Webology, Volume 18, Number 1, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I1/48

A WIFI and ZigBee based IoT device

[1]Rishabh Sati, [1]Gourav Verma, [2]Ms Sonali Gupta

[1]Department of Electronics and Communication Engineering, Graphic Era (Deemed to be University) Dehradun, Uttarakhand, India
[2]Assistant Professor, Department of Computer Science and Engineering, Graphic Era Hill University, Dehradun

ABSTRACT

In the last decade, the digital technology is efficiently utilized in home environment. This technology facilitates the home automation providing an interconnected environment of IoT based devices within homes. Furthermore, with the fast growth of the internet, it is possible to remotely management and tracking of network enabled gadgets in the couple of seconds. Although, the home automation systems are not adopted as expected. This paper highlights the drawback for home automation device been less popular and propose design and home automation system (HAS) that uses Wi-Fi along with ZigBee as possible modes of communications. This paper shows a of ZigBee and Wi-Fi network for better performance. WIFI is used as a gateway which provides wireless worldwide control. To test the proposed system a led bulb is used.

Keywords: Wi-Fi, Smart Home Automation, ZigBee, Smart buildings automation, Network, IoT

INTRODUCTION

Home automation is developing at rapid pace. it introduces the concept of integrating the embedded system and Internet of things (IOT) to control the appliances of our house wirelessly. Home automation systems (HASs) provide the centralized control of the devices connected over internet providing security comfort and efficiency. HASs are now very popular in the market due to its features and efficiency. There are many Communication protocols which can be used for data transmission for home automaton devices like Wi-Fi, ZigBee, LoRA, Z Wave Bluetooth, Wi-Fi, infrared technology. Due to suitable capabilities, we have chosen Wi-Fi and Zigbee as mode of transmission for sending sensor data between the device and the application. In this paper we will introduce how HAS connects devices uisng Wi-Fi and ZigBee within the home. Wi-Fi and ZigBee can be used as for long range and local accessibility respectively. The proposed system is a low-cost, integrated Wi-Fi and ZigBee based home automation system. The system is made cost-effective and less complex by using best and cheap components. This system can be controlled and monitored by ZigBee supported by Wi-Fi protocol. This paper shows how ZigBee can be integrated with Wi-Fi network for fast and cost-effective transmission of data. The delay of Wi-Fi and ZigBee is compared. Also, to test the proposed system a led bulb has been used.

The paper is divided into different sections as follows: Section 1 includes introduction. Section 2 Includes the literature review. Section 3 discuss the system architecture and discuss about the technology used. The implementation of the proposed system is discussed in Section 3. Section 4

Webology, Volume 18, Number 1, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I1/48

includes results and discussion. Section 5 contains the conclusion part.

LITERATURE REVIEW

In the last decade the home automation is significantly explored field of research. A first general-purpose home automation system X10 was introduced and launched in 1978 in US. In X10 the control signals were sent over the mains wiring, using radio frequency bursts. [1].

Paper [2] introduces a system with IR remote, Bluetooth for local control of devices and GSM for long-range controlling of home appliances. Over the conventional switch, they have designed an Android app to control the appliances. The integral features of mobile phones were used for home automation. Due to the large-scale use of GSM and its worldwide range, users can use this system from anywhere around the world. Even if there is any fault in the control circuitry, the device supports manual switching.

Paper [3] introduced a architecture with Bluetooth system as main controller and sub-controllers. Every device is directly connected to the sub controller. The sub-controller is connected to the primary controller wirelessly and which sends and receives the data wirelessly. However, as the circuitry for Bluetooth is expensive, a single module works as a hub and receives data from several devices. This method of using single Bluetooth controller increases the delay in transmission and reception of signals between device and controller.

In [4] author proposed a system which uses Arduino Uno microcontroller and addresses real-time solution in HAS for IoT-based application. A cell- based short message service (SMS), along with the use of GSM module are used to control numerous applications like bulbs, music systems and various other smart home appliances.

