

Economical Smart Home Automation System Using Arduino

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Abstract— “Smart Home” is an application of IoT based Home Automation System (HAS) which aims to reduce the cost of Home Automation. In this paper the design is proposed to monitor and control the home appliances from anywhere, even from remote locations because the device will be connected to a cloud server which can be accessed via internet. Consumer can customize the power consumption units or time of appliances according to their need and this device will have an auto power cut off feature which will automatically power off the appliance after reaching its threshold consumption units. To achieve this, different methodologies along with the enhanced features of Android and Java programming language are studied to automate home. This model used Wi fi Module ESP 8260 to automate appliances of a single room. Real Time database is created for the updating in states by using firebase.

Keywords— Home Automation, Internet of Things (IOT), Wi-Fi Module, Android SDK, Mobile Application, Real time Database, Firebase, Relays, Economical, Energy Saving.

I. INTRODUCTION

Automation is evolving in every field around us. As person living in the fastest growing age of technology development, we have moved from room sized computers to light and portable laptops, from insecure databases to highly secure web. Same is the case for Homes. There are several technological developments in this field of automation and one of them is Automation of Home or “Smart Homes”. By connecting personal devices and home appliances to a centralized hub and controlling each and every thing through that network is quite fascinating. The reason home automation is so important is that it offers homeowners tangible benefits that go beyond simple convenience. Smart home automation allows you to experience high-tech functionality and convenience that wasn’t possible in the past.

Numerous applications on IoT in different fields are medical as e-health, smart grid, smart cities, smart education system, smart transportation, smart agriculture, smart factories etc. Above all field applications Smart home (SH) has major attraction in academic and industrial due to its direct relation with the real life [1-3]. As per literature no of definitions for smart home is home with all automated control that consist of appliance control, to save time and also provide comfort to elderly and disable person, Intelligence in way of controlling home planting or gardening along with the security and surveillance. As per literature [4] [5] figure 1 depicts the various electronic gadgets with communication interface based on wireless, Bluetooth and Wi-Fi.

Home Automation System (HAS) are available in two broad categories based on controlled methodology as i) Native controlled and ii) Remotely controlled [6]. The former controlled

system depicts that user can control home appliances by using controllers in the form of wireless (Zigbee, GSM, Bluetooth) or stationary communication methods whereas in case of remotely control users can control their home appliances with internet connections through mobile phones. There are numerous flaws are their while setup the controlling procedure, thus requirement is home automation system (HAS) should provide understanding interface for observing and controlling the appliances [6].

Pros of Home Automation Systems (HAS):

Now days, for fast and reliable connection wireless communication systems like Wi-Fi become more promising candidate with ample advantages over wired connections as follows:

- i. Cost effective: as the installation cost is decreased due to non requirement of cables in contrast with wired system where the cable, its material and laying technology along with professionals added cost.
- ii. Easy deployment, installation, and coverage: Remote Devices or appliances can be easily access without wire along with easy deployment, installation of wireless system.
- iii. System Extension and scalability: Transport a native system is particularly invaluable when, due to new or changed prerequisites, augmentation of the system is essential. Rather than wired establishments, in which cabling expansion is expensive and time consuming [7]. This makes remote systems as an original essence.
- iv. Amalgamation of mobile devices: with advancement of the communication technology wireless platform gives the automation an easier and possible solution, where remotely devices or appliances can control or observe without any physical connections.
- v. Aesthetical benefits: in this not only covering large area but beautifully managed the architecture and give the immense benefits to historical buildings and tourist spots.
- vi. Security and Aid for old age: This home automation not only comforts the teenagers but is beneficiary for physically challenged and aged person [8]. For all above reasons the communication or data transfer technology is choice of innovation, renovate and new installations.

The remaining part of this paper is as follows: The following section explored the background of home automation systems and their comparison on various parameters. Section III; explore the various research gaps and motivation behind the proposed design. Section IV defines the proposed System and respective methodology and components that reflect the introduction about the conceptual framework and hardware and software components analysis. In section V discussion about the implementation and testing .Application working results are discussed in Section VI and finally, conclusion is drawn up and the future scope is explored in section VII.

