of the relay module. In case of driving a large power load, the jumper cap off is taken off and an extra power to RY-VCC is connected to supply of the relay. Connect VCC to 5V of the MCU board to supply input signals. Pins of 4 channel relay are VCC for power supply 5V, gnd for Ground, in1,in2,in3, in4 all are signal controlled pin and connected individually with Arduino ports. And COM is a common pin which is normally grounded unless using for HIGH Voltage. NO is for open connection and NC for closed connection.

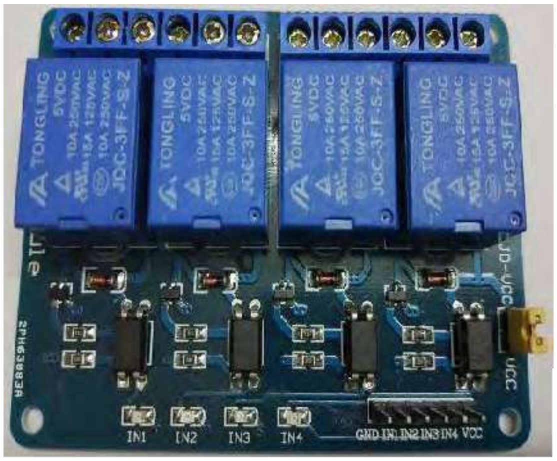


Figure 4: 4 Channel Relay Board

IV) LDR:

LDR means Light Dependent Register constructed with two Cadmium Sulphide Photoconductive cells with spectral response which is similar to human eye. With the change of density of light it reacts. The range of LDR is 1000lux to 10 lux. It has no polarity as a result it can be fit in the breadboard easily. As shown in Fig 3.5 both the legs are equal.

V) PIR

PIR sensor means Passive Infrared sensor which is used for detecting human movement into its range of 0 to 21 feet (7 meters) 140° detection range as shown in Fig 3.6(a). It is compacted having the size of (28x38 mm) and runs with the power supply of at least 5V.

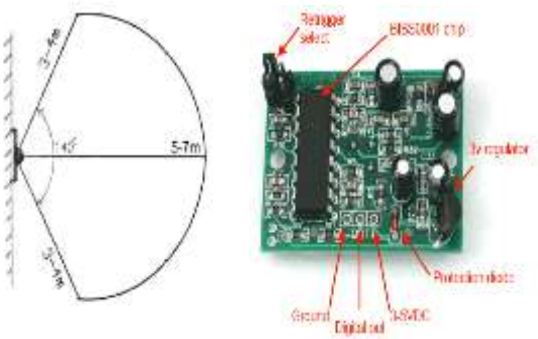


Figure5: (a) Range of PIR Sensor (b) PIR board

As shown in Fig 5(b) it has three pins having spacing of 0.1" where one is used for VCC, the middle one is for driving output voltage which is at least 3.3V TTL output or open collector output. Besides all of these it has two adjustment trimpot for adjusting sensitivity with the environment. They are Delay time adjustment and Distance Adjustment. Clock cycle is used for adjusting the sensitivity. PIR sensor is associated with two timeouts, one of them is TX for calculating the time after detecting movement how long the LED will lit and another one is Ti for calculating the time when will the LED will off when there will be no movement.

VI) DHT22:

DHT22 temperature and humidity sensors are very basic and slow, but are great for hobbyists who want to do some basic data logging. The DHT sensors are made of two parts, a capacitive humidity sensor and a thermistor. There is also a very basic chip inside that does some analog to digital conversion and spits out a digital signal with the temperature and humidity.