For actual-time scheduling, the SMS, down counter clock is used to keep the cut-off time. In [5], the authors introduced a IoT system for home automation that communicates between Wi-Fi and an android mobile application. The long-range Wi-Fi technology uses an Android application which can cover a large area and supports speedy transmission. The application is used control electrical and electronic devices connected to it. An android application is developed to monitor the results virtually from anywhere. Additionally, there is also a provision of access codes for the Wi-Fi, thus allowing minimized human intervention and provide a secure home automation system.

A circuitry based on PIC Microcontroller and GSM modem is introduced in [6] for controlling and monitoring home appliances. The GSM due to its worldwide coverage is an advantage in this system but the speed is slow as compared to local and wireless Wi-Fi protocols.

Message Queue Telemetry Transport (MQTT) protocol is used for developing IoT-based HAS [7] for energy management. On the server-side raspberry pi is used and nodemcu is used at the client-side. The link between the server and the cloud is established using MQTT broker. Publish request is generated by client-side devices for the Broker.

A proposed system in [8] utilizes Wi-Fi-based gateway for which a microcontroller with inbuilt Wi-Fi facilities is used along with Adafruit IO cloud server. Nodemcu is chosen because of its less cost

Webology, Volume 18, Number 1, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I1/48

and good performance. The collected piece of information in the form of sensor data from several deployed sensor units can be tracked using an amazing software service If This Then That (IFTTT) which allows us to set the parameters for the actuators by continuously comparing the condition and the sensor data values. The system proposed is made portable and small to be fitted anywhere without a requirement of large space.

The work of John J. Greichen [9] addresses few challenges of HAS which are installation, development, and manufacturing cost. Along with additional service cost, lack of home automation standards, and user's foreignness with technology

We have introduced some existing research on the home automation systems. Home automation technologies have now been adopted by many industries.

The home automation technology is adopted nut still not in a large scale. We address few problems limiting adoption of these systems as below.

Firstly, ***very complex circuitry and costly systems***: the systems already exist are expensive due to costly components and needs some supportive circuitry which adds complexity to the system, thus increases the cost of the system.

Secondly, ***complex installation*****:** most if the existing systems need external physical wiring. Hence this increases the installation cost and complexity.

Thirdly, ***security***: the existing systems are less secure for users as the data stored on the cloud and due to less secure encryption techniques. Up to some extent the security is handled by virtual home in the proposed system.

Home automation required a fast and secure cloud platform. Few required features are listed below

1. Robustness: A system can be considered robust when it can execute all the processing with negligible error rate. The cloud platforms containing the servers works as hub for data transfer between sensor and the applications. These clouds retain the sensor data. If in between the connection is lost on the application end the data keeps updating on the cloud and after the connection is back the sensor data is sent to the application.

2. Security Even though there are lot of technological advancements, the user only trusts the product when the product ensures users security and privacy. Also, the data should not be lost, and should be prevented from unauthorized external access. The cloud platform Sinric also provides the secure platform for the users with end user authentication which is used by us in our project. Sinric is based on Web socket protocol for transmission which in itself is a safe medium of data transfer.

3. Costs The cost includes the user's investment cost and directly or indirectly the facilities the user gets out of the product. Owners of household can monitor and automate home appliances and electronic gadgets. The user can monitor any appliance; it can be a

Webology, Volume 18, Number 1, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I1/48

submersible pump, an air conditioner, some heavy motors. Which can somehow directly or indirectly helps in reduction in household bills and save a lot of energy.

SYSTEM ARCHITECTURE

The architecture of the proposed system is shown below in Figure 1. Zigbee is used for low data rate functions, and high data rate needs are met by Wi-Fi (IEEE 802.11g) standard.

