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Multi-Purpose Smart Energy Efficient Home Automation by Using GSM and nRF24L01 Network

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***Abstract*- For the past few years, a lot of work had done to make our homes and buildings more comfortable, smart, and energy-efficient. Therefore, several home automation systems have been designed and implemented until now. In this submission, a cost-effective, energy-efficient, smart, and module base system has been presented by using Arduino boards, nRF24L01 module, GSM module, Ultrasonic sensor, Temperature sensor, Smoke and Flame sensor. In this proposed method, a bi-directional counter is designed which is composed of two ultrasonic sensors alongside a temperature sensor for the automation purpose which gives more accurate results. Unlike conventional automation systems, this system has also covered the protection aspect of the houses. The recommended system is based on the nRF24L01 wireless network which will be easy to implement in any environment. This paper also presents the future scope as well as tested and implemented on hardware which gave satisfactorily and expected results.**

***Index Terms—Bi-directional Counter,* Home Automation, Home Appliance, nRF24L01, Wireless System**

I. INTRODUCTION

Home automation systems are specially designed to save time and human efforts [1]. Over the years, intensive work has been done in this field to make our lives more comfortable and luxurious. The main purpose of making homes automated is to reduce labor work and to be more informed about our things while we are not at our places. Home automation does not just focus on the automation of appliances but also includes security as well as protection of our places [2] [3]. To be more precise, the home automation system supremely deals with four important factors that include automation of appliance, Accessing and controlling the system as well as its information, security systems with alerts, and protection from any inner malfunctioning. For this purpose, many wireless systems have been designed to make sure that users have more access to their information and system. This has been made possible by technologies like Global System for Mobile (GSM) [4], Wireless fidelity (Wi-Fi) [5], Zigbee [6], General Packet Radio Service (GPRS) [7], Infrared (IR) [8] and Bluetooth [9].

Saving time and reduction of labor efforts are not the sole purpose of home automation systems. As this world is growing day by day, the consumption of electricity is also increasing due to which the generation demands are intensified. Now, more power plants are required to meet these intensive demands which result in more environmental pollution. The incentive of this paper is to reduce the consumption of electricity by minimizing its misuse while designing a low-cost smart home automation system.

The proposed paper hand over the design and implementation of a low-cost, smart, efficient, and convenient home automation system. Unlike the conventional method of automation in which PIR sensors or a single ultrasonic sensor are used to automate appliances. In this proposed paper, a bi-directional counter is designed by the combination of two ultrasonic sensors along with a temperature and LDR. These sensors are attached with an Arduino Uno along with a Flame and Gas (MQ2) sensor. These Arduino Uno are connected with Arduino Mega by Nrf24L01 while Arduino Mega is connected with GSM and LCD module which will be the main controller. The proposed system is low-cost and more convenient than a conventional home automation System. The total implementation cost for this proposed system is to be less than PKR 10000 or USD 60 in which the cost of an android is not added. Now if we compare the proposed technology with the conventional systems the proposed method is a cost-effective system.

II. LITERATURE EXPLORATION

Over the years, many home automation systems have been designed and implemented. As in this paper [10], a network of PIR sensors is laid in a single room which is named as an individual cell and these cells are connected to a home server. The mesh of PIR sensors is used to track the location of a person moving in that room which then automates the appliances of that room. This system offers satisfactory accuracy but a mesh of sensors makes this system more complicated. Furthermore, the mesh depends upon the parameters of a room which makes it more difficult and costly. In another study [11], a combination of

PIR and PIEZO sensors is used for the automation of appliance ESP8266. The study proposed a low-cost system for automation but this combination of sensors works for a single person while enable to differentiate between multi-person directional movements. In this study [12], a Bluetooth-based home automation system has been designed to automate the appliances as well as it also presents a water level detector with an ultrasonic sensor and a soil moisture indicator for automatic plant irrigation.

