Low Power, Intelligent, Wireless, Home Security System for the Elderly People

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Abstract— **In this paper, we suggest a Low Power Intelligent, Wireless, Home Security System (IWHSS) for Elders. The elders can avail the services of this IWHSS, conveniently within their room. If the elder is uncomfortable with a stranger trying to get into the home, services of IWHSS can be availed. The strangers can be identified and in emergency situations where the elder feels the necessity of the external help, the police and relatives can be informed via IWHSS. In addition to informing the police, the system also activates an emergency alarm to alert the neighbors. The elders can also see the stranger at the door and make a conversation with them. The system uses GPRS Modem which is interfaced directly with PIC 16F877A microcontroller to make the system power efficient. We have used low cost RF modules, PIC 16F877A microcontroller, IR-TSOP modules and Image Capture module as part of the hardware implementation of the system. The simulation software's used were MPLAB IDE and PROTEUS.**

Keywords-elders, home security, low power, wireless interface, GPRS modem

I. INTRODUCTION

The health and security of an elderly person in a house is a prime area of concern for the others. In almost every country the proportion of people aged over 60 years is increasing faster than any other age group, which results in the change in population structure [1]. Most people, particularly in India, wish to take care of their elderly parents at home itself. Also the elders would like to stay with their offspring's rather than being in old age homes. But in today's world, the adults are busy with their own job and the children are busy with their academics. So there will be less people to take care of the elders and the home safety becomes a serious issue. Studies have shown that the amount of crime and robbery on them is also increasing [2]. Criminals and thieves find elders as an easy target. So we propose IWHSS, which can help the elders in such a way that their security threats are removed. The system alerts the police or other authorized people if there is a theft attempt at home and the elders can make use of IWHSS to know who is at the door entrance. The GPRS modem can be made to send a SMS or call the corresponding people manually or automatically. By this method, immediate help is provided and the elders feel safe and comfortable. We begin with the Motivation and Problem definition, which explains about the necessity of Low Power IWHSS in the current scenario. The rest of the paper is organized as follows – Related Work, Low Power, Intelligent, Wireless, House Security System, Working, Experimental Results, Future Work, Conclusion, Acknowledgment and Reference.

978-1-4244-8679-3/11/$26.00 ©2011 IEEE

II. MOTIVATION

In our society, unfortunately the elderly have become a far too easy target for criminals. Whether living alone or going about daily lives, the elderly are viewed as helpless and easy victims for them. Elders may be victims of frauds like con games and insurance, home repair, telephone, or Internet scams as shown in [2]. The most threatening fact is that even friends or family members have been known to steal an elderly person's money or property when they are left alone at home. These statistics and reports motivated us to propose IWHSS, to help the elders in identifying a critical situation of robbery or break in and inform the authorities and relatives immediately.

III. PROBLEM DEFINITION

The amount of crime on elders is increasing manifolds. Most of the time they are incapacitated to call the police or others for help during emergency situations as of theft or house break-in, as they are left alone. Robbers find these houses as their perfect places to rob. So there is a need of a system which can detect a break in automatically. It should also help the elders to identify the strangers at the entrance of the house and deny or grand permission for their entrance. Such a system should also be easier for the elders to use. IWHSS, a low power system, makes use of the wireless mobile technology to send SMS or call the police when there is an emergency situation. This system which includes a camera and intercom, can be switched on or off as per the requirements by the user.

IV. RELATED WORKS

A home security system using phone net and Bluetooth technology has been discussed in [5]. That system also equips a host computer and a server computer. It is too expensive to use two computers and [6] shows the defects of BT technology. A low cost GPRS based home security system, which does not mention about its low cost at implementation level, is shown in [7]. It also informs the theft attempt to a property management person and only through SMS, whereas our system directly informs the police and that too through a voice call. A home automation system in which only SMS is sent for emergency is discussed in [8]. The difficulties that elders face in handling modern technology devices are shown in [9]. Our system is semi-automated and does not require much assistance from the elderly. An emotional computing system that does not describe about its implementation is described in [10]. A care system for elderly which detects their motions in the room is discussed in [11]. As discussed in [1] the elderly

persons psychology does not wish to be in such a system. Systems to monitor and automate activities of elders are shown in [12]. A medical care for elders making use of bed sensors are described in [13]. But it does not provide help in all the emergency situations.