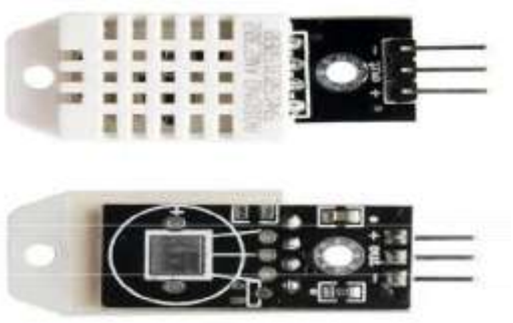


Figure 6: DHT22 temperature and humidity sensor

It has the following features:

1. Low cost

2. 3 to 5V power and I/O

3. 2.5mA max current use during conversion (while requesting data)

4. Good for 0-100% humidity readings with 2-5% accuracy

5. Good for -40 to 125°C temperature readings ±0.5°C accuracy

6. No more than 0.5 Hz sampling rate (once every 2 seconds)

System Architecture:

I) System Overview:

In our proposed system we have developed an android based home automation system which is capable of controlling home appliances based on user command. It also has own intelligence to control all the appliances according to user given modes. If user wishes to turn on or off any individual appliances it is capable of doing that. The most significant feature of this system is mode based operation. Like when user activates the auto mode than all the lights and fan will turn on or off with its own intelligence. If there is sufficient light on the particular room than lights will remain off. On the other hand if light is insufficient than lights will be turned on automatically. Based on different sensor values these actions are executed.

II) System Architecture:

As shown in Fig 7 user controls the modes and appliances by an android based device through our application. User command is transmitted from device via internet. The esp8266 NodeMCU than receives the command from internet via Wi-Fi. The NodeMCU than passes the command to the controller board arduino mega 2560. Arduino than executes the commanded operation. So android app is for end users to give input. Esp8266 NodeMCU and arduino mega is the control unit of the system. The arduino takes input from the esp8266 for executing actions. For execution of the action arduino also takes inputs from the sensors. Lastly the arduino runs the appliances according to user desired command.

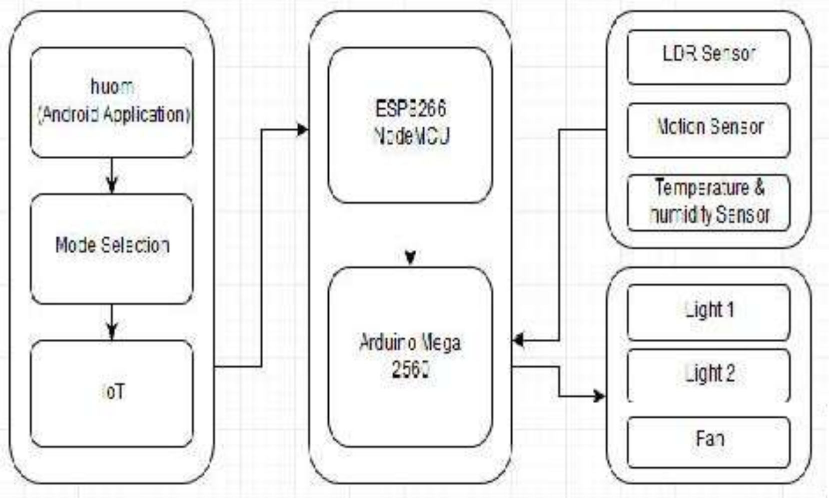
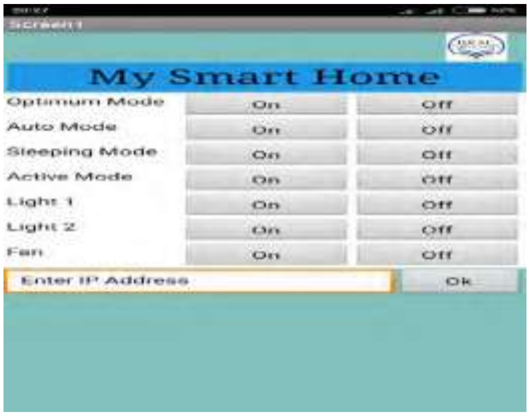


Figure 7 Architecture of the proposed system

III) Android Application:


Screen1

My Smart Home

Optimum Mode On Off
Auto Mode On Off
Sleeping Mode On Off
Active Mode On Off
Light 1 On Off
Light 2 On Off
Fan On Off
Enter IP Address Ok

Figure 8 User interface of the Android application

An android based application made to fulfill the purpose of our system. It is for the end user to control the system. User can control everything of the system by android app. User can also set modes from the application. As shown in Fig 3.2 it has 14 buttons to control different appliances and modes. The first 8 buttons are for turning on or off optimum, auto, sleeping and activate mode. The last 6 buttons are for controlling individual lights and fan. There is another text box for entering ip address. As our esp8266 module generates dynamic ip addresses after connecting new networks or after reset of previous connection. The user interface of the application is very interactive and very user friendly. User can turn any button on by pressing the on button and which will give command the system to proceed on the command. We have developed this application by using the MIT app inventor 2. MIT app inventor 2 is an open platform for developers to develop useful android based application. In MIT app inventor 2 the back-end operations are designed by block coding. Block codes are easier to design algorithms.