Similarly, another system was proposed which uses Raspberry Pi and GSM to automate the home appliances. Though the presented system was described as a low-cost system still the price of Raspberry Pi is much higher as compared to Arduino controllers [13] [14]. In another research [15], a GSM-based home automation system was presented in which relays are used to control the appliances by GSM module integrated with PIC microcontroller. This designed system is cost-effective but it does not cover all the aspects of automation.

A smart gas cylinder was also studied [16] where Arduino Uno along with a gas sensor has been used to monitor the gas cylinder and checks if there is any leakage. An LCD is also connected for an alert indication.

III. DESIGNED SYSTEM

The system has been divided into two main parts software and hardware. Arduino IDE and Proteus are two main software's that are used while devolving this system. The main hardware parts are Arduino Mega, Arduino UNO, MQ-2 Gas sensor, Flame Sensor, LM35 Temperature Sensor, GSM Module, Ultra-Sonic Sensors, and nRF24L01. The system is designed in such a way that it can be easily installed at a low cost. The proposed system is energy efficient while making the designing a simple, reliable, and compact system.

IV. SYSTEM WORKING MECHANISM AND ARCHITECTURE

The proposed system hardware is divided into two parts. In the first part, an Arduino board is connected with the combination of two Ultra-Sonic Sensors which formed a bi-directional counter, MQ-2 Gas sensor, LM35 Temperature Sensor, Flame Sensor, Relay board, LDR, and nRF24L01.Each room will be configured with this formation which will form a single Unit. The bi-directional counter is used for detecting a person's movement. Unlike conventional methods, it is used to detect multi-persons directional movements. The counter will be placed at the entrance of each room. In Fig. 1 block diagram of the first portion is presented which is named as a Unit.

In the second portion, another Arduino board is connected with the GSM module, LCD module, and nRF24L01. The LCD will display the alerts and current temperature. Through GSM the whole system can be monitored, controlled as well as get the alerts in case of any emergency. Each Unit will be connected through nRF24L01 to the main Arduino. A single nRF24L01 can connect to six other units but this limit is breakable by creating an interconnected mesh of nRF24L01.In Fig. 2 block diagram of the second portion is presented.

This System also considered the protection aspect of a home therefore each unit is equipped with a gas and a flame sensor which will give a more precise location of any emergency and can be dealt with more caution. This proposed system is capable of describing a particular location that will be affected by any kind of gas leakage.

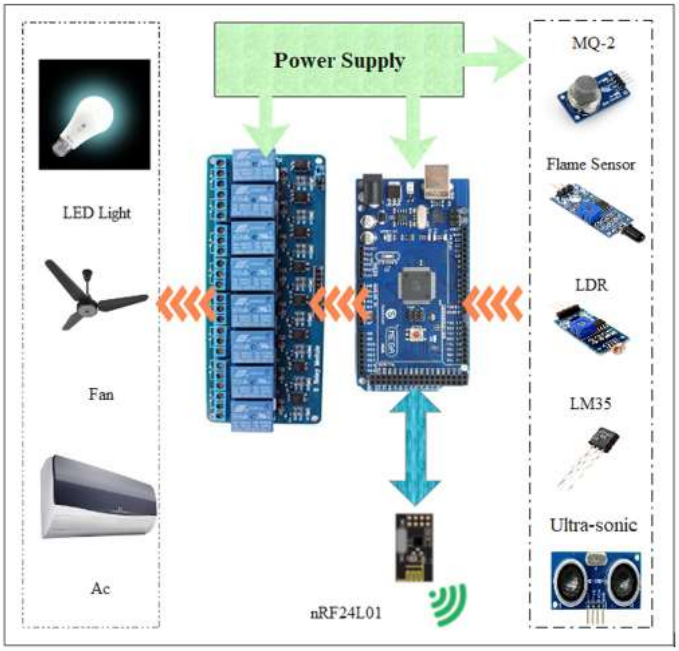

FIGURE 1. Block Diagram of first portion named as Unit.

