

Zigbee based System for Individuals with Multiple Handicapness in Household Environment

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Abstract—Most of the prevailing smart home monitoring and control systems do not accommodate special indigent users to manage their home appliances. A wireless sensor network [WSN] based system for smart home automation can be developed, built and tested to address such missing functionality. The system's major contribution is that it is customized to provide the special needy residents with tools and services to monitor and operate home appliances remotely. The 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 independently. The system is programmed so that it can be configured to adjust to the customer's disability providing them with better and convenient lifestyle. The system can be scalable and might be extended to incorporate additional and different services and tools. The system can provide portability, compactness, affordability and easier to use.

Keywords - sensor, WSN, embedded, special needs, home environment

I. INTRODUCTION

Nowadays physically challenged individuals especially people with visual and hearing impairment find it troublesome to do their daily activities during loneliness. Existing system is that either there family members are concerned about them to take care or might have an aided person to assist them by payment basis. This becomes hectic for family members to keep a servant to take care of them. Therefore in order to overcome these problems a system should be developed for these kinds of physically challenged people such that the system will ensure the safety of disabled peoples and also assist them to live independently.

Therefore to beat these issues, system will be enabled for dealing with controlling of hardware appliances using the electronic relay based switching circuit. As a part of security, system will have sensor based circuitry which will alert user in critical condition. By configuring, system can send a SMS based alert to assistant user. To work all modules together and to make modules accessible through the ZigBee interface, system modules communicate with each other using IEEE 802.15.4 Protocol.

In this paper, section II deals with METHODOLOGY for work while section III includes system IMPLEMENTATION with block diagram. Section IV summarizes performance analysis and results are discussed.

II. METHODOLOGY

A. Subjects

A ZigBee based system was developed for people with hearing impairment, visual impairment, physical handicapness, etc. The system can enable user to urge notification and applying dominant actions in keeping with choice of handicapness. For testing of system, five normal subjects in age group of 21-30 years participated in experiment. The persons were normal subjects with simulated disabilities. The integrated control system is a sort of automated smart home. By taking this point in consideration, any type of situation can arise at any time. Therefore some accidental situations were made to happen randomly and system performance was tested by collecting the data of these five subjects. Subjects were asked about their comfortable level while handling the system and qualitative analysis was carries out.

B. Material

The system is a distributed wireless network of master and slave units for controlling and monitoring different appliances to assist disabled individuals. The master node is responsible for instructing slave nodes to perform actions according to user's needs. To develop such integrated standalone embedded system;

1. Controller Required

Each appliance has its own control board which contains an individual microcontroller and another controller is used for master controller. ARM 7 LPC2148 is programmed as master

controller and Arduino Uno ATmega328P is used as slave controller.

2. Communication Media Required

The control system is a distributed wireless sensor network which requires faithful trans reception between nodes. For fulfilling this purpose efficient communication media has to choose. Xbee S2C module from digi international is used as transceiver in WSN. This module utilizes 2.4 GHz ISM frequency band.

C. Procedure for establishing WSN

In a home area network environment, a home with m appliances can be denoted by (1).

$$A = \{A_1, A_2, \dots, A_m\} \quad (1)$$

An appliance is a physical device that is capable of executing tasks or requests and exchange data. For example, in a smart home environment an appliance can be a television, lights, a washing machine, etc. Each appliance can be defined by a set of capabilities in (2)

$$A_i = \{c_i^1, c_i^2, \dots, c_i^{a_j}\} \quad (2)$$

a_j is the number of capabilities that describe A_i . For example, capabilities for a washing machine can be rinse, normal wash, hand wash, water temperature, and spin speed. Each appliance in the smart home environment is placed in a specific home zone. A home zone defines specific areas inside the home. For example, living room can be a zone. A home zone can be presented in (3).

$$Z = \{Z_1, Z_2, \dots, Z_q\} \quad (3)$$

Let A_{iq} denote appliance i in zone q .

A set of n tasks for in a home environment, denoted in (4).

$$T = \{T_1, T_2, \dots, T_n\} \quad (4)$$

Task $T_j \in T (j=1, \dots, n)$ is formulated as a set of operations .

In a home area network environment, there is a need to allocate requests to the capable appliances/devices at specific time. A request may be processed by a single appliance A_i or a group of appliances in A , in which the appliances are capable to process request T_j . For example, a request in a household environment can be lightning outdoor bulbs when it gets dark. The system can allocate the request to the different lightning units at home to achieve this request.

III. IMPLEMENTATION

The block diagram of system is as shown in figure 1. 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 capability based on the user special needs. For visually impaired user all notifications from the master controller will be sound based. Different notifications will sound differently.

During 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. For user with hearing impairment, 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. At the moment temperature reaches beyond a certain limit, the node alerts the master controller and turn ON the LED connected to the node.

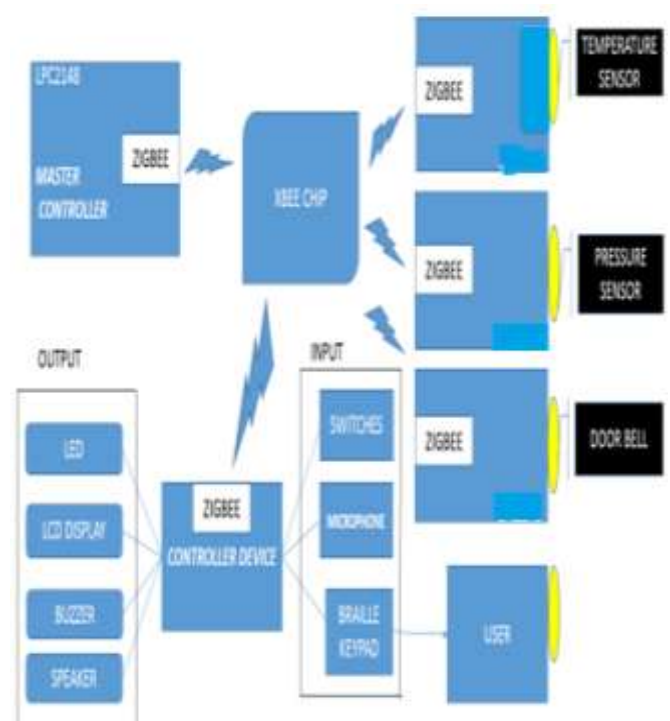


Fig. 1 Block Diagram of ZigBee Based system for Individuals with Multiple Handicaps in Household Environment