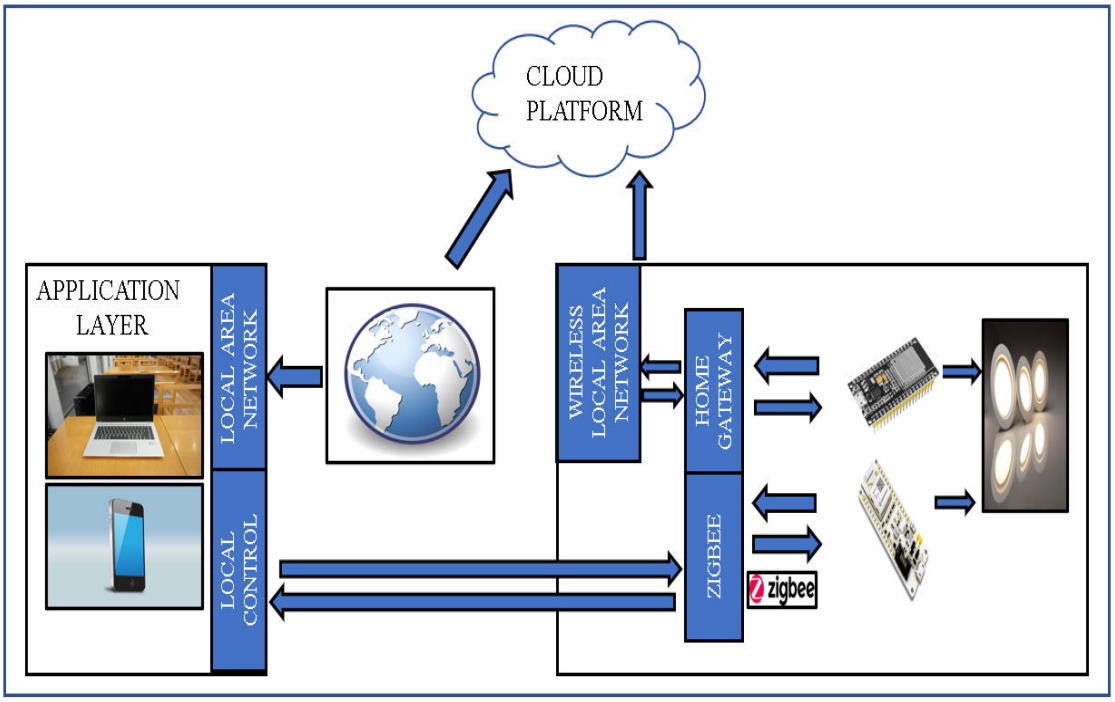

Fig. 1. Proposed system design.

The data transfer is done through the request by the user between Zigbee and Wi-Fi. Wi-Fi networks is supported by a home gateway and makes the control and monitoring of devices possible over these protocols. Remote user can use internet for accessing the system. A WLAN consist of home gateway. The remote user keeps on checking for accessing internet. The signal using the internet is passed on to Wi-Fi network. When everything seems to be ok. The data can be sent to the connected home automation devices. If somehow the Wi-Fi connection is lost user can used ZigBee to directly control connected devices within range.

A. NETWORKS USAGE

Integrated use of Wi-Fi and Zigbee protocols in the same system have few advantages. Low data rate functions are supported by Zigbee technology which consumes less power as compared to Wi-Fi, and it is a duplex communication. The data containing multimedia needs high data rate and are supported by Wi-Fi. Because Wi-Fi has widespread presence In Indian homes and industries it is feasible to use Wi-Fi. The Zigbee and Wi-Fi protocols together opens a huge potential for IoT based smart devices

Webology, Volume 18, Number 1, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I1/48

B. ZIGBEE TECHNOLOGY

ZigBee is standard based on IEEE 802.15.4. It provides 250kbps and 40kbps data rate. Figure 2 below shows a Zigbee architecture. Each device to be controlled are connected using Zigbee protocol to send and receive information. The low cost of installation and functioning which ZigBee offers helps to overcome complexity and cost of the architecture.

