Voice Controlled Home Appliances: The use of Android Phone

Sonia Akhter**, Md. Faisal Arif*, Md. Nur-Amin*, Nafiz Mustafiz*, Roman Khan*, Shah Waliullah* and Khalid Hossain*

Home automation is one of the major growing industries that can change the way people live. Some of these home automation systems target those seeking luxury and sophisticated home automation platforms; others target those with special needs like the elderly and the disabled. Typical wireless home automation system allows one to control house hold appliances from a centralized control unit which is wireless. These appliances usually have to be specially designed to be compatible with each other and with the control unit for most commercially available home automation systems. The developed system can be integrated as a single portable unit and allows one to wirelessly control lights, fans, air conditioners, television sets, security cameras, electronic doors, computer systems, audio/visual equipment's etc.

Keywords: Automation, voice controlled, arduino nano, android phone, bluetooth module.

1. Introduction

The aim of this project is to develop a device which control home appliances via human voice. Google Voice search software will be used as voice capture device. The Graphical User Interface (GUI) will be created using Android Meets Robots software (AMR). For this project this system is called voice controlled electrical appliances. This is a project to produce a system that can control any electrical appliances by using user's voice. User's voice is an input to activate the electrical appliances through this system. This system can make the daily work at home easier for disable persons who use this system. Speech recognition software converts spoken words to machine readable input. The term voice recognition may also refer to speech recognition but more precisely refers to speaker recognition which attempts to identify person speaking as opposed to what is being said. With today's computer technology human voice can be recorded and saved into computer memory for future references. This system needs a GUI (graphical user interface) which provided by Android Meets Robots software (AMR). This software is used to build a graphical user interface and programming that can recognize the voice of human. The recognized voice can activate the electrical appliances that user want to use. The system is portable and constructed in a way that is easy to install, configure, run, and maintain.

_____

**Sonia Akhter, Department of Industrial & Production Engineering, Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh, E-mail: sonia_ruet@yahoo.com
*Md. Faisal Arif, *Md. Nur-Amin, *Nafiz Mustafiz, *Roman Khan, *Shah Walliullah, *Khalid Hossain, Department of Industrial & Production Engineering, Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh.

The perfect user interface still does not exist at present and to build a good interface requires knowledge of both sociology and technology fields. According to major companies that are involved in speech recognition researches, voice will be the primary interface between humans and machines in the near future (Conte, G. and Scaradozzi, D., 2003). The problem lies with the situation of the elderly or disabled people, who cannot usually help themselves to move around, and might require external assistance. People who live alone might also need a helping hand at home. Therefore a voice controlled home automation system is designed, so that the users can perform certain tasks by just the use of their voices, moreover, the system is designed to have a hand-held device(mobile phone) as a remote so that the user can easily speak their commands, otherwise they would have to walk over to the microphone to speak. Having a mobile phone as a remote will make the system more user-friendly and portable.

Voice controlled home automation systems have drawn considerable attention in the recent years. Initially, home automation systems were designed for the people seeking luxury and sophisticated home. But, there was always a need to develop home automation system for the people with special needs like the elderly and the disabled. According to a report published by the World Health Organization (WHO) around 785 million people of 15 years and older live with disability (Obaid et al, 2014). Of these, the World Health Survey reports that 110 million people have significant difficulties in functioning. Another report published by the Population Division of United Nations show that about 10% of the World's population is older than 60 years and it is estimated that this figure will reach up to 21% by 2050 (Obaid et al, 2014). In order to assist the old people and the people with disability home automation technologies are adopting voice control or voice recognition techniques. The main idea is to control and monitor home appliances by using voice command. The motivation behind this work is also the same. The rest of the paper is organized as follows: Section 2 presents some related works. System model has been presented in Section 3. Section 4 contains system operation, circuit details, and implementations. Section 5 discusses the framework, working procedures of the system. Section 6 explains the results, section 7 presents discussions and this paper is concluded with section 8 which explains conclusions and the future work.