The Door connected to a pressure sensor which allows the node to perform operations. While pressing the pressure sensor, 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. The refrigerator monitoring node has a pressure sensor connected to it. When the pressure is below a certain value, it means that the fridge-door is closed while pressure is above a certain limit indicates the door is open and the LED is lite. This node notifies the master controller of the status of the refrigerator's door and automatically close the door if the user forgot to do so. The node waits until 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 status of door in every 10 seconds. After a certain time has passed and the door is still open, the node will automatically close.

A. Experimental Model of Control System

Experimental model of the system has master controller, wireless communication unit and four slave nodes designed as prototype model of home appliances as major building blocks. In line with the block diagram shown, system is developed by interfacing the building blocks with each others making the node as a single unit.

The whole system is built around ARM 7 board as master controller which will monitor and control system functionality. The prototype system is designed for three types of disabilities like visual handicapness, hearing handicapness and physical handicapness. This system relies on IEEE 802.15.4 ZigBee standard for wireless communication. There are four prototype slave modules for updating the status at different positions in home. The slave module contain refrigerator control unit, door control unit, fire alarm unit and home automation unit.

Master controller unit performs function of selecting type of disabilities, accordingly gives notification and enters input from user. For performing controlling action by user various devices are added to master board. Various output devices like LED, LCD display and buzzer is connected for notifying user according to disability type selected. Also keypad, voice recognition module and switches are used for applying input to perform controlling action by user to control various situations.

Refrigerator control unit implemented with tactile switch as a pressure sensor for checking status of refrigerator door and Arduino Uno ATmega328P works as controller for slave units. Door control unit also has pressure sensor to check door status and motor assembly to open and close door automatically. Fire alarm control unit contains thermistor as temperature sensor which is connected in voltage divider biasing of transistor. Sensitivity of temperature can be changed by changing value of resistors in voltage divider. Home automation unit contains relay driver circuitry for driving home appliances like light, fan, etc.

IV. RESULTS AND DISCUSSION

To analyze the system performance normal subjects with simulated disabilities are considered and numbers of trials executions are carried and the results are summarized in following tables:

Table 1: Experimental Results of System for Normal Subjects with Simulated Visual Handicapness

Sr. No.	Subject	No. of Successful Trials for Different Control Units (Out Of 20)				Efficiency (%)
		Ref. Control	Door Control	Fire Control	Home Automation	
1	S ₁	20	20	20	20	99
2	S ₂	19	20	19	20	
3	S ₃	20	20	20	19	
4	S ₄	20	19	20	20	
5	S ₅	20	20	20	20	
	SD	0.45	0.45	0.45	0.45	

Table 2: Experimental Results of System for Normal Subjects with Simulated Hearing Handicapness

Sr. No.	Subject	No. of Successful Trials for Different Control Units (Out Of 20)				Efficiency (%)
		Ref. Control	Door Control	Fire Control	Home Automation	
1	S ₁	20	20	20	20	99.5
2	S ₂	20	20	20	20	
3	S ₃	20	19	20	20	
4	S ₄	20	20	19	20	
5	S ₅	20	20	20	20	
	SD	0	0.45	0.45	0	

Table 3: Experimental Results of System for Normal Subjects with Simulated Physical Handicapness

Sr. No.	Subject	No. of Successful Trials for Different Control Units (Out Of 20)				Efficiency (%)
		Ref. Control	Door Control	Fire Control	Home Automation	
1	S ₁	20	20	20	20	99.25
2	S ₂	20	20	20	20	
3	S ₃	20	20	19	20	
4	S ₄	20	19	20	20	
5	S ₅	20	20	20	19	
	SD	0	0.45	0.45	0.45	

Table 1, 2 and 3 indicates experimental results of given ZigBee based system. S₁ to S₅ were normal subjects with simulated disabilities under test. Twenty trials were carried out for each node and for each subject. Overall eighty trials were tabularized for each subject. Table 1,2 and 3 show experimental results of system for normal subjects with simulated visual, hearing and physical handicapness respectively.

Data of normal subjects with simulated disabilities are summarized in above tables and standard deviation is calculated. Standard deviation of a system provides an indication of how far the individual responses vary or "deviate" from the mean. For this system the value of standard deviation ranges from 0 to 0.45. Standard deviation should have small value for desired performance. Here deviation is negligible therefore the system will perform faithfully and all types of subjects can handle system with ease.

Above results also indicate that GUI of system should be better than provide to reduce deviation to zero so that system will be more interactive with user. Therefore system can be implemented in field as per requirements.

V. CONCLUSIONS

The ZigBee based control system developed as assistance system for disabled peoples has met its goals based on simulations, tests results and cost analysis. The proposed system not only makes disabled peoples self-reliant but also provides them with multitude of input options to carry out their daily living activities with more ease. The system provides indoor communication range up to 40 meters. Results obtained from progressive testing of system indicate that deviation is lesser. Its better results were observed with sufficient training.

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