Power Saving Mode:

I) Optimum Mode: Optimum is the most power saving mode among all. The algorithm of this mode is, first it will activate after getting motion from the motion sensor. Then, based on temperature and light intensity from the temperature and ldr sensors appliances will activate. Condition for turning on fan is temperature must be greater than 21 degrees celsius. As shown in Fig 9 for turning on the lights ldr sensor value must be less than 1000. Otherwise both appliances will be turned off. This is an automatic process where users do not need to bother about controlling. Moreover this mode is saving power consumption by deactivating every appliance when there is no motion detected. So if no one is 16 in room every appliances will remain in off condition. Than if someone enters in room all appliances will activate and execute according to sensor values.

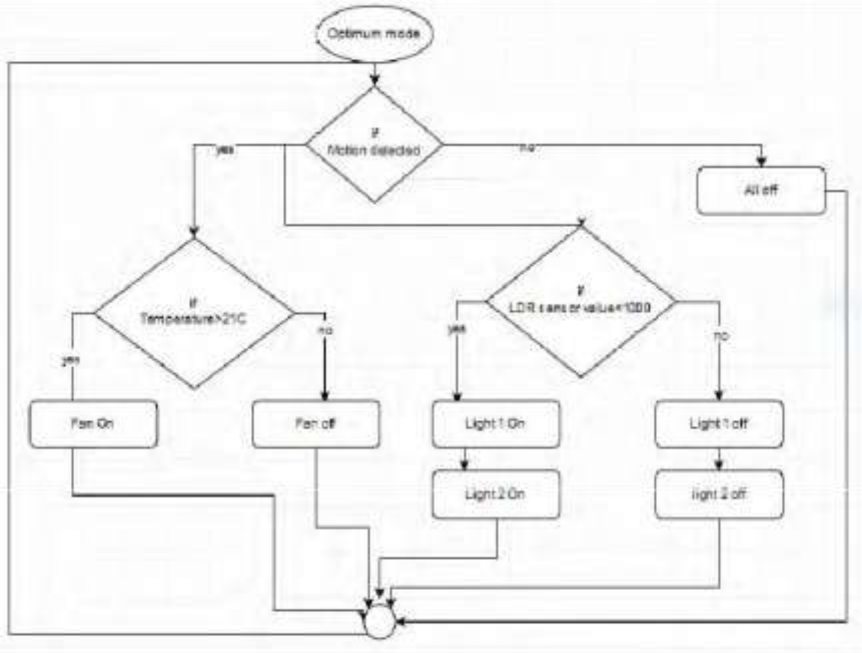


Figure 9 Flow chart of optimum mode

II) Auto Mode: Features of this mode is it controls the appliances automatically. It is more comfortable than the optimum. Auto mode has the same features of optimum mode except activating after getting any motion in the room. It does not depend on motions. So the algorithm for turning fan and lights on are the same as previous. Based on threshold temperature and LDR sensor value as mentioned in optimum appliances will turn on and off. Condition for turning on fan is temperature must be greater than 21 degrees Celsius. For turning on the lights LDR sensor value must be less than 1000. Otherwise both appliances will be turned off. So this mode is very reliable and comfortable for users.