2. Literature Review

There are many research and journal papers which worked about this project. There are many papers which were working with the procedure like sms or computerized based. Khiyal et al (2009) worked on the sms based home automation system which was time consuming and costly. It took longer time to respond properly. Delgado et al (2006) considered the problems with the implementation of home automation systems. Furthermore the possible solutions are devised through various network technologies. Several issues affecting home automation systems such as lack of robustness, compatibility issue and acceptability among the old and disabled people are discussed. Ciubotaru-Petrescu et al (2006) presented a design and implementation of SMS based control for monitoring systems. The paper has three modules involving sensing unit for monitoring the complex applications, a processing unit that is microcontroller and a communication module that uses GPRS modem or cell phone via serial port RS-232. The SMS is used for status reporting such as power failure. It requires much labor and money. Conte and Scaradozzi (2003) said

that home automation system is a multiple agent system (MAS). Authors had proposed a home automation system that includes home appliances and devices that are controlled and maintained for home management which major task is to improve performance. In their paper, Alkar and Buhur (2005) proposed an Internet Based Wireless Home Automation System for Multifunctional Devices. That paper proposed a low cost and flexible web-based solution but their system had some limitations such as the range and power failure. Murthy (2008) explored primary health-care management for the rural population. They proposed the use of mobile web-technologies providing the PHC services to the rural population. The system involves the use of SMS and cell phone technology for information management, transactional exchange and personal communication. Jawarkar et al (2007) proposed a system that uses a PC based application to convert voice command to txt and transmit this command via a user mobile to the cellular network, on the receiver the mobile receive the SMS which is read by the microcontroller using AT command structure, the communication medium between the microcontroller and mobile is RS232 standard which is a wired communication. Jawarkar et al (2008) proposed a remote monitoring through mobile phone involving the use of spoken commands. The spoken commands are generated and sent in the form of text SMS to the control system and then the microcontroller on the basis of SMS takes a decision of a particular task but it takes too much time. Potamitis et al (2003) suggested the use of speech to interact remotely with the home appliances to perform a particular action on behalf of the user. The approach is inclined for people with disability to perform real-life operations at home by directing appliances through speech but ambiguity in voice recognition results in time consuming device. Butt et al (2010) proposed a system where a user can make a voice call in order to perform certain actions such as switching lights on/off, getting the status of any appliance etc. and when system finds intrusion it sends an alert voice message to preconfigured cell when the user is away from the place. Authors used Global System for Mobile Communications (GSM) and wireless technology based on .NET framework and Attention (AT) commands but it is time consuming and costly because making a call and voice message over GSM costs money.

After reviewing the literatures it has found that response time of the total operation of previous projects is quite high which motivates us to renovate the system reducing the response time. The proposed new system which uses a smart phone incorporated with AMR voice recognition software, arduino nano, bluethooth module will help to reduce the response time of the operation.

3. System Components

This system is designed considering the present scenario of home appliances. It consists of seven main components. They are arduino (Nano), Bluetooth module, android phone, voltage controller, relay, PCB board and diode.

3.1 Arduino Nano

At controlling unit Arduino Nano is used which is a microcontroller board based on the ATmega328 .It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. One of its most important

features is its ease of programmability. Motor Driver of L293D IC model is used which is a monolithic integrated, high voltage, high current, 4-channel driver. Using chip it is possible to use DC motors and power supplies of up to 36 Volts and maximum current of 600mA per channel.

Figure 1: Arduino Nano
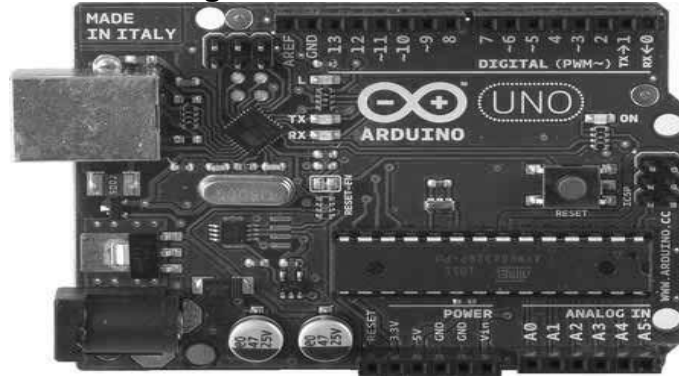
3.1.1 Arduino Nano Pin Layout

