ZigBee Based Control System for People with Multiple Disabilities: A Review

Ms.Parashar Shraddha Rajendra
Electronics and Telecommunication
Govt. College of Engineering,
Jalgaon, India.
e-mail: shraddha911994@gmail.com

Prof. M. R. Dhotre
Electronics and Telecommunication
Govt. College of Engineering,
Jalgaon, India.

***Abstract*—** Most of the existing smart home monitoring and control systems do not accommodate special needy users to manage their home appliances. A wireless sensor network based system for smart home automation will be designed, built and tested to address such missing functionality. The to be implemented system's major contribution is that it is customized to provide the special need residents with tools and services to monitor and operate home appliances remotely. The implemented system provides home residents with disabilities to take advantage of the advancement in technology. It enables them to perform their daily activities by remotely monitoring and controlling their home appliances without having to depend on others. The system will be programmed so that it can be configured to adjust to the customer's disability providing them with better and convenient lifestyle. It is worth mentioning that the system is scalable and can be extended to include more and different services and tools. The system is portable, compact, affordable and easy to use.

Keywords-*smart home; control system; disabilities; compact;*

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I. INTRODUCTION

Nowadays, home appliances manufacturers are increasingly relying on wireless sensor network and single chip embedded technologies to build smart environment. Many existing systems are already in the market, however, they were designed without envisioning the need of residents with special needs. This work presents a framework that enables the integration and control of devices within a smart home environment for residents with disabilities. The framework supports the integration of multiple control devices for different residents with different disabilities. Moreover, the work addresses the safety of the users by providing warnings and notifications in case of an emergency.

Smart grid communications are based on wireless and wired networks technologies. Regardless of the technology, these networks can be classified based on their functionality within the smart grid. This classification as reported in the literature are: home area network, neighborhood area network, access network, backhaul network, core and external network. These networks connect many smart grid objects such as home appliances, smart meters, switches, reclosers, capacitors bank, integrated electronic devices (IEDs), transformer, relays, actuators, access points, concentrators, routers, computers, printers, scanners, cameras, field testing devices, and the list can go on to many devices. This work proposes a framework for homes to enable people with different types of disabilities the control of appliances and devices within their home environment. Home Area Networks (HAN) are implemented and operated within houses or other small boundary offices to enable communication between user's peripheral devices to various home appliances. Such appliances are: televisions, air conditioning systems, security systems, and other devices like fax, printers, as well as small network attached storages.

Moreover, HAN technology allows the user to control and monitor many digital devices throughout the house. The basic HAN includes devices such as, an access point, the home appliance(s), and a smart meter. The HAN's access point has network switch services that provide users with wired LAN ports or wireless connectivity. Wireless Sensor Network (WSN) is being implemented to monitor and broadcast information from different applications. It is being developed in various fields such as homes and hospitals. WSN consists of a large number of wireless sensor devices working together to achieve a common objective. A wireless sensor device is a battery-operated device that has the capability of sensing physical quantities, provides efficient wireless communication and data storage. Moreover, a WSN has one or more base-stations that gather information all the sensor devices. The base stations provide an interface through which the WSN interacts with the outside world. This work designs and implements a wireless sensor network inside a house that provide users with special needs essential and basic control within a home environment. The proposed work enables the user to perform his/her daily activities by remotely monitoring and controlling home appliances without depending on others. The input and output are automatically adjusted depending on the user's special needs and environment. The smart home area network (HAN) technology offers users a wide range of services. Users that integrate HANs into their homes can monitor and/or control their appliances remotely and within the house using smart phones or control panels.

II. MOTIVATION

The term Internet of Things is a challenging research topic which integrates various concepts to develop a luxurious lifestyle. The primary aim behind such astute integration is to simplify the people's lives by having a technology that can

deliver incessantly assuming ubiquitous presence of Internet. By incorporating the home automation systems (HAS), which are extensively based on the wireless sensor nodes, the lie will be more secure and safe. However, in spite of technological advances in IoT and HAS over the past decade, the inability to use such technologies is bigger issue than their cost.