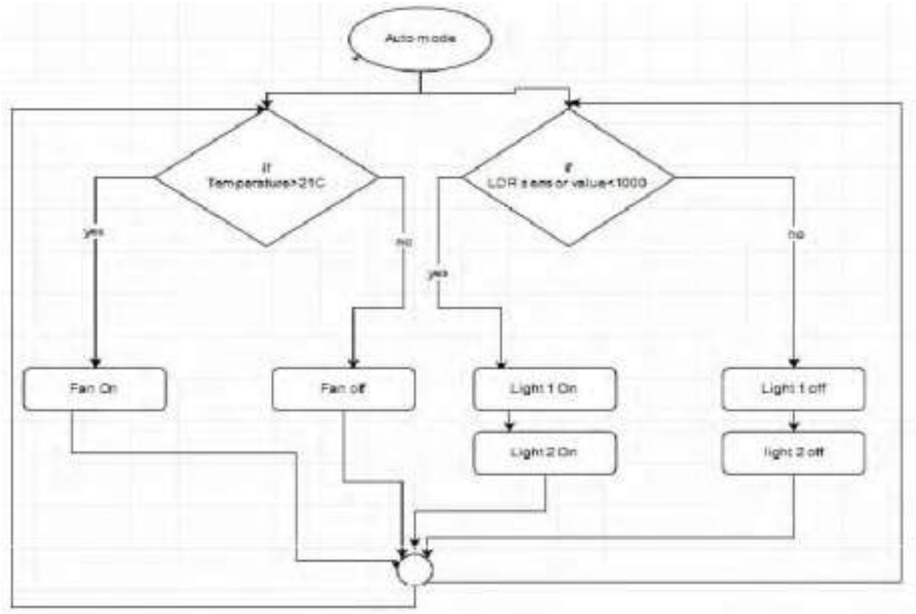


Figure 10 Flow chart of auto mode

Just activate the auto mode and relax. Once the mode is on than it does not change its mode until user changes it. Once auto mode is activated than if the application goes offline it does not change its state of mode or functionality. It will continue running on this mode.

III) Sleeping Mode: This mode is designed for sleeping time. The features of this mode is it will turn off all the lights and make the room dark so that users can sleep without any disturbance of light. The other feature is fan controlling. It will also control fan based on temperature. As shown in Fig11, here the algorithm of fan is designed in a way, it will be turned on if the temperature rises above the threshold value.

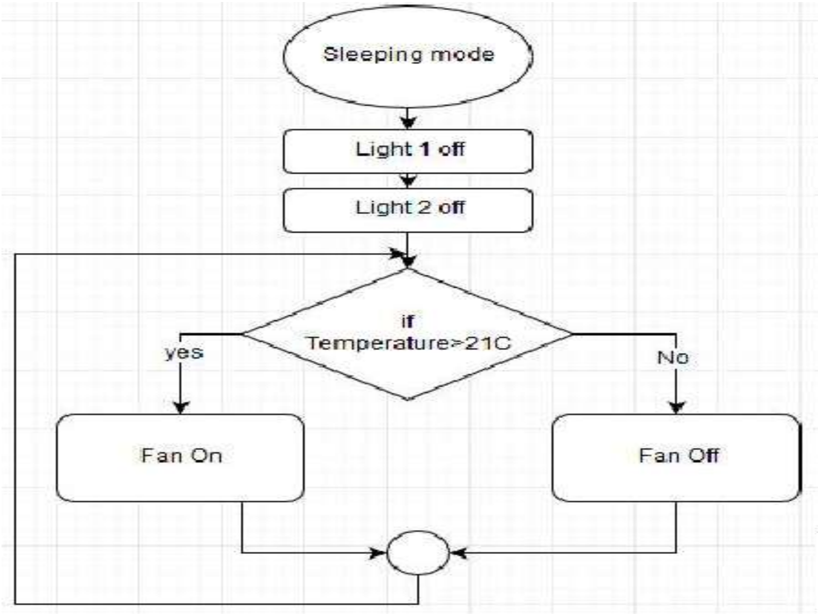


Figure 11 Flow chart of sleeping mode

The threshold temperature we have set is 21 degrees Celsius. So if temperatures goes above the threshold fan will be turned on and again if temperature goes down of threshold temperature fan will be turned off. This mode is comfortable and reliable to run in the time of sleeping.