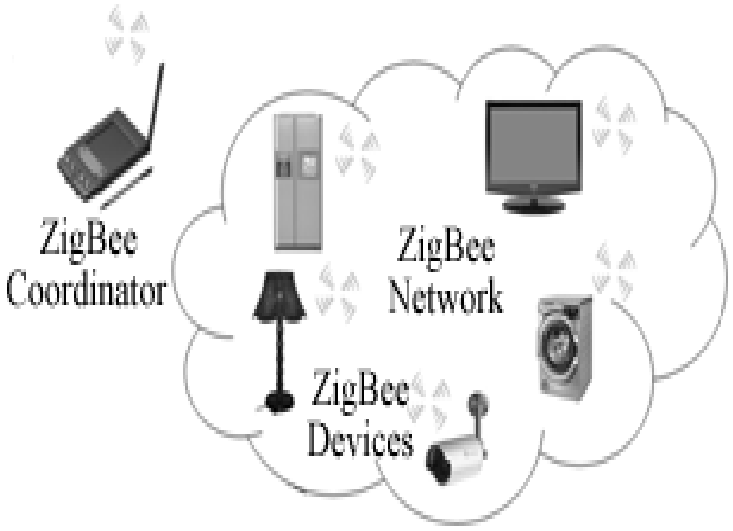

Fig. 2. Architecture OF Zigbee network.

C. WI-FI TECHNOLOGY

The latest version of Wi-Fi currently available is IEEE 802.11ax standard. Its range is approx. about 40-300 feet. Wi-Fi utilizes 2.4 GHz band for data transmission. Wi-Fi can be used as an alternative to the local Zigbee protocol. The use of Wi-Fi worldwide made it very popular. using Zigbee increases the cost. Moreover, Wi-Fi is flexibility and provides high data rate for better and fast processing.

SYSTEM IMPLEMENTATION

Figure 3. Below introduces the implemented hardware design consisting of connected devices. As depicted, a Wi-Fi and ZigBee system can be seen along with different sensors and devices connected to the system for monitoring and controlling household devices. To fulfill the need of multimedia, a Wi-Fi router is used. For exchanging data, a home gateway is implemented. This home gateway acts as a unified interface for local and remote access of devices. For testing the proposed system, a led bulb is used, and many iterations are performed turning the state of the bulb ON/OFF. A ZigBee microcontroller is implemented inside the smart PCB board. The system is thoroughly described below.

The system consists of a Wi-Fi module, and also a good high performance ZigBee Microcontroller. The fast data rate is supported by the Wi-Fi module. For using ZigBee network protocols, ZigBee Microcontroller is used. The microcontroller esp32 used in the system connects to the Wi-Fi

Webology, Volume 18, Number 1, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I1/48

network and similarly for connecting to the ZigBee network a microcontroller which supports ZigBee is used. Wi-Fi connection is established once gateway enters the configuration stage.
The parameters such as SSID and password is fetched from the smart phone application. Similarly, the ZigBee microcontroller also establishes a connection. This is how the device