V. LOW POWER, INTELLIGENT, WIRELESS, HOME SECURITY SYSTEM

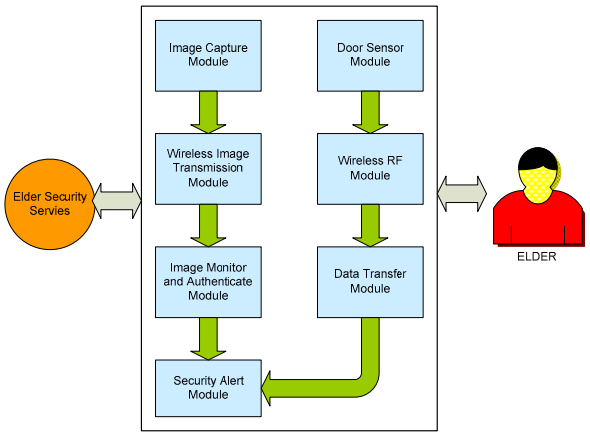

Figure 1. IWHSS System Overview

Fig.1 illustrates the proposed IWHSS system. Two functions Person Identification Function (PIDF) and Security Breach Function (SBF) are integrated into the IWHSS.

A. *Person Identification Function (PIDF):*

Usually the main door of the house consists of a calling bell. But an elder may be inside his/her room, who has to walk all the way to the entrance or use their wheel chair to go to the entrance to open the door. Most of the time, it would be very inconvenient for the elders. IWHSS provides an easy solution for the elder to overcome this situation. It automatically captures the image and beams it to the elder in their room with a beeping sound to attract the attention. The elder checks the image on the LCD monitor which is part of the Image Monitor and Authentication Module (IMAM) and takes a decision to open the door. If not satisfied with the image, the door is not opened. The elder can also have a conversation with the person outside and decide whether to permit or not. This is provided through the intercom which is attached with the PIDF. If the person at the entrance stays there for more than predetermined time, the elder may decide to request for help from police and relatives. In that case, when the emergency button is pressed, automatically enables the GPRS to SMS and also place a call to the police and relatives. The entire IWHSS works on the assumption that the elder's health is not in bad condition. Also the elder's eyes and ears are in good condition.

a) Image Capture Module (ICM): This module consists of a camera and an interface to the Wi-Fi Direct wireless module. Wi-Fi Direct is a relatively new technology that allows Wi-Fi devices to talk to each other without the need for wireless access points (hot spots). The camera is placed next to the door. It is automatically activated once an object comes into the vicinity of the lens. It captures the image of the person at the entrance. The digital image is provided to the WITM and provides it to the elderly person inside the house who could view the image via an LCD Monitor attached to IMAM with a beep sound.

b) Wireless Image Transmission Module (WITM): This module uses the Wi-Fi technology to transmit the captured digital images to the IMAM. The IMAM and the Security Alert Module (SAM) are inside the elder's room. The WITM and IMAM are connected by WLAN.

c) Image Monitor and Authentication Module (IMAM): IMAM receives the transmitted image from the WITM and displays it to the elder via an LCD screen. The IMAM consists of a PC with Wi-Fi enabled. The elder observes the image on the monitor and decides to allow or decline the entrance of the person outside the door.

d) Security Alert Module (SAM): The SAM consists of a GPRS modem attached to the PC of IMAM. It also consists of the alarm module to alert the security breach to the neighbors which is to be explained in the next section. If the elder does not identify the outsider at the entrance, he can deny permission. But if the person at the entrance does not leave the place even after a certain time also, the elder has got an option to SMS and also place a call to the police and relatives through the GPRS modem by just pressing an emergency button. This setup informs the police about the security concern at that particular house.

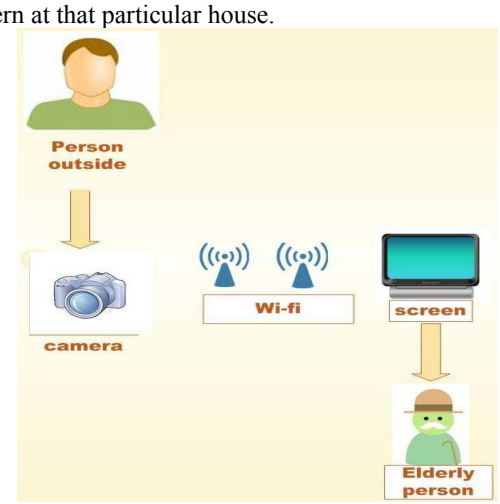

Figure 2. PIDF to know who is at the entrance

Fig.2 illustrates system 1 to know who is at the entrance. This can be employed in houses where elders live alone. Elders may not be able to stand up, walk and see through the keyhole and identify who has come at the entrance. This system helps the elderly person to identify who has come at the entrance and also to grand permission for that particular person. The main door of the house is usually attached with a calling bell. In addition to that the entrance also has a Camera and an Intercom. Intercom means a telecom system with

which the newly arrived person at the entrance can make a conversation call with the elderly person sitting inside the house. The face of the arrived person in the entrance is captured in a camera and displayed on a screen which is kept according to need of the elderly inside the house. If the elderly person inside the house recognizes the outside person, he can talk with the outsider through intercom if needed.