IV) Active Mode:

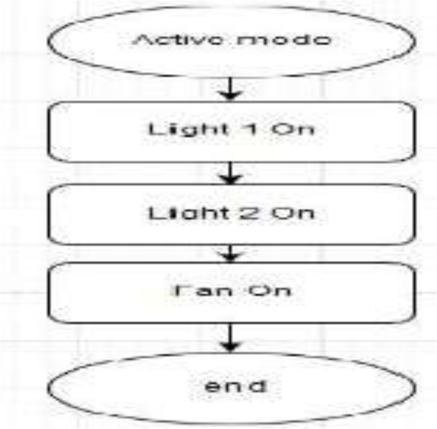


Figure 12 Flow chart of active mode

Active mood is designed for turning on and off the appliances at the same time. Activating this mood will turn on all the appliances and do not change its state until the mode is deactivated. So this mode is for very busy environment where users want to activate all the fans and lights at the same time. The algorithm of this mode is very simple. As shown in fig 12 when the mode is activated all the appliances are instructed to turn on. On the other hand if this mode is off it is instructed to turn off all the appliances.

Result:

I) Implementation of Home Automation: In the implementation process firstly, we have tested the home automation part. For home automation we have used all our sensors as input, arduino mega as the controller and lights as appliances or output. In this process optimum and auto modes are tested separately. We have checked weather the conditions for turning on fan and lights work properly or not, as shown in Fig 5.1. After succeeding this part we moved into the next phase which is controlling over internet.

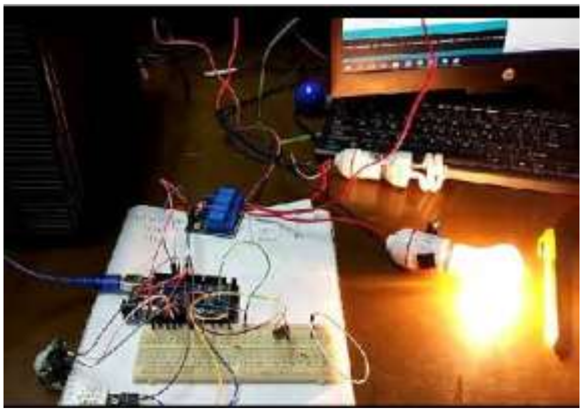


Figure 13: Implementation of home automation

II) Controlling from Android Application: In this phase we have controlled the above operation mentioned earlier from an android phone. We have used “blynk” which is an open application for beginners to test IoT stuffs. We have tested our home automation modes from this app. For this case we needed the blynk app installed in our phone. On the other hand another controller NodeMCU is added with the arduino. So the process is command was sent through the blynk app to internet towards the NodeMCU which is connected to internet via Wi-Fi. The NodeMCU takes input from internet and according to input it gives output to the arduino mega. Arduino mega than works according to the home automation algorithms. Like when optimum mode on is pressed in the blynk app, the command is sent to NodeMCU via internet. Than the NodeMCU will make the pin high which is assigned to optimum mode on. So the NodeMCU's output is the input of arduino mega. Arduino mega now gets an input pin high which is actually telling the arduino to run the optimum mode part. This is how the appliances was controlled from blynk app.

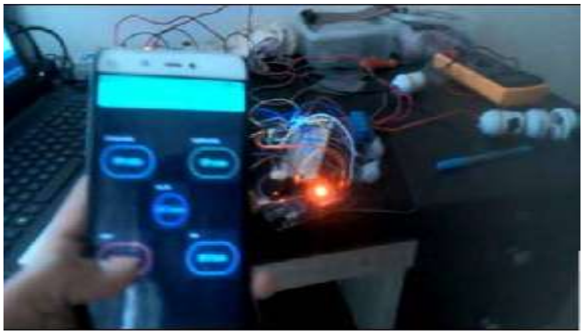


Figure 14: Controlling from blynk app

Conclusion

In our model a high percentage of accuracy has been achieved though implementation. This system is capable controlling the home appliances based on user's desired mode. All the modes work with a good accuracy which was found during implementation. Users only need to select modes from their smart phones and our system will do the rest of controlling the appliances. This proposed project is highly reliable. So it can be said that this system has higher accuracy with great efficiency.

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