Pin layout of Arduino Nano has shown below which indicates various ports where various connections are made.
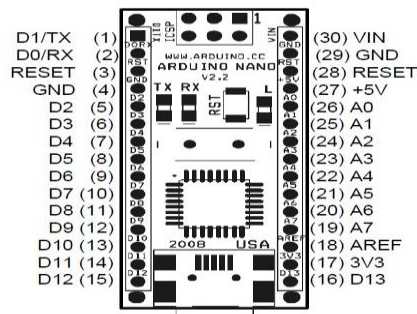
Figure 2: Pin Diagram of Arduino Nano

Table 1: Description of pins of Arduino Nano

| Pin No.	Name	Type	Description
1-2, 5-16	D0-D13	I/O	Digital input/output port 0 to 13
3, 28	RESET	Input	Reset (active low)
4, 29	GND	PWR	Supply ground
17	3V3	Output	+3.3V output (from FTDI)
18	AREF	Input	ADC reference
19-26	A7-A0	Input	Analog input channel 0 to 7
27	+5V	Output or Input	+5V output (from on-board regulator) or +5V (input from external power supply)

3.2 Relay

This is a 5V 2-Channel Relay interface board, Be able to control various appliances, and other equipment with large current. It can be controlled directly by Micro-controller (Raspberry P**i**, Adriano, 8051, AVR, PIC, DSP, ARM, ARM, MSP430, TTL logic).

3.2.1 Features

5V 2-Channel Relay interface board, and each one needs 15-20mA Driver Current   Equipped with high-current relay, AC250V 10A ; DC30V 10A   Standard interface that can be controlled directly by microcontroller (Adriano , 8051, AVR, PIC, DSP, ARM, ARM, MSP430, TTL logic)indication LED's for Relay output status

Figure 3: Relay
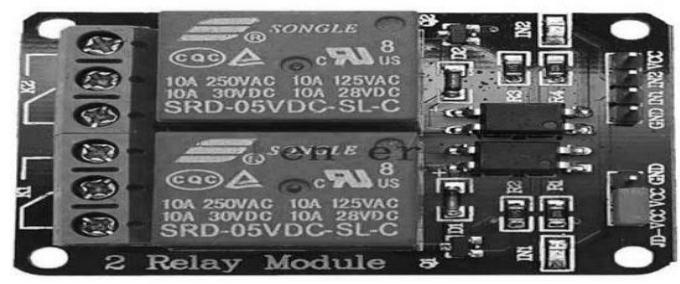
3.3 Bluetooth Module

Bluetooth wireless technology standard for exchanging data over short distances (using short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz) from fixed and mobile devices, and building personal area networks (PANs). Invented by telecom vendor Ericsson in 1994, it was originally conceived as a wireless alternative to RS-232 data cables. It can connect several devices, overcoming problems synchronization .Bluetooth operates at frequencies between 2400 and 2483.5 MHz (including guard bands of 2 MHz at the bottom end and 3.5 MHz at the top). This is in the globally unlicensed (but not unregulated) Industrial, Scientific and Medical (ISM) 2.4 GHz short-range radio frequency band. Bluetooth uses a radio technology called frequency-hopping_spread spectrum. Bluetooth device plays an important role in this project.
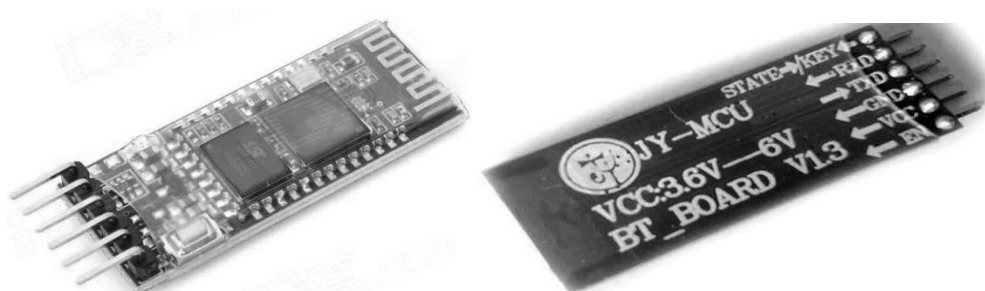
Figure 4: Bluetooth Module