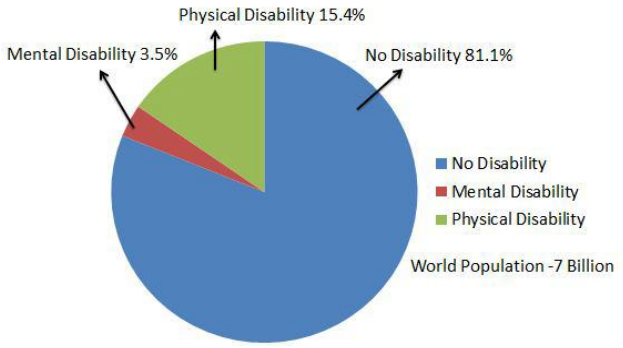

Figure 1 Data disabled people statistics

Such technological advancements and smart systems are immaterial if they cannot be afforded and utilized by the people who need them the most. According to the World Health Organization (WHO) statistics as shown in Figure 1, out of world's total population 3.5% of population is mentally disabled and 15.4% of population is physically disabled. Most of the population in world's total population is situated in the continents like Asia and Africa. People with physical disabilities mostly having disabilities in walking, hearing and seeing. It is quite apparent from the statistics that significant portion of the world population are dependent on someone or need some sort of external assistance to carry out their day to day activities. To promote individual living of disabled and elderly people a system has to be developed which will assist those peoples.

However, the currently available systems are expensive and cannot be afforded by people living in developing countries. The average monthly income of an individual in Asia and Africa is less than 500$ however, a HAS, price ranges from $300 to $10000. So, a full-fledge automation system is out of bound of most people living in developing countries, moreover so for the elderly and disabled who are already dependent on others for their basic day to day activities. Apart from above, most of these systems are very complex to operate and are largely ineffective in solving the diversified needs of such people.

III. LITERATURE SURVEY

Integration of Bluetooth and Wi-Fi technology in Controlling home appliances can help and improve lifestyle of all user groups especially to the disabled and elderly people in term of safety and comfortable. The implementation of combined wired and wireless systems would be of most practical in designing a smart home system especially in cutting the system's installation cost for conventional home. The smart elderly home monitoring system (SEHMS) is divided into three different modules which are safety monitoring system, telehealth system and telecare system. The smart phone is then connected to the monitoring system by using the TCP/IP networking method via Wi-Fi. A graphical user interface (GUI) is developed as the monitoring system which exhibits the information gathered from the system. The GUI opens an option to the user to examine the fall as well as making the confirmation or cancellation. A remote panic button has also been tested and implemented in the same android based smartphone. In addition, the monitoring system can also answer the call automatically after the emergency alarm has started. The SunSPOT development kit will be used to simulate smart home devices. In this paper, the functionalities of a digital home temperature reader, as well as light switches will be demonstrated on the SunSPOTs. Possibilities of remote access to the SunSPOTs can be breakdown into two alternatives that can be either through the Internet cloud or through the GSM cloud. Appliance control subsystem enables the user to control home appliances remotely whereas the security alert subsystem provides the remote security monitoring. The system is capable enough to instruct user via SMS from a specific cell number to change the condition of the home appliance according to the user's needs and requirements. The second aspect is that of security alert which is achieved in a way that on the detection of intrusion the system allows automatic generation of SMS thus alerting the user against security risk. In addition, the monitoring system can also answer the call automatically after the emergency alarm has started. This project will also not be a research or analytic based system to monitor human behavior. It will only provide ease of access to control house appliances and also monitor certain areas of the house. In terms of connection variant, this project proposed mixture of wired and wireless connection, where wired connection will run from the home appliances to the main control board while wireless connection will only exist in between the main control board and the UI platform, which is the phone or PC connected via Bluetooth.