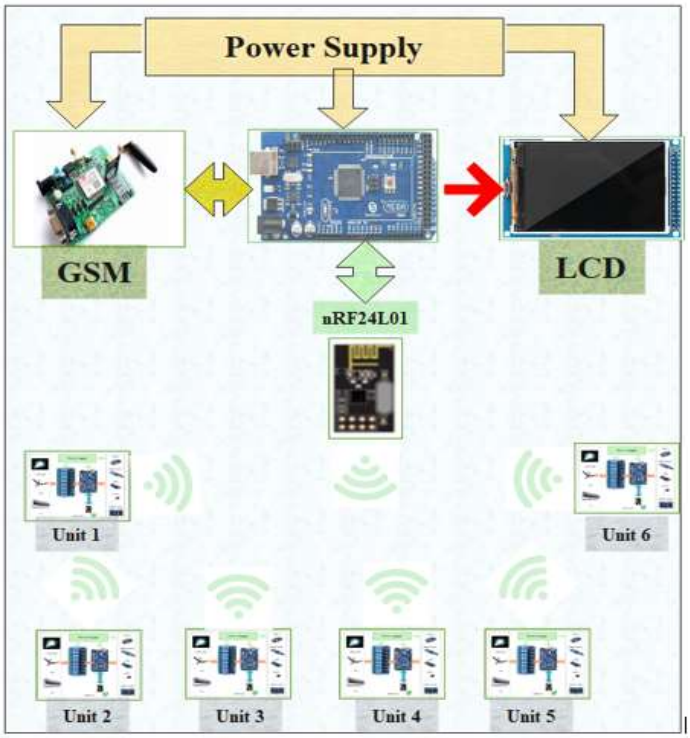

FIGURE 2. Block Diagram of the second portion.

A. ARDUINO UNO

Arduino UNO is mostly used as a board as compared to other boards. It is preferred by most of the users because its cost is reasonable as well as it is well-balanced with a sufficient number of digital and analog pins. But it has its limitation as it offers only 14 digital and 6 analog pins which in some applications does not fulfill the requirements. It is an open-source board that has an ATmega328P Processor and all the supportive hardware. It has 2KB SRAM, 32 KB flash memory, and 1 KB EEPROM.

B. ULTRASONIC SENSOR

The ultrasonic sensor consists of two main parts. One is a transmitter that will send the sound wave and the other one is a receiver that will receive the sound wave after it bounces back from any object. In this suggested system, a combination of two ultrasonic sensors is used to form a Bi-directional counter which will sense and automate the appliances within any Unit. This Bi-directional counter is the initiator part of any Unit. In Fig.3 Flow chart of the Unit is presented which shows its automation part.