Table 2: Description of Pins of Bluetooth Module

Pin No.	Name	Description
2	RXD	UART_RXD, Bluetooth serial signal receiving PIN, can connect with the MCU's TXD PIN, There is no pull-up resistor in this PIN. But It needs to be added an eternal pull-up resistor.
3	TXD	UART_TXD, Bluetooth serial signal sending PIN, can connect with MCU's RXD PIN
4	GND	Supply ground
5	VCC	VCC, voltage supply for logic, the standard voltage is 3.3V, and can work at 3.0-4.2V

4. Circuit Diagram

The circuit diagram of the project is given below which will help to prepare the project easily. Arduino nano is connected to Bluetooth device by four I\O points .AMR software is used to recognize voice which is installed to the android phone. Relay is also used as switch. Voltage regulator is also connected to complete the circuit. The devices are connected according to the circuit diagram.

Figure 5: Circuit Diagram
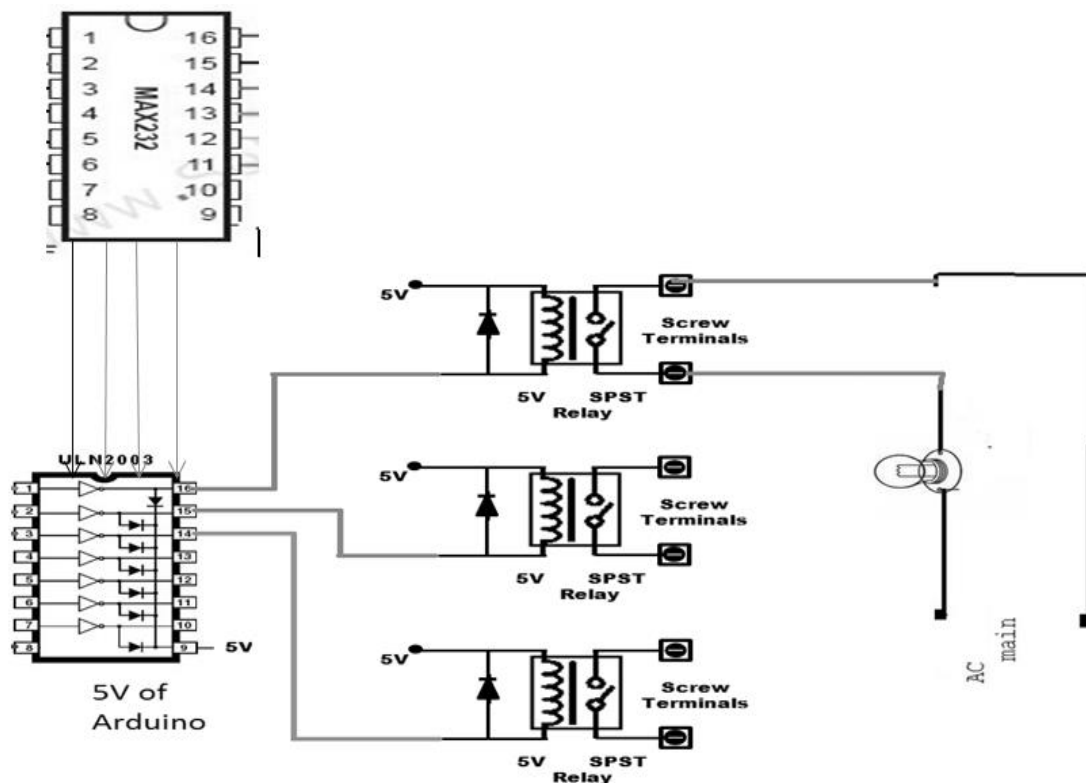
5. Working Procedure

The following steps have to be followed to run the project properly:

- Arduino nano is the main component of this project. It performs the main function of the project. C programming codding language is used to operate the Arduino nano.
- Bluetooth device is used to receive data from the android mobile phone. It is connected to the Arduino nano.
- A PCB board is also working in this project where different kinds of electrical equipment are assembled which is connected to the Arduino and Bluetooth device.
- AMR voice recognition software is used to act as a voice source which is installed on the phone.
- AC source is also working to show the output i.e. turn on or off the light , fan or other home appliances.
- Different kinds of relays, connecting wires and voltage regulator are properly connected.