II. EXISTING SYSTEM

Currently if we look at other Home automations in the market there are a lot of techniques they use. Different modes of wireless communication used to transfer of data and signals between their various components such as Bluetooth, Zigbee, Wireless-Fidelity and Global system for Mobile (G.SM).Bluetooth (HC-05) is act as slave device which is used for communication among Arduino (Mega) IDE and smartphone. The operating voltage is 3.6 V to 6V . Bluetooth Board HC-06 has 6 pins such as State, RXD,TXD,GND,VC C and EN. As shown in figure 1 block diagram illustrating the connection mode of home appliances with the smartphone through Bluetooth BT cell with enhanced data rate at 3Mbps modulation at frequency of 2.4 GHz. Internally input/output port of Arduino board (microcontroller) is programmed using C language /python and the connection made to home appliances through Bluetooth BT cell [9].

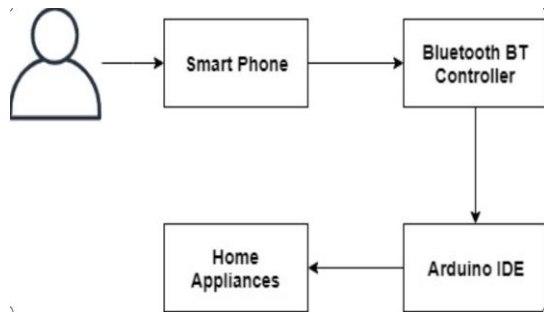


Figure1. Bluetooth Based Automation System

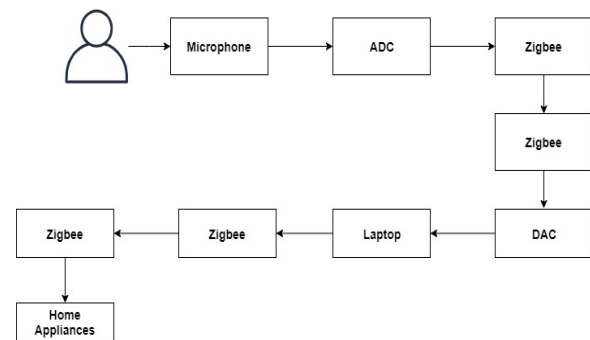


Figure 2. Zigbee Home Automation system

ZigBee is under radio frequency (RF) communication, having an IEEE 802.15.4 standard. The reflection of the ZigBee standard illustrates the packet routing between the network where large number of nodes and transmission of the data is in zigzag pattern. Zigbee supports application in all fields. The main component in ZigBee is its coordinator (ZC) which maintains the network and routing table. This standard has three frequency bands, and prominent band use is at 2.5 GHz at data rate of 250 kbps and 40kbps. This method have numerous advantages as per literature reported as low cost, inter-operability, low signal to noise ratio, low power consumption, implemented by using any microcontroller, innovations are easily to deploy, high data security and low bandwidth required for minor projects [10].

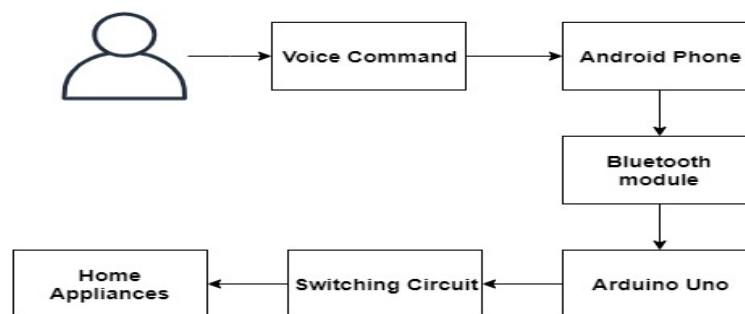


Figure 3: Voice Recognition

As per the literature voice control method is used for home automation as shown in figure 3 with the help of Arduino, various wireless technologies such as GSM, Bluetooth, Wi-fi and NFC. In reported literature [11-13] the experiment is worked on five groups different voice commands on Access, fan, light, utility and the safety were performed at baud rate of 115200bps to make smart home automation system (SHAS) [14]. In addition to smart home automation the advancement of the feature along with voice is motion of the objects or appliances is recognized [15]. The home automation is controlled through voice by using Arduino as controller and the Bluetooth HC-05 module as wireless communicator and HC-SR04 as ultrasonic sensor to detect the motion.