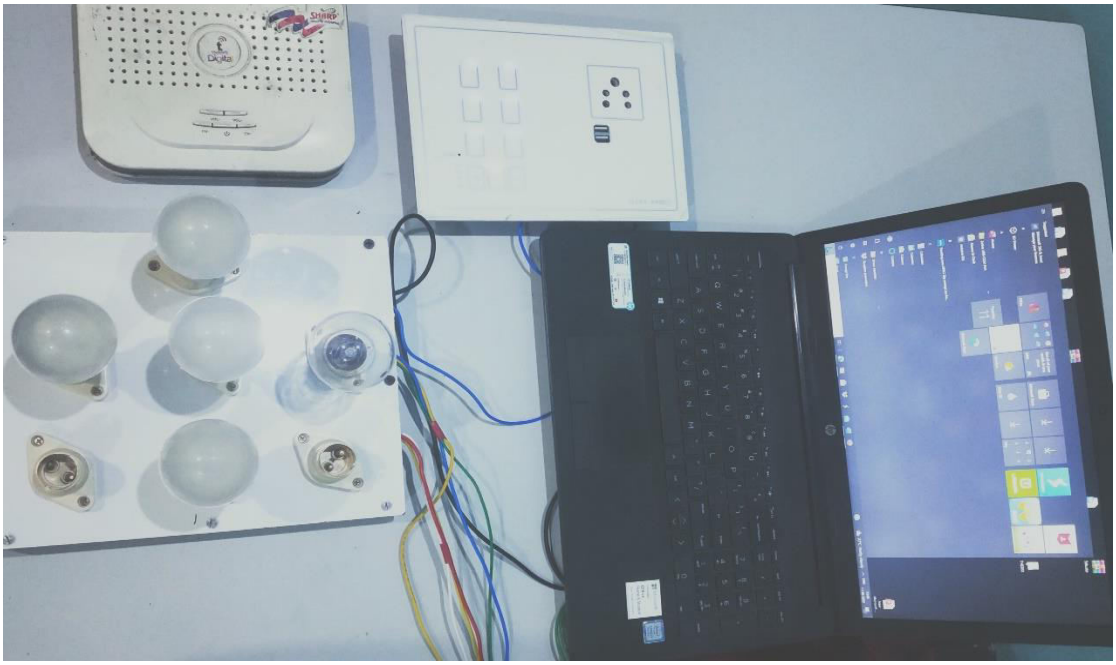

Fig. 3. System Implementation.

is provisioned. After establishing the connection, the input is received and sent to the cloud and the Wi-Fi module through the internet for further processing. This data is sent to the server inside the cloud and then to the Wi-Fi network. This data is data is further exchanged between microcontroller and the connected appliances. In case of ZigBee the ZigBee device handles the local requests from the user and the

D. SYSTEM WORKING FLOW CHART

The flow starts with checking if the device is provisioned or not. If the device is not provisioned user can only control, it manually or locally. If the device is connected to the internet it checks for the type of request generated by the application. It can be either Wi-Fi or local control. If request is local, then the user can use Zigbee device for sending and receiving messages between user and the system. If the request type is over the cloud using Wi-Fi, then data is sent to and from the cloud platform and the data is handled at the cloud level and the process ends after completion of request. Fig.5. shows the flow chart of working of the system.

Webology, Volume 18, Number 1, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I1/48