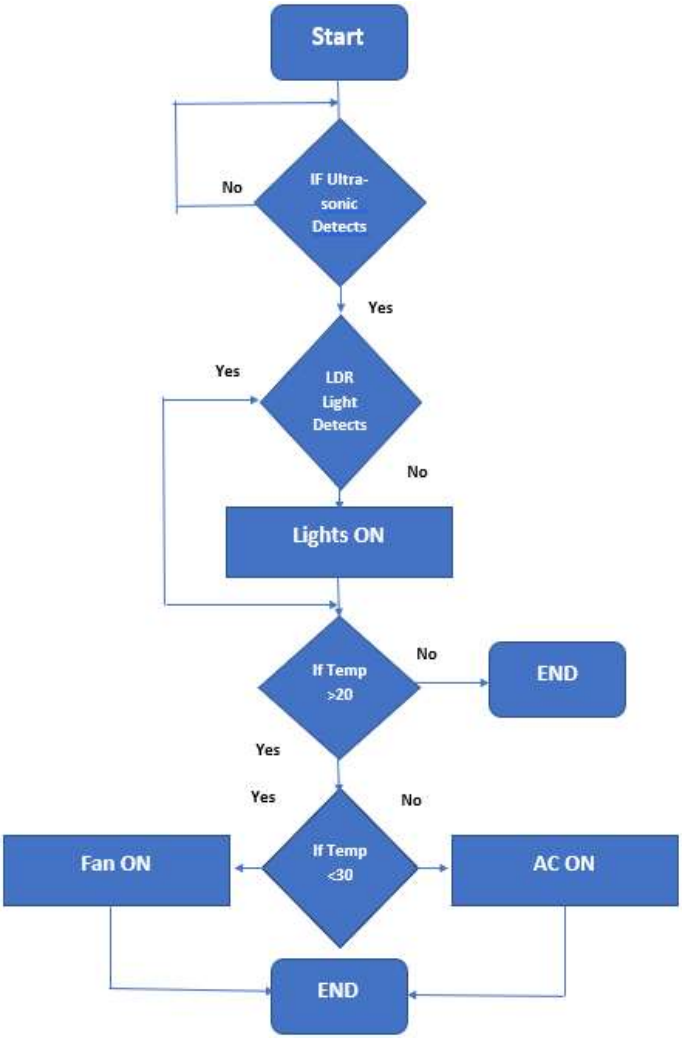

FIGURE 3. Flow Chart of a Unit.

C. NRF24L01

nRF24L01 was manufactured by Nordic Semiconductor ASA. It is a transceiver that works in a 2.4-2.5 GHz bandwidth worldwide. Its operating voltage is in the 1.9V-3.6V range. NRF24L01 has various applications as it provides reliable wireless communication. It provides 1 Mbps to 2Mbps data rate in the air while it uses a digital interface (SPI) which can speed up from 0 to 8 Mbps. In the proposed system, one Unit is connected with the main controller but nRF24L01 can communicate actively with six other nRF24L01. In this presented method, nRF24L01 is interfaced with Arduino. So, in a designed system six Units can be connected with the main controller through nRF24L01 because a single nRF24L01 can connect to six nodes actively as shown in Fig.4. Interfacing nRF24L01 with Arduino makes it easy to use the Tree Topology of nRF24L01 by using Arduino Network Library. The proposed system is not limited to only six Units. As the datasheet suggests [17-21], if required by using Tree Topology, one nRF24L01 will set as a base and can have five nodes as shown in Fig. 5. Each node can have five nodes again with a different address and can go to five-level deep giving a total of 3125 nodes.

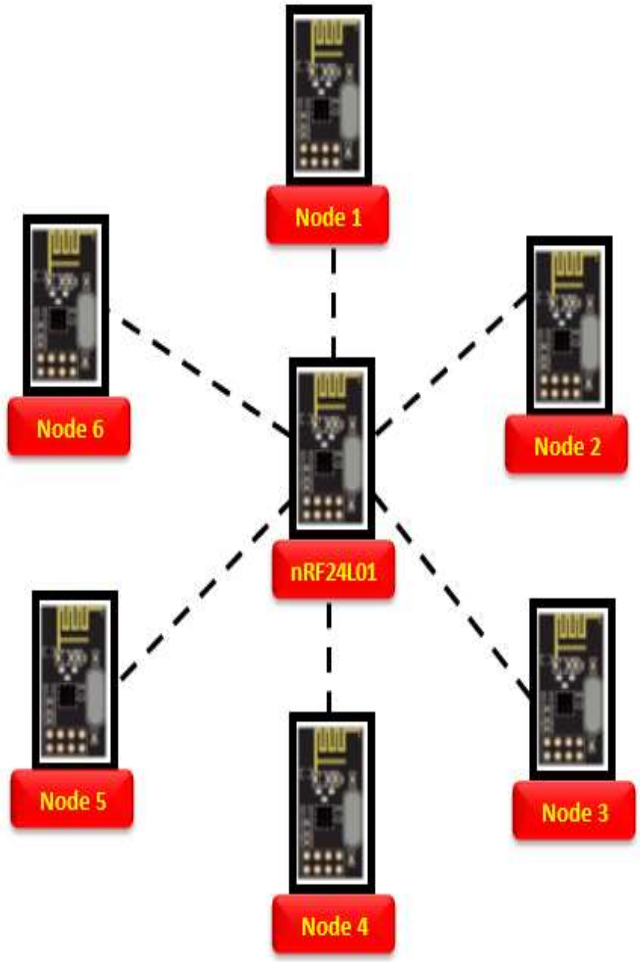

FIGURE 4. A single nRF24L01 connected to six nodes.