The flow of the overall working procedure is given below in the form of block diagram which will give the clear realization of the working procedure of the project.

Figure 6: Block Diagram of the Working Procedure
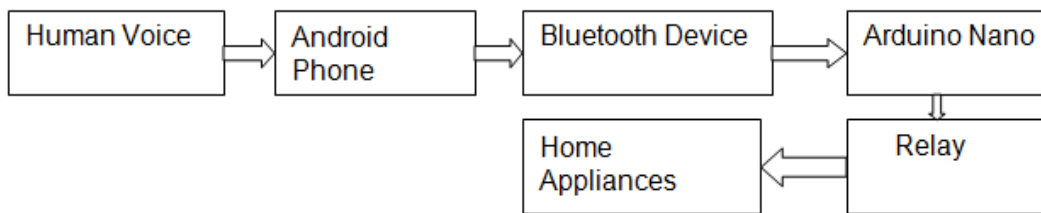
The block diagram is shown in the picture diagram to clearly understand the overall working procedure very clearly and properly which will be helpful to operate the project.
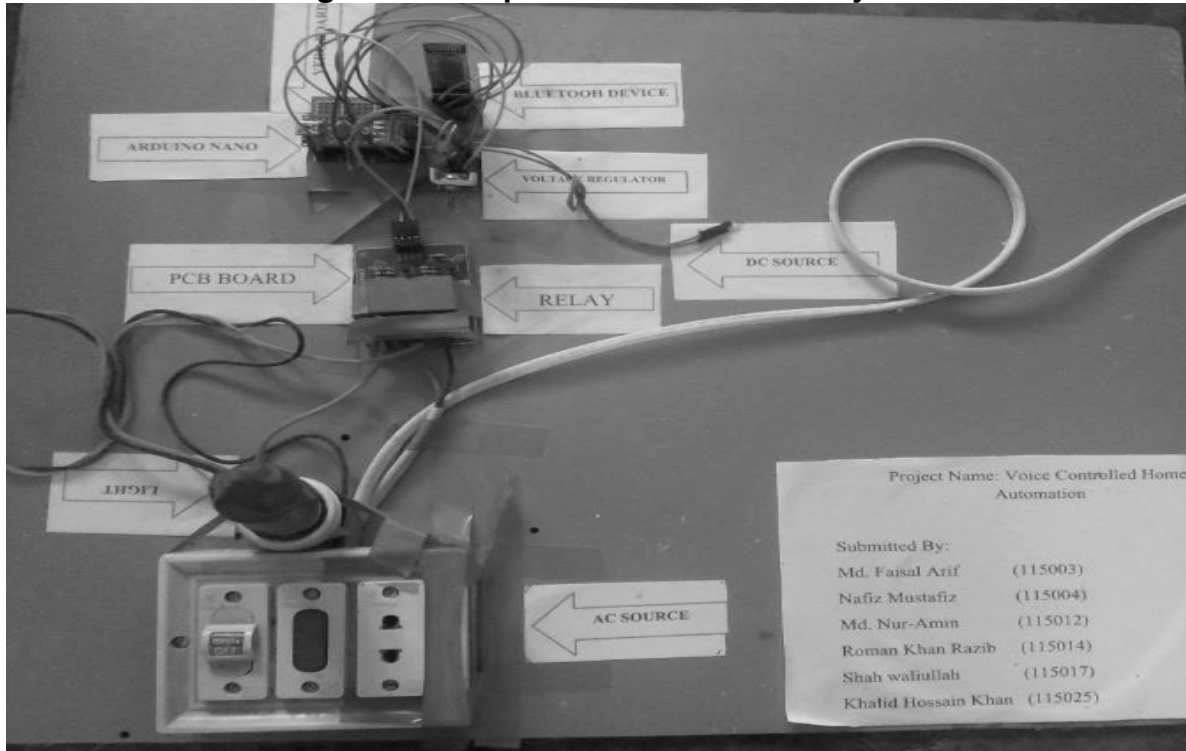
Figure 7: Diagram of Working Procedure
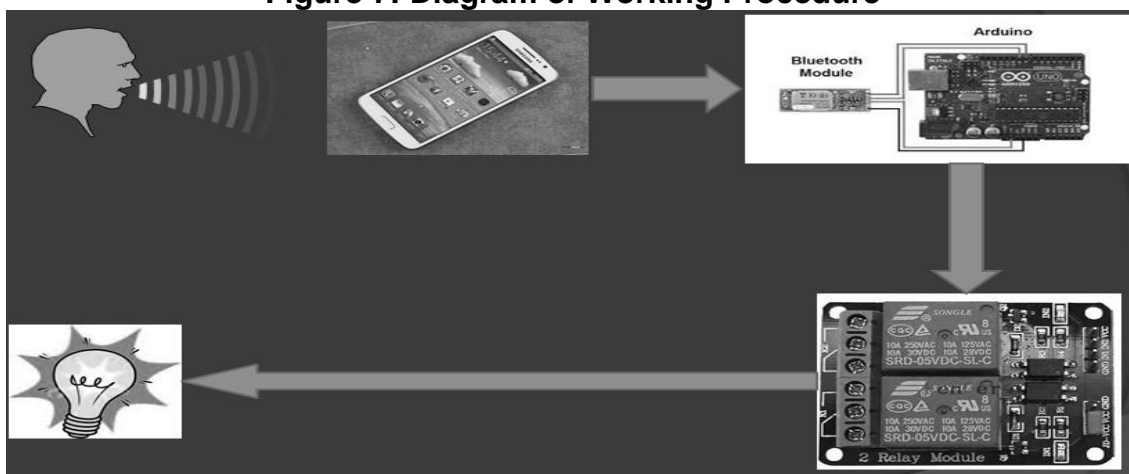
The complete picture of the project named voice controlled home appliances using android phone is given below.