A. Existing Smart Home Technologies

Home based system automations can range from systems as simple as for heating, ventilation, and air conditioning, Lighting control, or Audio and Video distribution to multiple sources around the house, to more complicated systems such as for security (involving presence simulations, alarm triggering and medical alerts) and robotics for home care or home management. Smart home applications; or task automations in a general household can be grouped by their main functions such as,

i) Alert and sensors – heat/smoke sensors, temperature sensors
ii) Monitoring – Regular feed of sensor data i.e. heat, CCTV monitoring

iii) Control – switching on/off appliances i.e. sprinklers, lightings
iv) Intelligence and Logic – Movement tracking i.e. security appliances
v) Telecare/telehealth – distress sensor, blood pressure monitoring

Current smart home devices are usually a customized hybrid of one or more of these applications for broader applications. Access to these applications can be generally grouped into 4 access types that are the hardwired type using bus line or power line based technology, as well as the wireless type utilizing radio, infra-red or Bluetooth technology. Future smart-home appliances are moving towards the wireless environment and hence the Bluetooth and radio spectrum will be widely used. It is to date, a rather new technology that needs to be further proven in terms of stability and security. Providers of this technology will have to take into accounts used frequency bands for current appliances such as Bluetooth, cordless phones or Wi-Fi routers to ensure devices are robust from interference. The use of radio frequencies such as at 2.4 GHz for wireless LAN and 8.643 MHz (Z-wave UK) enable the systems to be designed for high bandwidth data flow. Currently one of the existing issues that are associated to smart home applications are the fact that in a home with all sorts of automated application, there will be too many remote controls or monitoring terminal, if the user installed a range of proprietary applications from different providers. There is also the fact that the access range to remotely control these devices are limited by either length of cables or wireless network coverage in a personal area network. It is a widely known fact that an important example of wireless technology application is the mobile phone technology. Mobility' is now a lifestyle adopted by all walks of the society, where a United Nation survey has recently revealed that 60% of the world population has a mobile phone subscription. Taking into account a mobile phone's necessity in the majority of our society, this solution will attempt to transfer the functionalities of a smart home device's remote control to a mobile-phone, to achieve a truly remote access convenience. Enabling a single remote access to a single corresponding server in a smart home household will also resolve the issue on 'too many control terminals'.

IV. RELATED WORK

Research on smart homes began in the late 1980's with the intent on making homes more intelligent. By the mid 1990's the focus had turned to incorporating these innovations into the lives of the elderly and disabled people. In Canada the elderly population had been increasing faster relative to the younger population and still does so today. As such, home automation is becoming a viable option for the elderly and disabled people and there has been a considerable amount of research devoted to this topic. In this project, the form of smart home focuses on making it possible for disabled people to remain their life at home, safe and comfortable.

The work by Hussain et. al combined WSN and Radio Frequency Identification (RFID) technology for door control system. Their system deals with the Radio Signal Strength Indicator of WSNs. RSSI is a measurement of how strong a signal appears to the node that is receiving the signal. The RSSI can be affected by many factors that can cause it to change quickly. Two nodes placed at the outside of door frame look at the sudden changes that occur in RSSI when somebody moves between two nodes. They also used RFID that is a technology used for identifying people who carry identification badges. This technology consists of reader which reads an approaching badge to identify the person who is carrying the badge. The problem in their system is that WSN nodes always make radio transmission in a very short period of time. A sensor expends maximum energy in radio communication both for transmission and reception. Thus, it causes to consume the battery of node shortly because of their limited source of power.

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V. SYSTEM ARCHITECTURE

The figure 2 depicts proposed block diagram of system. The system consist of master controller and its various controlling elements.