Table 1: Comparison Between different Methodologies

	Communication Interface	Controller	User Interface	No. of Devices	Cost	Speed	Range	Energy Saving
Bluetooth	Bluetooth and AT instructions	Arduinio-uno	android	Unlimited	moderate	low	10 meters	no
GSM	SMS messages	Arduino ADK	Mobile phone	limitesd	low	Very low		no
ZigBee	Zigbee with Instructions	Zigbee Controller (ZC)	Smart phone	unlimited	high	low	10 meters	yes
Wireless Proposed Design	Wi-Fi (NODEMCU)	Arduino SDK	Smart phone	unlimited	low	high	unlimited	yes

II. Research Gaps

Technology is advancing in every field and that's how the concept of Home Automation came. Technology is all about making each and every task easier. There are different technologies that are used to automate your home or offices that are discussed. These implementations have some problem or something that can be developed like:-

- i. **Dependency on range:** Home Automation Systems (HAS) that connect all the devices to the mobile app through Bluetooth works when you are in the range of the central hub. Generally the range for Bluetooth connectivity is 100 meters [16]. You cannot control your home appliances from outside of this range.
- ii. **Expandability:** New Home Assistants like Alexa, Google assistants are trending a lot these days but the appliances they interact with are limited. They can only interact with smart appliances and won't control our standard home appliances like tube light fan or old LCD TV [16] [17]. The other way to control them is hardwiring. That again is an expensive alternative.
- iii. **Economical:** The main motive of technology is to empower each and every individual but sometimes the cost of a new technology is a barrier [18]. Being new in the market, Home automations are quite expensive and cannot be afforded by everyone.
- iv. **Energy Saving:** In this regard the saving of the electricity is automatic switch off the appliances when not in required. Similarly now a day smart grid system [19] helps to save energy with the implementation of smart condenser banks which cover all reactive power generated by the Current Transformers (CT) and Potential Transformers (PT). Monitoring the electricity usage can be helpful in saving the energy and predicting the cost for an individual.

IV. PROPOSED SYSTEM

In proposed system there are total three modules each module has been made for different purpose and each of them functions differently. The mobile application is to provide a user friendly interface that will help to control and monitor the usage of Home Appliances. For this module the enhanced features of Android and Java programming language are used. The second purpose is to connect the application to a database; this can be achieved through Firebase. The third module in system is to connect devices to a central hub which is then sending and receiving data from server. This feature has been done using IOT devices and C programming languages.

Methodology

A. Framework

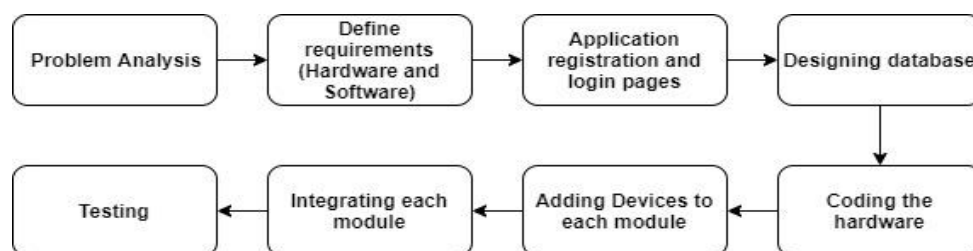


Figure 4: Design Flow of Proposed System

In the above design flow after analyzing the functionality and feasibility of the problem, the requirements of hardware and software for the communication is framed as explored in below section. The software section is consist of design of mobile application with login and registration page having the designed home page and dedicated page for each device. In addition more functionality to the application like monitoring energy usage, controlling devices etc is added. Then the designing of the real time database to store the state of each device in the system is performed. Code is written for hardware components and connected them to the Database created earlier along with the application. After this an authentication

and authorization page is created that enabled login through Google and connected different home appliances to our central hub like fan, bulb, and mobile charger. Finally, the j-unit-testing was done for modules. The manual application testing on different android devices running different platforms from Lollipop to Android 10 is explored [19].