Figure 8: Complete Picture of the Project

6. Performance Test

For the performance test fifty trials are taken for light, fan and both. The percentage of success is higher in light on and off than the fan on and off. In case of light the performance is up to the mark. It detects the signal very successfully. In terms of fan it takes time higher than the light. For both the option light and fan the result is also satisfactory. Overall performance result is shown below which will give the actual picture of our project.

Table 3: The Performance Test of the Voice Controlled Home Appliances

| Components	No of trial	No of success	% of success
Light on	50	50	100
Light off	50	50	100
Fan on	50	48	96
Fan off	50	46	92
Both on	50	47	94
Both off	50	45	90

The result shows the better performance of the turning light on and off. It shows the relatively poor performance of the turning on and off of fan. When turn on and off the both devices the result is also good but it takes a little bit more time to respond.

A. Graph of Experimental Results:
As user says a command regarding the appliances the system match the command with its vocabulary if it finds match it follows the instruction. If the timer exceeds from certain limit the system discard the call. The graphs of average response time of appliances are given. These have been taken from the test cases given above. As soon as the system receives the voice command from the preconfigured cell phone

number regarding any appliances like light ON, light OFF, fan ON, fan OFF and both ON, both OFF to change the status of them or to know the current status of them the system response in 3,2.8, 3.3, 3.2, 7 and 7.5 seconds respectively. This is the average response time of appliances. Graph of response time of appliances like light, fan and both are shown in the figure 9.