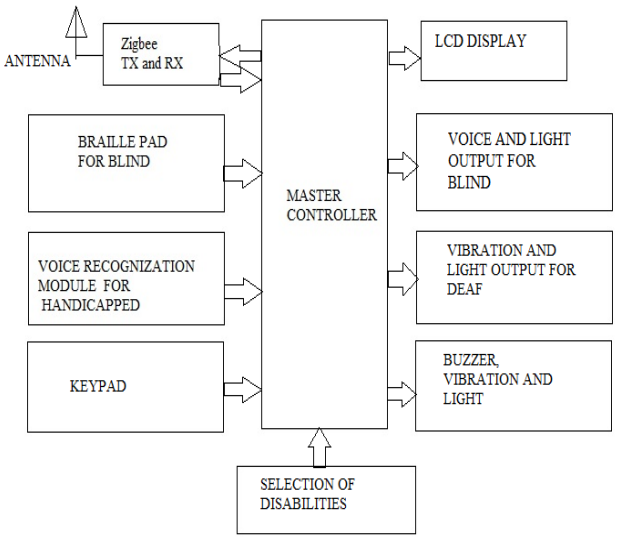

Figure 2 Master Controller Unit

A. Working of System

The master registers the capabilities of the control device such as LCD screen, and a buzzer. The master controller allocates the request to the control device capbility based on the user special need. Figure 3, Figure 4 and Figure 5 shows various sections of system which will be designed at respective ZigBee Node. And the total system working is briefly depicted in figure 6 which is a flowchart.

For example, if the user is visually impaired, then all notifications from the master controller will be sound based. Different notifications will sound differently. For example, if there's fire, the buzzer will keep running until the temperature goes back to normal. On the other hand, to notify that a light or refrigerator door is open, the buzzer will beep with a delay. Similarly, if the user is deaf, all alerts and notifications will be displayed on the LCD. The fire alarm node is connected to a temperature sensor, LED and Xbee board. The node keeps monitoring the temperature of the surrounding. If the temperature reaches beyond a certain limit, the node alerts the master controller and turn ON the LED connected to the node. The Door and Doorbell node are connected to an RFID tag reader and a pressure senor which allows the node to perform two operations. First, when the user swipes the RFID card that matches that connected to node, the door opens for a specific amount of time then automatically closes. Secondly, when a person (visitor) presses the pressure sensor (demoed as doorbell), the node will notify the master controller of this event and the master controller will transform into an output action based on the user special need through the control device.

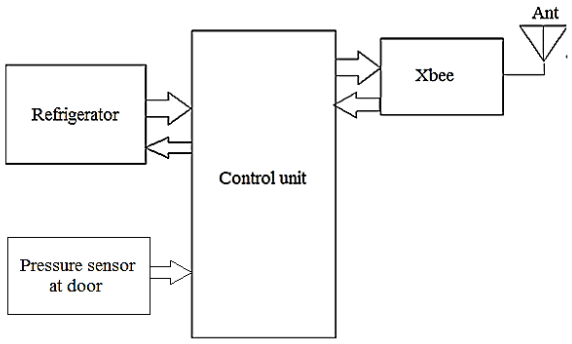

Figure 3 Refrigerator Control Unit

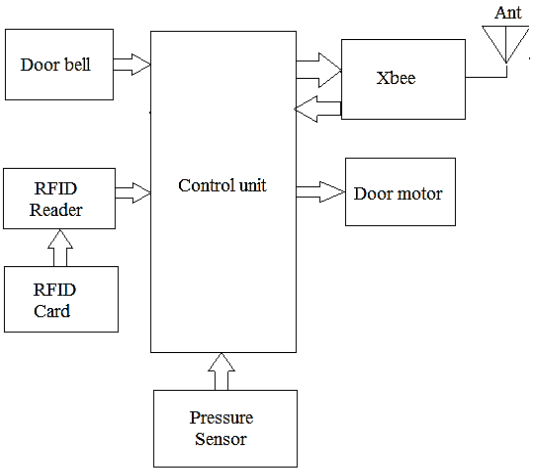

Figure 4 Door Bell Control Unit

The refrigerator monitoring node has a pressure sensor connected to it. When the pressureis below a certain value, it means that the fridge-door is closed. When the pressure is above a certain limit, it means that the door is open and the LED is lite. This node notifies the master controller of the status of the refrigerator's door (opened/closed) and automatically close the door if the user forgot to do so. The node waits untill it receives the appropriate command from the master controller, check the status of the door, and send the status back to the master controller. For auto closing the door, the system will start a timer when the refrigerator's door is open, the timer checks every 10 seconds if the door is closed

or still open. If, after a certain time has passed and the door is still open, the node will automatically close.