B. Component Requirement Analysis

. The main categorization of the proposed system is in two hardware and software requirements. Thus in this section the analysis of the hardware components and software is explored. The features and demanded configuration of the microcontroller is studied along with the compatible software's.

a. Hardware Requirements

- i. Relay (an electrically operated switch)
- ii. Wi-Fi module (ESP8266 NODEMCU) (integrated TR switch, Low noise amplifier, TCP/IP protocol, Integrated PLL, regulator and power management section, along with 19.5dBm output power in 802.11b mode.
- iii. Jumper Wires
- iv. General purpose PCB
- v. Temperature and Humidity Sensor (DHT11) (digital type ,capacitive humidity sensor, it uses thermistor for measuring outside air and send digital signal on data pins)



Figure 5: Wi-Fi module (ESP8266 NODEMCU)

b. Software Requirements

- i. Android Studio 3.0.1
- ii. Python 2.7
- iii. Arduino IDE 1.8.9

V. IMPLEMENTATION

In the following section the flow graph depicting the user can control and observed the functionalities of the developed application that incorporates the devices (visualization, addition, deleting and controlling) along with the reading about the energy consumption feature which is newly added in the smart home automation system (SHAS).Moreover the maintenance or support feature is controlled by administrator in addition with customers.

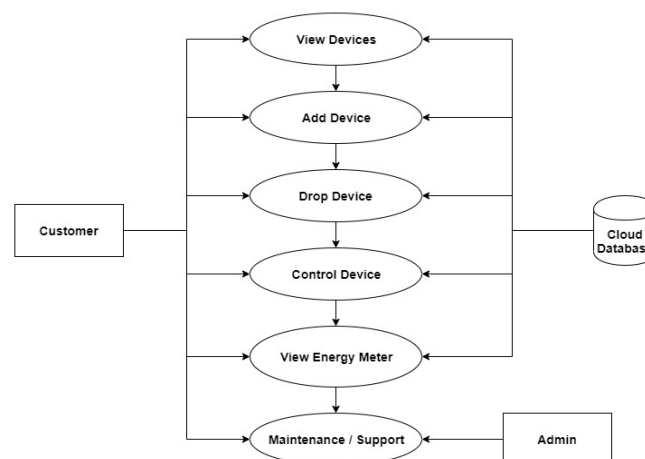


Figure 6: Functionalities in HAS Application

All related information is shared in cloud database that runs on cloud computing platform, where the data can be access as-a-service provider. In database services scalability and high availability of the database is ensured by database service provider. As per the design the firebase platform provided by Google where various services offers like storage, real time database, online processing, authorization of the user along with the their updated usage information.