Figure 9: Response Time of Appliances
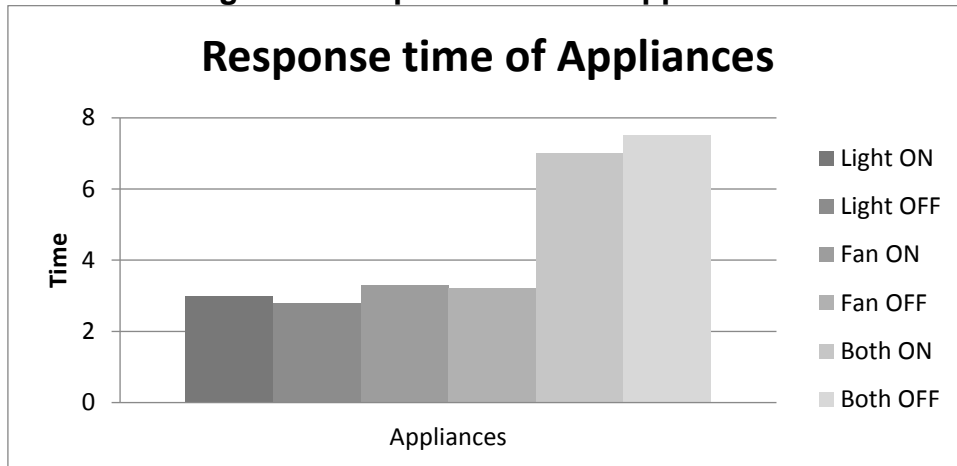
B. Comparison of Proposed System with Other Systems:

The comparison of different systems with proposed system is given in table 4. Proposed system is using voice GSM technology and bluetooth module for sending and receiving the voice command to control the home appliances. This is cost effective (Nguyen et al, 2007) and provides security and is highly accessible. While the other system is not cost effective and does not provide security and everywhere access (Jawarkar et al, 2007). Another system was proposed that controls the home appliances remotely using two cell phones for communication and system was developed by using the J2ME language which is not cost effective since it uses the internet for communication (Nasr et al, 2009).

Table 4: Comparison of Systems

No.	System	Technique	Characteristics			
			Cost effective	highly Accessible	security	Response time
1.	Ubiquitous Access to Home Appliance Control System using Infrared Ray and Power Line Communication [Nguyen et. Al., 2007]	Power Line Communication (PLC),IR	No	Yes	Available	Too high
2.	Remote Control using Mobile through Spoken Commands [Jawarkar et. al., 2007]	GSM technology	Yes	No	Not available	High
3.	Friendly Home Automation System Using Cell Phone and J2ME with Feedback Instant Voice Messages[Nasr and Azwai, 2009]	GSM technology	Yes	Yes	Available	low
4.	Controlling Home Appliances Remotely Through Voice Command [Butt et. al. 2010]	Voice GSM technology, AT command	Yes	Yes	Available	Medium
5.	Proposed System	Voice GSM Technology, bluetooth module	Yes	Yes	Available	Low

7. Discussion

The performance test of the project shows the rate of success of the project. The rate of success of the project is at most satisfactory which will encourage us to do further research on the project which will pave the way to bring better result for the all devices. Further studies and work will be continued to bring the better result and more modification to ensure the best performance of the project. This project is very helpful for the disabled person who will not capable of doing works properly. This project will reduce the burden of the disable person and rely on others.

8. Conclusions

Voice controlled home automation is an ongoing project & the main objective is to assist handicapped/old aged people. This project gives basic idea of how to control various home appliances and provide a security using Android phone/tab. This project is based on Android and Arduino platform. Android phone is cheap, easily accessible and user friendly than other devices. So the overall implementation cost is very cheap and it is affordable by a common person. User can interact with the android phone and send control signal to the Arduino which in turn will control any other embedded devices/sensors. If voice controlled home automation feature is embedded on Android phone then it will be a wow factor for its user's. A simple prototype of this project has been discussed here and it shows some difficulties during execution of two commands at a time which can be eliminated by conducting further research. Prototype of this project has been designed for operating only two devices but in future it can be expanded to many other areas.

References

Alkar, AZ and Buhur, U 2005, 'An Internet Based Wireless Home Automation System for Multifunctional Devices', *IEEE Consumer Electronics,* vol. 51, no. 4, pp. 1169- 1174, viewed 30 September 2014,
< http://www.thaieei.com/embedded/pdf/Automation/20022.pdf>.