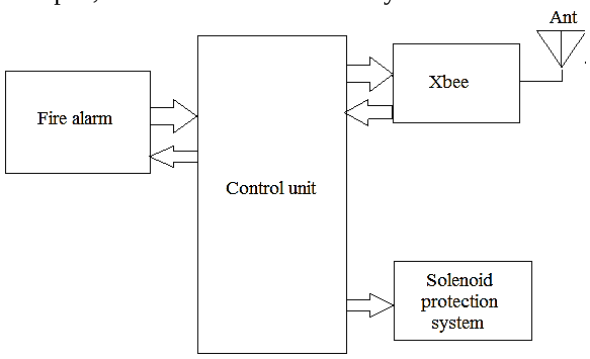

Figure 5 Fire Alarm Control Unit

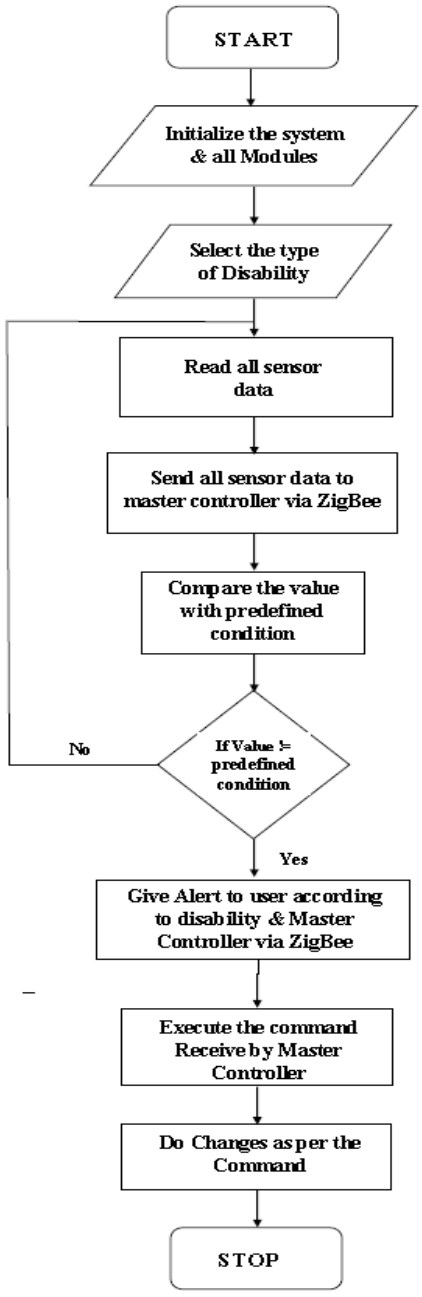

Figure 6 Flow Chart of System Working

VI. CONCLUSIONS

A. *Advantages*

i. Cheap in cost: Due to use of wireless network, no wiring is required so cost is reduced. Wired solutions require cabling and it is expensive.

ii. System is scalable and portable: for adding or removing the features is not tedious work as network is wireless.

B. *Conclusions*

Most of the existing smart home monitoring and control systems do not accommodate special needy users to manage their home appliances. This system enables the independent living of people with disabilities with the use of sensor network. This system is scalable, one can add or delete required functionality according to individual's need and requirements. The control system is portable also. The system is one step toward implementing digital India and making living being to leave safely.

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