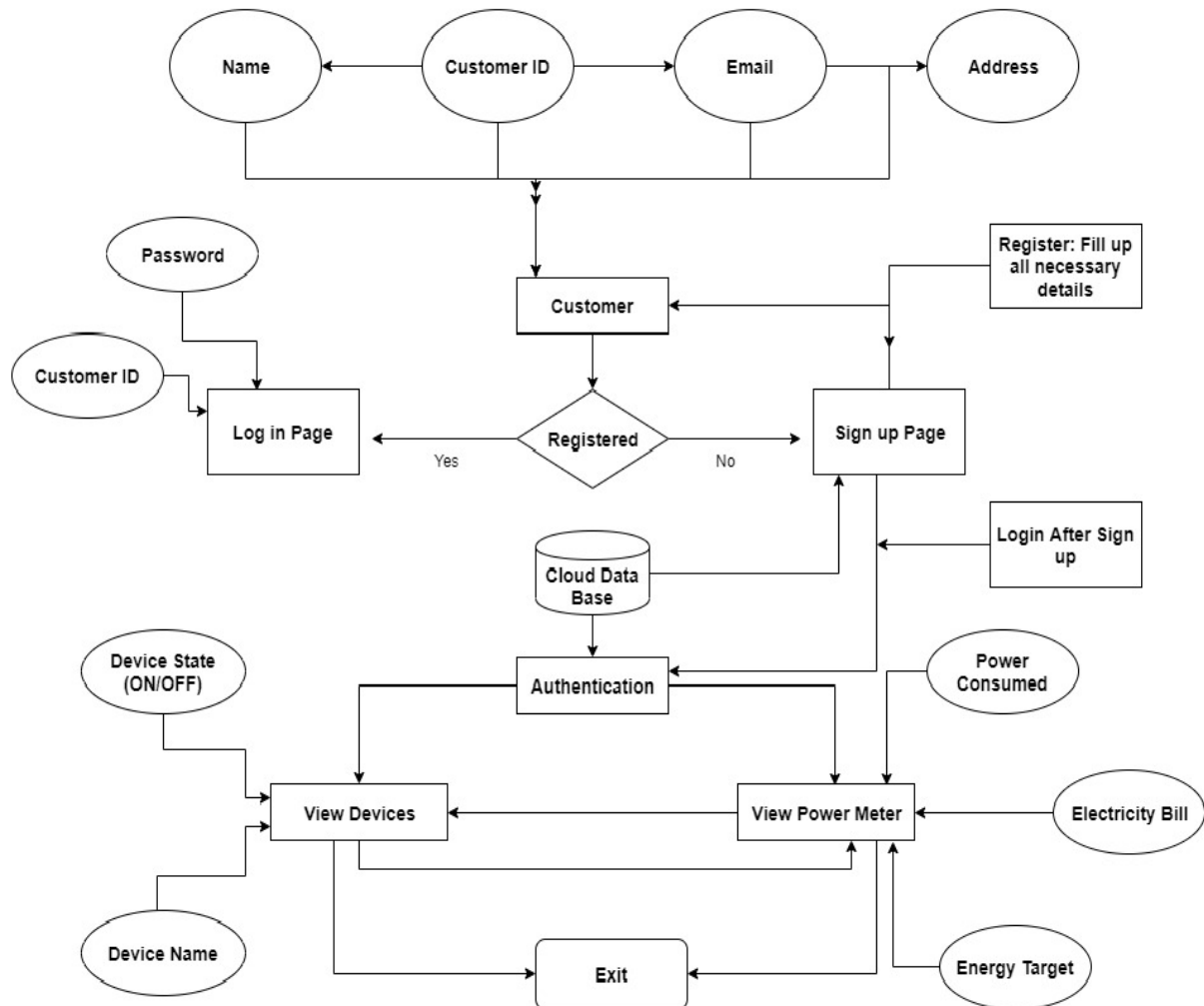


Figure 7: Implementation of Proposed Architecture of Application

FUNCTIONAL REQUIREMENTS

Functional Requirements 1: Measurement of parameters Estimating of the considerable number of parameters, for example, current stream, vitality utilization, time interim for which gadget is being utilized in room is important to spare and control the gadgets by utilizing the different sensors and versatile application.

Functional Requirements 2: Fetching of Data Sensors measure the parameters and those parameters fetch for further process like data analysis. Measuring and Fetching data are the basic functional requirements of this system.

Functional Requirements 3: Manipulation of Data after fetching data, manipulation is done with provided database and the current data. They are analysed to generate the ideal solution.

Functional Requirements 4: Device Selection Device selection process looks for the time interval and give the notification which is used to turn off the device.

Functional Requirements 5: Notification on Mobile phone While detecting if there is any device being used for more than its usual time, it notified the user that there is going something wrong.

Functional Requirements 6: Registration/login Users can login into the system, they can get usage time, notification into mobile phone, can give feedback for any sort of improvement, can complain about error. Admin can manage all the database and the system and manage the complaining from farmer and can give best suggestions to them.

VI. Results and Discussion

In the following section the results based on the implementation of the application as proposed and various images shown in this section as login page , registration ,home and control page.Login page is shown in Figure 8 provides the option for the user to login with their credentials into the app. For a first-time installation the user must register for the app on the registration page shown in Figure 9. In this page a user can set up his profile and by entering E-mail id and password for the further usage of the app.