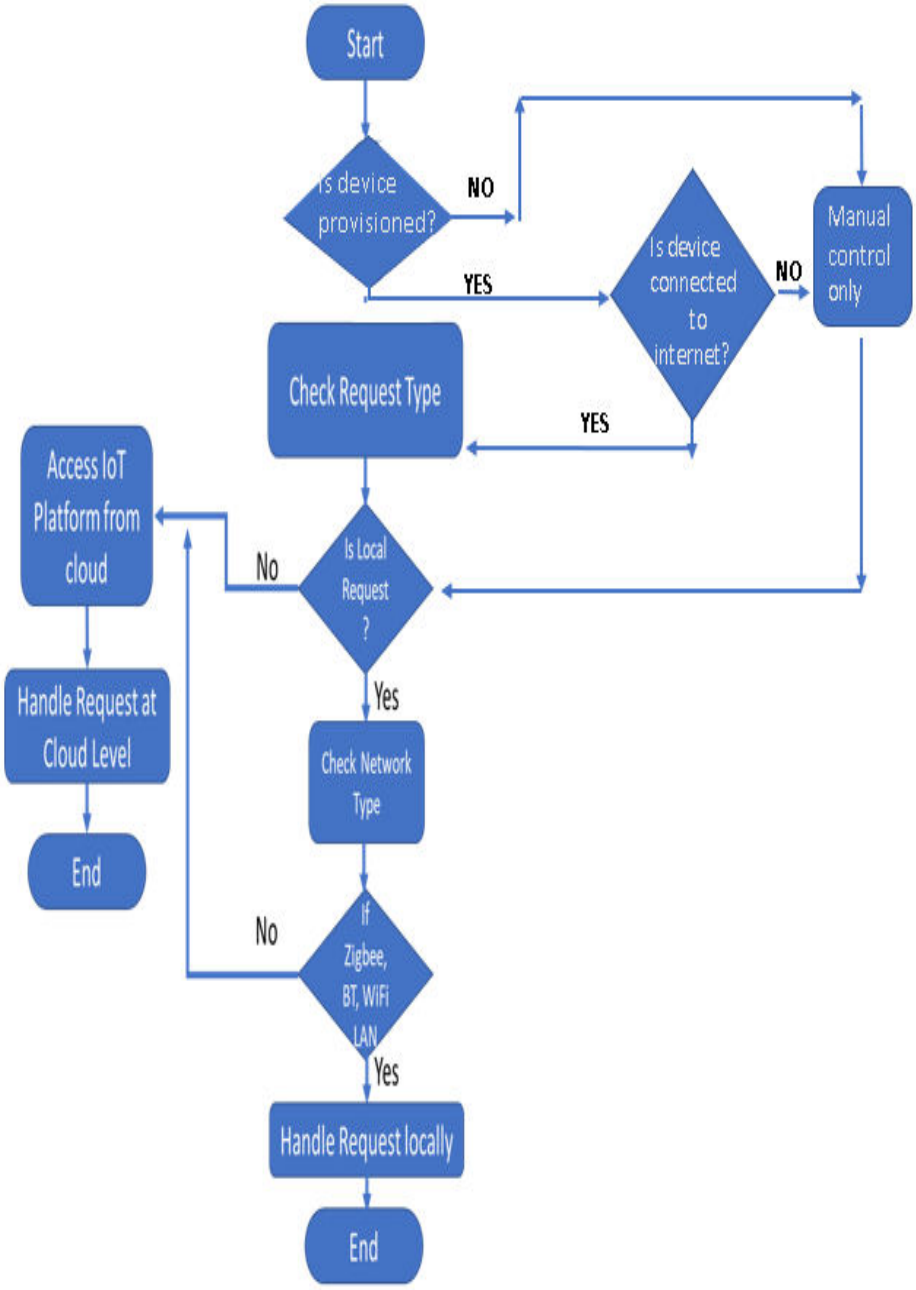

Fig. 4. Flow Chart of working.

E. TESTING APPLIANCES

For testing the proposed system, a led bulb is used. The Test module device depicted in figure 5. The bulb is tested and turned ON and OFF and many attempts are practiced for calculation of delay.

Webology, Volume 18, Number 1, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I1/48

The setup is shown in Fig.5(a) and (b). Fig.5(a) shows a bulb in OFF state and Fig.5(b) shows a bulb in ON state.

Fig.5(a). The bulb turned off

Fig.5(b). The bulb turned on

RESULTS AND OBSERVATION

To test the system designed, a led bulb is used. For simulating everyday usage many iterations were performed. The light state (ON/OFF) was changed 15 times both for ZigBee and 15 times using the Wi-Fi. Table below provides a summary of the average delay for both Zigbee and Wi-Fi.

TABLE 1	
COMMUNICATION DELAY FOR ZIGBEE AND WIFI	
	LED BULB
WIFI Communication delay	**600 ms**
Zigbee Communication delay	**1230 ms**

As Table 1 shows, the comparison of communication delay for Wi-Fi unit and the ZigBee unit and proves that the delay for Wi-Fi is more than that ZigBee. The ZigBee unit experimentally shown a communication delay of 600 ms while operating the led bulb. The communication delay comes up to be (1230 ms) for led bulb.

Other than this, we have considered the packet loss and average packet latency. we took 10 STAs i.e., nodes which are connected to sensors. Figure 6 shows packet loss in transmission.