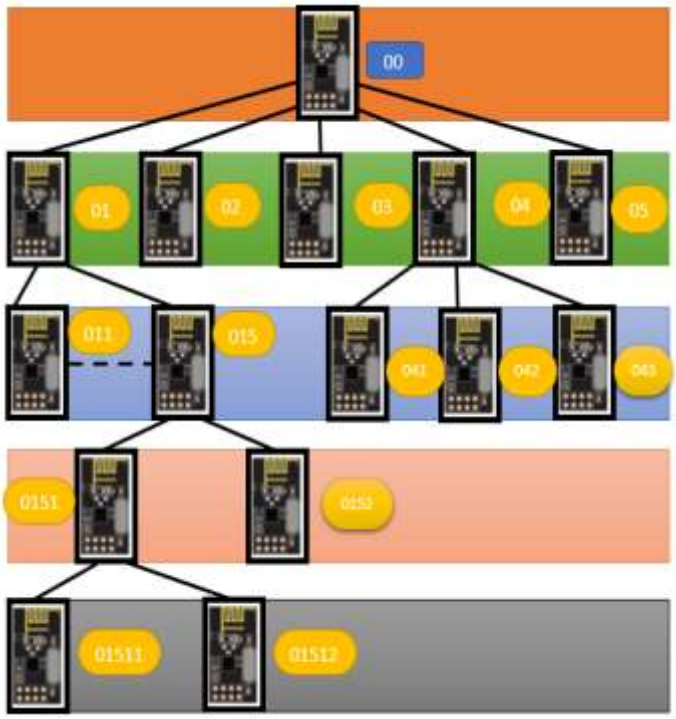

FIGURE 5. Tree Topology forming nodes.

D. GSM MODULE

In this hardware implementation, the SIM 800c GSM module is used as shown in Fig.6. This shield is specially designed to be compatible with Arduino boards. GSM module is used to get alerts if there is any gas leakage or fire takes place. This proposed system is integrated with the main Arduino controller so that it can send information of all units via the main controller to cell phones. Similarly, it will be able to automate all Unite if required.

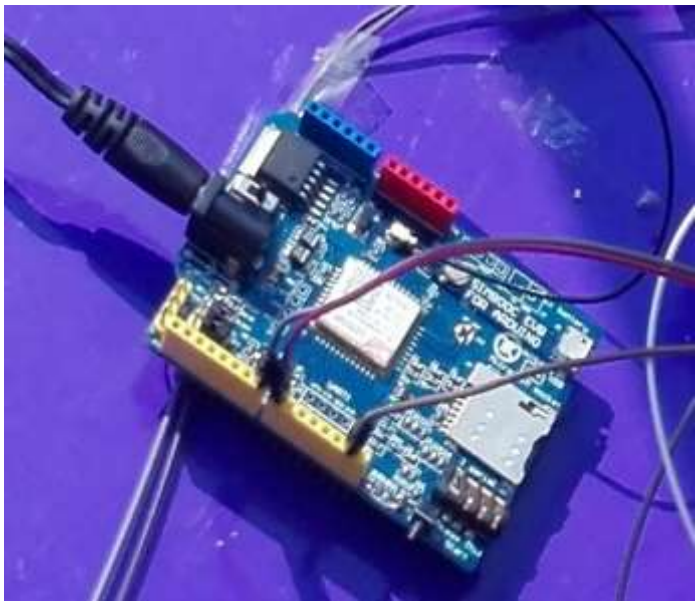

FIGURE 6. SIM 800c GSM Module.