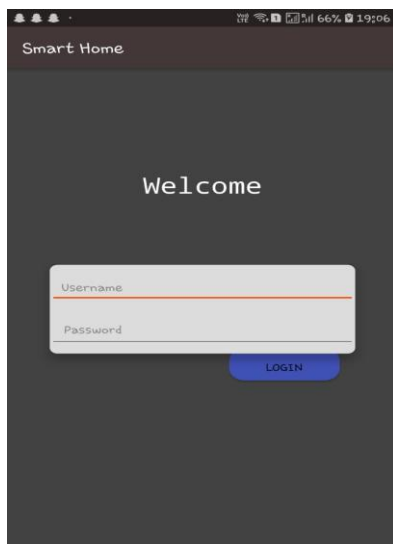


Figure 8: Login Page

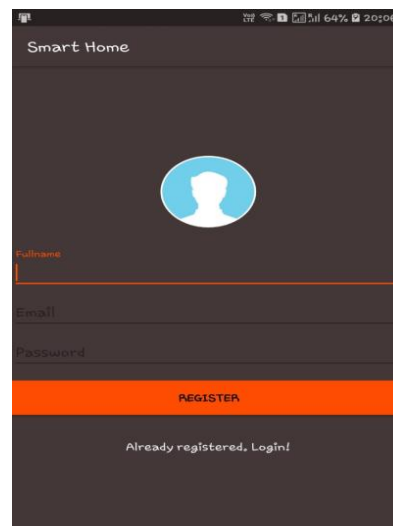


Figure 9: Registration Page

Also, they'll have to confirm their mail id by clicking on the link sent to their email id. The purpose of email-id is that if in any case a user forgets the password then it can be retrieved using the email-id. Appliances can be switch on/off using the Home page. After logging in to the application there will be a list of devices available. Devices can be renamed according to the appliances connected to them Power consumption of each appliance is shown on the home page shown in Figure 10.

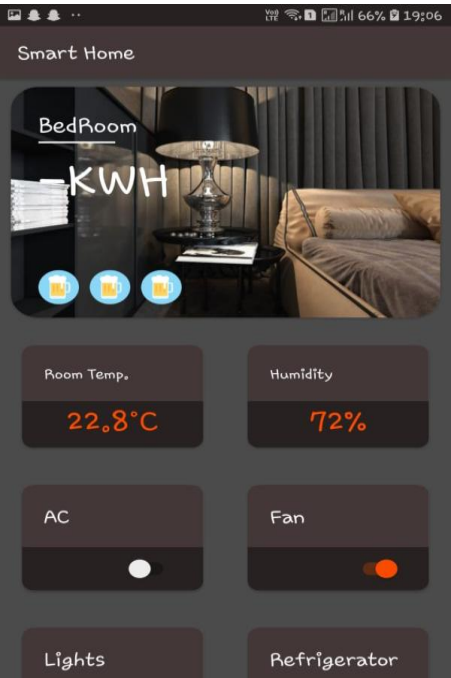


Figure 10: Home Page

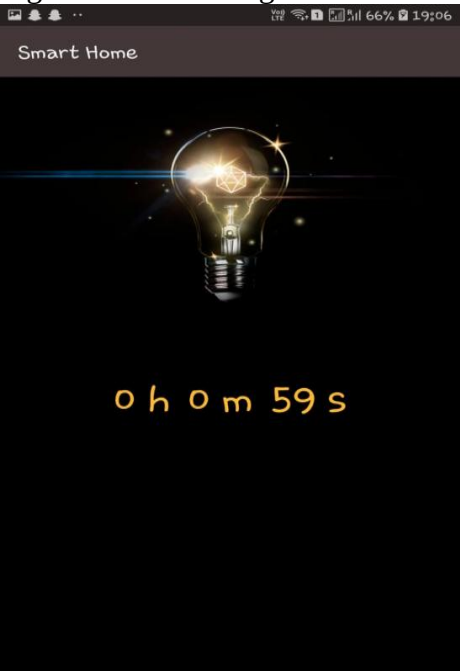


Figure 11: Control Page

VII.CONCLUSION

In the nutshell the implemented app is working successfully with hardware as Arduino controller. The advance feature is energy consumption reading is shown in app, thus the user can control the saving as per requirement along with the addition and deletion of the devices. This paper also supports the real time database, online processing and authentication and authorization of the user by means of implemented application names as "Smart Home". Further in future scope the concept of smart grid along with raspberry pi is used for further independent system controller. In addition for smart home automation, interfacing with the sensors like motion sensor, light sensor to control the intensity of light and save the energy .Temperature sensor to automatic control of heat or time management to make device or appliance on. Moreover the security is also a major concern in Smart home which leads the requirement of Home Automation Systems (HAS).