Butt, M, Khanam, M, Khan A and Khiyal MSH 2010, 'Controlling Home Appliances Remotely Through Voice Command', *International Journal of Advanced Computer Science and Applications,* pp. 35- 39, viewed 02 October 2014, https://thesai.org/PdfFileHandler.ashx?filen=SpecialIssue_Volume1No2 .

Ciubotaru-Petrescu, B, Chiciudean, D, Cioarga, R and Stanescu, D 2006, 'Wireless Solutions for Telemetry in Civil Equipment and Infrastructure Monitoring'*, 3rd Romanian-Hungarian Joint Symposium on Applied Computational Intelligence (SACI) May 25-26, 2006,* viewed 30 September 2014, <http://www.bmf.hu/conferences/saci2006/Ciubotaru.pdf>.

Conte, G and Scaradozzi, D 2003, 'Viewing home automation systems as multiple agents systems', *RoboCUP2003*, Padova, Italy, viewed 05 October 2014, http://www.robosiri.it/ROBOCUP_2003/ROBOCUPSITOSIRI/articles/pdf/Conte.pdf.

Delgado, AR, Picking, R and Grout, V 2006, 'Remote-Controlled Home Automation Systems with Different Network Technologies'*, Proceedings of the 6th International Network Conference (INC 2006),* University of Plymouth, 11-14 July 2006, pp. 357-366, viewed 02 October 2014,
< http://www.newi.ac.uk/groutv/papers/p5.pdf >.

Jawarkar, NP, Ahmed, V, Ladhake, SA and Thakare, RD 2008, 'Micro-Controller Based Remote Monitoring Using Mobile Through Spoken Commands', *Journal of Networks,* vol. 3, no. 2, pp. 58-63, viewed 02 October 2014, <http://www.academypublisher.com/jnw/vol03/no02/jnw03025863.pdf>.

Jawarkar, NP, Ahmed V and Thakare, RD 2007, "Remote Control using Mobile through Spoken Commands*". IEEE - International Consortium of Stem Cell Networks (ICSCN), pp.622-625.*

Khiyal, MSH, Khan, A and Shehzadi, E 2009, 'SMS Based Wireless Home Appliance Control System (HACS) for Automating Appliances and Security', *Information Science and Information Technology*, vol. 6, pp. 887-894, viewed 02 October 2014, <http://iisit.org/Vol6/IISITv6p887-894Khiyal592.pdf>.

Murthy, MVR 2008, 'Mobile Based Primary Health Care System for Rural India*', W3C workshop on Role of Mobile Technologies in Fostering Social Development, Jun 2008 .*

Nasr, MS, Azwai, FHAS 2009, 'Friendly home automation system using cell phone and J2ME with feedback instant voice messages', IEEE/ACS International Conference on Computer Systems and Applications, pp. 531-538, viewed 05 October 2014, < http://ieeexplore.ieee.org/document/5069375/?reload=true&arnumber=5069375 >

Nguyen, TV, Lee, DG, Seol, YH, Yu, MH and Choi, D 2007, 'Ubiquitous Access to Home Appliance Control System using Infrared Ray and Power Line Communication', *3rd IEEE/IFIP International Conference in Central Asia,* Tashkent, Uzbekistan, vol 1, pp1-4, viewed 02 October 2014, http://ieeexplore.ieee.org/document/4401668/authors .

Obaid, T, Rashed, H, Ali Abu El Nour, AAE, Rehan, M, Saleh, MM and Tarique, M 2014, 'Zigbee Based Voice Controlled Wireless Smart Home System', *International Journal of Wireless & Mobile Networks (IJWMN),* vol. 6, no. 1, pp. 47-59, viewed 17 November 2015, < http://airccse.org/journal/jwmn/6114ijwmn04.pdf>.

Potamitis, I, Georgila, K, Fakotakis, N and Kokkinakis, G 2003, 'An integrated system for smart-home control of appliances based on remote speech interaction', *8th European Conference on Speech Communication and Technology*, EUROSPEECH 2003, Geneva, Switzerland, pp. 2197-2200, viewed 02 October 2014, <http://www.wcl.ee.upatras.gr/ai/papers/potamitis14.pdf>