E. GAS SENSOR

In this presented system an MQ-2 Gas sensor is used. It is a multi-purpose sensor that can detect Methane, LPG, CO, Alcohol, Hydrogen, and Propane. The current consumption of the MQ-2 sensor is so it cannot be driven through Arduino supply pins therefore an additional source is required to drive that sensor. The output of this sensor is both analog and digital depending upon the application either one can be used. In this proposed system digital output is used.

V. SOFTWARE DESIGNED CIRCUIT

There is two main software that is being used in this system. Proteus is used for circuit designing while Arduino IDE is being used for Programming controllers. Fig. 7 shows the designed circuit in Proteus. A relay board consists of transistors, resistors, led, switch, a four-light bulb which represents the appliance in a Unit is designed. These appliances are controlled by Arduino with the help of this relay board.

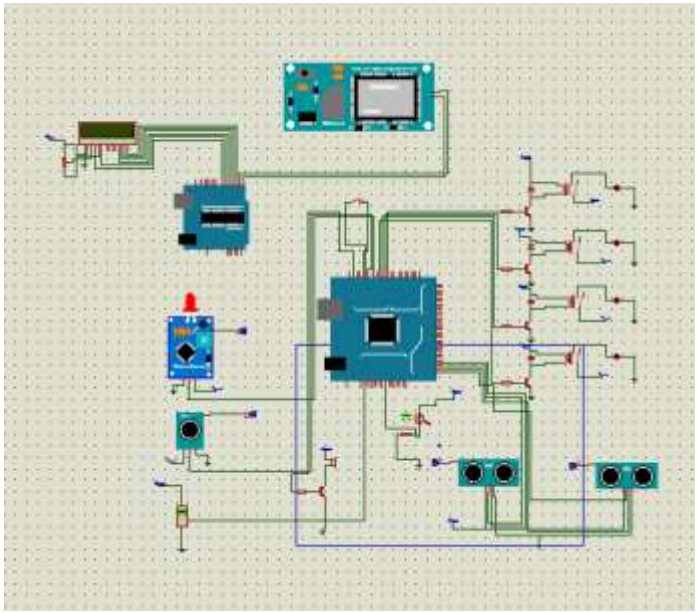

FIGURE 7. Circuit Designing in Proteus.

VI. SYSTEM RESULTS

The hardware is completely tested and showing a satisfactory result. Here is the bi-directional counter is shown in Fig.8. This combination of ultrasonic sensors is adjusted in such a way that if the right-sided sensor detects the motion first then the left-sided, it means a person is entering into the room. Now if the left-sided sensor detects the motion first then the right-sided, it means a person is leaving a room. Using this principle, room appliances will be automated until there is no person in the room.

Similarly, Fig.9 shows the working of complete hardware implementation. As soon as a bi-directional counter detects a person enters the room, lights will be automated according to LDR light detection, and the fan or Ac will be automated according to the temperature sensor. The SMS will be sent to the

cell phone showing the status of the appliance and alerts due to the detection of smoke.