REFERENCES

- [1] W. A. Jabbar, M. Ismail, and R. Nordin, "Evaluation of energy consumption in multipath OLSR routing in Smart City applications," in *2013 IEEE 11th Malaysia International Conference on Communications (MICC)*, 2013, pp. 401-406.
- [2] K.-M. Lee, W.-G. Teng, and T.-W. Hou, "Point-n-Press: An intelligent universal remote control system for home appliances," *IEEE Transactions on automation science and engineering*, vol. 13, pp. 1308-1317, 2016.
- [3] P. P. Gaikwad, J. P. Gabhane, and S. S. Golait, "A survey based on Smart Homes system using Internet-of-Things," in *2015 International Conference on Computation of Power, Energy, Information and Communication (ICCPEIC)*, 2015, pp. 0330-0335.
- [4] W. A. Jabbar, M. Ismail, and R. Nordin, "MBA-OLSR: a multipath battery aware routing protocol for MANETs," in *2014 5th International Conference on Intelligent Systems, Modelling and Simulation*, 2014, pp. 630-635.
- [5] T. Song, R. Li, B. Mei, J. Yu, X. Xing, and X. Cheng, "A privacy preserving communication protocol for IoT applications in smart homes," *IEEE Internet of Things Journal*, vol. 4, pp. 1844-1852, 2017.
- [6] R. Piyare and M. Tazil, "Bluetooth based home automation system using cell phone," in *2011 IEEE 15th International Symposium on Consumer Electronics (ISCE)*, 2011, pp. 192-195.
- [7] W. A. Jabbar, M. Ismail, R. Nordin, and S. Arif, "Power-efficient routing schemes for MANETs: a survey and open issues," *Wireless Networks*, vol. 23, pp. 1917-1952, 2017.
- [8] M. N. Jivani, "GSM based home automation system using app-inventor for android mobile phone," *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, vol. 3, 2014.
- [9] E. M. Wong, "A phone-based remote controller for home and office automation," *IEEE Transactions on Consumer Electronics*, vol. 40, pp. 28-34, 1994.
- [10] K. Gill, S.-H. Yang, F. Yao, and X. Lu, "A zigbee-based home automation system," *IEEE Transactions on consumer Electronics*, vol. 55, pp. 422-430, 2009.
- [11] M. R. Kamarudin, M. Yusof, and H. T. Jaya, "Low cost smart home automation via microsoft speech recognition," *International Journal of Engineering & Computer Science*, vol. 13, pp. 6-11, 2013.
- [12] B. Yuksekkaya, A. A. Kayalar, M. B. Tosun, M. K. Ozcan, and A. Z. Alkar, "A GSM, internet and speech controlled wireless interactive home automation system," *IEEE Transactions on Consumer Electronics*, vol. 52, pp. 837-843, 2006.
- [13] S. Kumar and S. R. Lee, "Android based smart home system with control via Bluetooth and internet connectivity," in *The 18th IEEE International Symposium on Consumer Electronics (ISCE 2014)*, 2014, pp. 1-2.
- [14] Y. Mittal, P. Toshniwal, S. Sharma, D. Singhal, R. Gupta, and V. K. Mittal, "A voice-controlled multi-functional Smart Home Automation System," in *2015 Annual IEEE India Conference (INDICON)*, 2015, pp. 1-6.

- [15] M. E. Abidi, A. L. Asnawi, N. F. Azmin, A. Jusoh, S. N. Ibrahim, H. A. M. Ramli, *et al.*, "Development of Voice Control and Home Security for Smart Home Automation," in *2018 7th International Conference on Computer and Communication Engineering (ICCCE)*, 2018, pp. 1-6.
- [16] A. Z. Alkar and U. Buhur, "An Internet based wireless home automation system for multifunctional devices," *IEEE Transactions on Consumer Electronics*, vol. 51, pp. 1169-1174, 2005.
- [17] N. Dickey, D. Banks, and S. Sukittanon, "Home automation using Cloud Network and mobile devices," in *2012 Proceedings of IEEE Southeastcon*, 2012, pp. 1-4.
- [18] Y. Cui, M. Kim, Y. Gu, J.-j. Jung, and H. Lee, "Home appliance management system for monitoring digitized devices using cloud computing technology in ubiquitous sensor network environment," *International Journal of Distributed Sensor Networks*, vol. 10, p. 174097, 2014.
- [19] Q. Yang, "Internet of things application in smart grid: A brief overview of challenges, opportunities, and future trends," in *Smart Power Distribution Systems*, ed: Elsevier, 2019, pp. 267-283.