Webology, Volume 18, Number 1, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I1/48

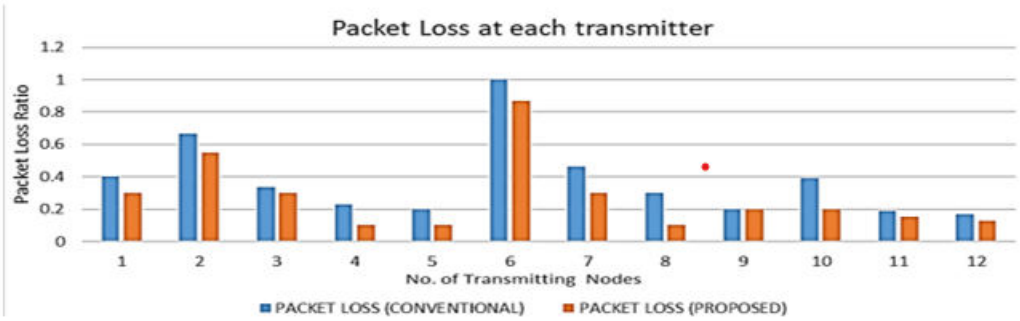

Fig.6. packet loss during transmission over Wi-Fi

STAs are responsible for data transmission and reception to and from the server. Due to pinging in the nodes overall load on the server increases and packet loss also increases. This is one of the problems when using Wi-Fi communication.

CONCLUSION

We have compared the conventional home automation system and presents the new architecture to overcome few of them. The system addresses solution for: The cost and complexities of the systems, old architectures and their problems, the lack of interoperability, security, and safety. To overcome these, we introduce and implemented it using Wi-Fi and ZigBee protocol. ZigBee provides local control and reduces cost of the system. virtual home ensures security and safety of the system. home gateway tackles network interoperability problems. Home gateway supports the communication between the Gateway and the Internet. Furthermore, the home gateway acts as a communication link. The system has been successfully tested through experimental trials. After the proper testing of the module, it is seen that performance and cost of the system is balanced by the improved and fast architecture. Wi-Fi and ZigBee protocols a r e practically tested, and the issue od packet loss is also addressed.

REFERENCES

1. Jeremy Linskell, Guy Dewsbury, in Handbook of Electronic Assistive Technology, 2019
2. A Shinde, S Kanade, N Jugale, A Gurav, RA Vatti and MM Patwardhan, "Smart Home Automation System using IR Bluetooth GSM and Android", 2017 Fourth International Conference on Image Information Processing (ICIIP), pp. 1-6, 21–23 Dec 2017.
3. N. Sriskanthan, F. Tan and A. Karande, "Bluetooth based home automation system", Microprocessors and Microsystems, Vol. 26, no. 6, pp. 281-289, 2002
4. Bhattacharyya, R., Das, A., Majumdar, A., Ghosh, “P Real-time scheduling approach for IoT based home automation system”. In: Data Management, Analytics and Innovation, pp. 103113.Springer, Singapore (2020). VLSI Design and Systems 2020-2022 48
5. Dandge JA, R. Shirwadkar, P Gite, N Odhekar and C Kakad, "Electric Switch On/Off System Using Android App Via Wi-Fi", International Research Journal of Engineering and Technology (IRJET), vol. 03, March 2016.
6. M. Al-Qutayri, H. Barada, S. Al-Mehairi, and J. Nuaimi "Modular RF communication module for automated home and vehicle systems." U.S. Patent No. 6,374,079. 16 Apr. 2002.
7. Gourav Verma, Vidushi Sharma, Monika Kashyap, “Implementation and Analysis of IoT

Webology, Volume 18, Number 1, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I1/48

Based Automation Using MQTT" 2021 IEEE 4th International Conference on Computing, Power and Communication Technologies.

8. W. A. Jabbar et al., "Design and Fabrication of Smart Home with Internet of Things Enabled Automation System," IEEE Access, vol. 7, pp. 144059–144074, 2019, doi: 10.1109/ACCESS.2019.2942846.
9. H. Lin and N. Bergmann, "IoT Privacy and Security Challenges for Smart Home Environments", Information, vol. 7, no. 3, p. 44, 2016.