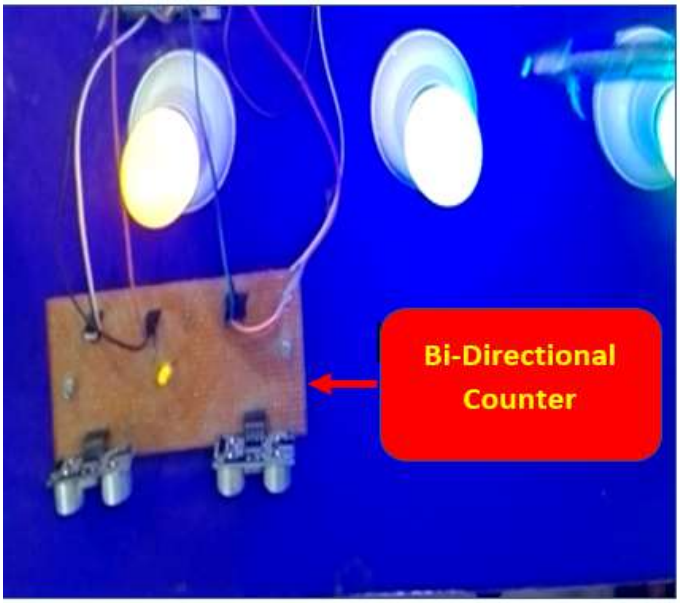

FIGURE 8. Working of Bi-directional Counter.

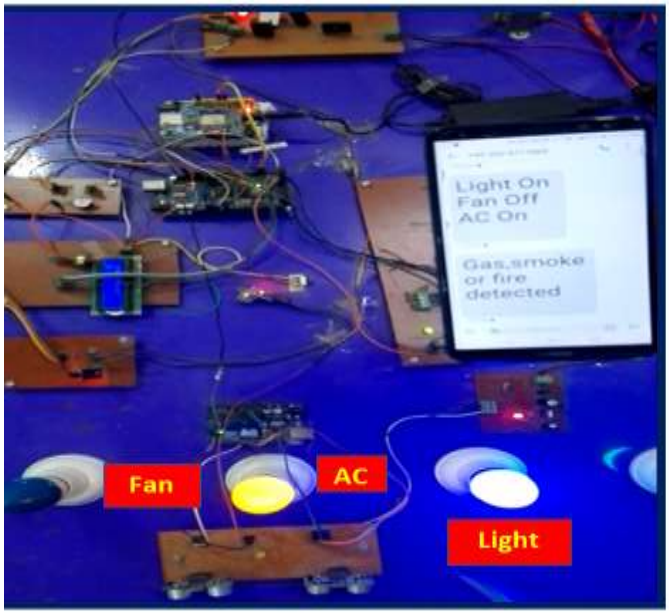

FIGURE 9. Complete hardware implementation.

VII. CONCLUSION AND FUTURE WORK

In this rapidly evolving world, a lot of home automation system has been developed. As this field is not very much developed yet, therefore many human detection methods used in those systems were either complicated or expensive or are too simple to cover all the aspects.

This proposed system of home automation is balanced. It is cost-effective, easy to install, and covers the protection aspects of the homes as well. nRF24L01 network gives a low-cost and reliable wireless communication system as compared to some other technologies. On the other hand, an Ultrasonic sensor-based Bi-directional counter solves the problem of multi-person detection in home automation systems.

Since this proposed system is the basic version that considers all aspects of home automation in a balanced way but some additional tools make it an even more versatile system. First, if we connect this system with the Internet of things, the system will be more efficient and versatile. Secondly, the security of data transfer between the nRF24L01 networks would make the system even more reliable.

REFERENCES

[1] MF Shahriar Khan, Toufiq Ahmed, Israq Aziz, Fahad Bin Alam, MD Salah Uddin Bhuiya, MJ Alam, Rocky Chakma, and SS Mahtab. Plc based energy-efficient home automation system with smart task scheduling. IEEE Sustainable Power and Energy Conference (iSPEC), pages 35–38. IEEE, 2019.

[2] Ashwini Pawar and VM Umale. Internet of things-based home security using raspberry pi. Fourth International Conference on Computing Communication Control and Automation (ICCUBEA), pages 1–6. IEEE, 2018.

[3] D Pavithra and Ranjith Balakrishnan. Iot based monitoring and control system for home automation. Global conference on communication technologies (GCCT), pages 169–173. IEEE, 2015.

[4] GM Sultan Mahmud Rana, Abdullah Al Mamun Khan, Mohammad Nazmul Hoque, and Abu Farzan Mitul. Design and implementation of a gsm based remote home security and appliance control system. 2nd International Conference on Advances in Electrical Engineering (ICAEE), pages 291–295. IEEE, 2013.

[5] Ravi Kishore Kodali and SreeRamya Soratkal. Mqtt based home automation system using esp8266. IEEE Region 10 Humanitarian Technology Conference (R10-HTC), pages 1–5. IEEE, 2016.

[6] Jieming Zhu, Xuecai Gao, Yucang Yang, Hang Li, Zhati Ai, and Xiaoyan Cui. Developing a voice control system for zigbee-based home automation networks. 2nd IEEE InternationalConference on Network Infrastructure and Digital Content, pages 737–741. IEEE, 2010.

[7] S Brilly Sangeetha et al. Intelligent interface based speech recognition for home automation using android application. International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS), pages 1–11. IEEE, 2015.

[8] Ayad Ghany Ismaeel and Mohammed Qasim Kamal. Worldwide automobi: Arduino iot home automation system for ir devices. International Conference on Current Research in Computer Science and Information Technology (ICCIT), pages 52–57. IEEE, 2017.

[9] Sukhen Das, Sanjoy Ganguly, Souvik Ghosh, Rishiraj Sarker, and Debaparna Sengupta. A bluetooth based sophisticated home automation system using smartphone. International Conference on Intelligent Control Power and Instrumentation (ICICPI), pages 236–240. IEEE, 2016.

[10] Kyoung Nam Ha, Kyung Chang Lee, and Suk Lee. Development of pir sensor based indoor location detection system for smart home. In 2006 SICE-ICASE International Joint Conference, pages 2162–2167. IEEE, 2006.

[11] Santosh Anand, MU Pranavya, GS Vaibhavi, R Apoorva, and Shraddha R Shenoy. Efficient model for automated home management system. International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE), pages 1–4. IEEE, 2020.

[12] Muhammad Asadullah and Khalil Ullah. Smart home automation system using bluetooth technology. International Conference on Innovations in Electrical Engineering and Computational Technologies (ICIEECT), pages 1–6. IEEE, 2017.

[13] Shrikrushna Khedkar and GM Malwatkar. Using raspberry pi and gsm survey on home automation. International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT), pages 758–761. IEEE, 2016.

[14] Ahmed Imteaj, Tanveer Rahman, Hosna Ara Begum, and Mohammed Shamsul Alam. Iot based energy and gas economic home automation system using raspberry pi 3. 4th International Conference on Advances in Electrical Engineering (ICAEE), pages 647– 652. IEEE, 2017.

[15] Rozita Teymourzadeh, Salah Addin Ahmed, Kok Wai Chan, and Mok Vee Hoong. Smart gsm based home automation system. IEEE Conference on Systems, Process & Control (ICSPC), pages 306– 309. IEEE, 2013.

[16] Gautami G Shingan, SV Sambhare, VS Bhokare, AL Nikam, and HD Shinde. Smart gas cylinder: Leakage alert and automatic booking. International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS), pages 1127–1130. IEEE, 2017.

[17] Nordic Semiconductor. 5V, 900nA Single chip 2.4 GHz Transceiver,2006. https://www.sparkfun.com/datasheets/Components/nRF24L01 prelim prod spec 1 2.pdf.

[18] Kashif, Hasnain, Muhammad Nasir Khan, and Ali Altalbe. "Hybrid optical-radio transmission system link quality: link budget analysis." *IEEE Access* 8 (2020): 65983-65992.

[19] Khan MN, Naseer F., "IoT based university garbage monitoring system for healthy environment for students," In2020 IEEE 14th International Conference on Semantic Computing (ICSC) 2020 Feb 3, pp. 354-358.

[20] Khan MN, Hasnain SK, Jamil M., "Digital Signal Processing: A Breadth-first Approach," Stylus Publishing, LLC; 2016 May 15.

[21] Tariq F, Rashid M, Khan MN., "Implementation of smart homes and industrial automation system with secure communication over GSM," Universal Journal of Electrical and Electronic Engineering, vol. 3, no. 4, pp. 10, 2015.