B. *Security Breach Function (SBF)*

The SBF is to detect a theft attempt and inform the same to the nearby police station. Usually the thieves enter through either one of the doors- front door or the back door or any other door of the house connected with the outer world. Fig.3 shows a sample home structure which has a SBF installed in it. The SBF consists of RF Transmitters, IR-TSOP Sensors, RF Receiver and a GPRS Modem. As shown in the Fig 3, each RF transmitter has a specific address. This is done by assigning a particular value to the address pins on the encoder and decoder IC's. There will be a RF receiver to get the data of every sensor. The RF receiver will be changing its address at regular intervals so as to receive the data from every transmitter. The data transmitted by the RF transmitter will be received by the RF receiver but it will be decoded only if the address bits of both encoder and decoder matches. It consists of the following modules:

a) Door Sensor Module (DSM): We have used an IR - TSOP module to sense whether the door is opened or not. This is given as an input to the IR transmitter. We had made the setup in such a way that if the door is opened then it acts as an obstacle to the IR rays thus they get reflected and TSOP receives it. Thus using this sensor module we get a signal when the door is opened.

b) Wireless Module (WM): The transmitter module used is a 4-pin module and can operate on input voltage ranging from 2-12 volts DC power supply as shown in [3]. There will be a specific RF receiver to receive the serial data. The range of RF transceivers being used was 100 meters under ideal conditions.

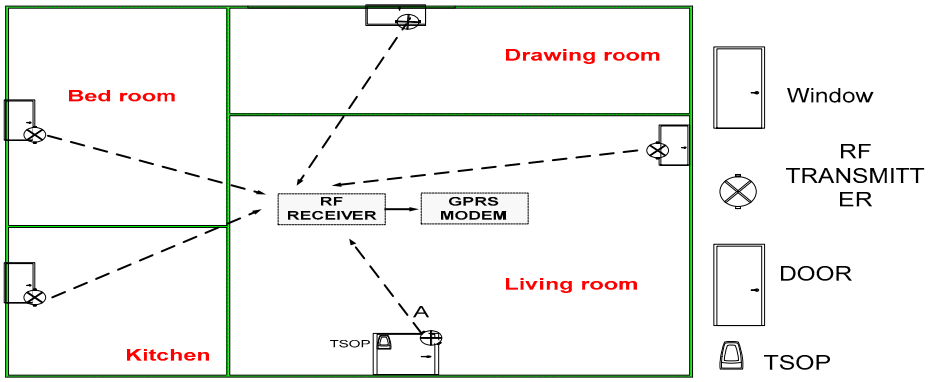

Figure 3. SBF to detect and inform theft attempt in a sample Home structure

The encoder and decoder IC's implemented uses Manchester encoding routine to encode the parallel input data from the microcontroller to the serial data which can be fed as input to the RF transmitter. This Manchester Encoding routine can be implemented in the PIC microcontroller if we wish to reduce the power consumption by not using the encoder IC itself. The data will be received by the RF receiver and fed as input to the decoder IC which decodes the serial data into parallel data and feeds as input to the microcontroller.

c) Data transfer Module (DTM): All encoders use a common word format. They all pack the bits of information in the same number and position in the transmission sequence. Many advanced encoders provide Manchester encoding for RF modulation and transmission. The RF modules which we have worked with also employ Manchester Encoding.

d) Security Alert Module (SAM): The received signal from the RF receiver is given to a PIC 16F877A microcontroller, a microcontroller manufactured by Microchip. The microcontroller performs two functions. First, it activates an emergency alarm for the people inside the house and the surroundings to know that there is a theft attempt. Second, it interfaces with a GPRS modem. The interface with the microcontroller and GPRS modem is done via a RS 232 and MAX 232 IC manufactured by Maxim. The GPRS modem used was Wavecom multiband 900E 1800. The GPRS modem uses AT (Attention) commands for its functioning. A programmed voice message in the modem is played automatically, when the call is placed to a police station. The modem can also send a SMS to the police, indicating that there is a theft attempt at this particular house.

VI. WORKING

A change in the data line of the transmitter which is placed on the door is automatically detected by the receiver inside. Fig. 6 shows the hardware setup of RF Transceivers.

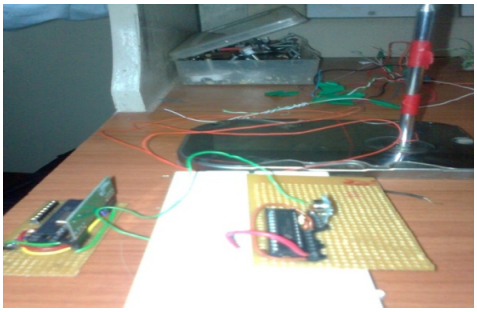

Figure 4. Laboratory setup of RF transceiver

The GPRS modem was controlled using AT commands. A blinking red light on the modem indicated that the modem was correctly connected using the serial port. The GPRS modem used could support placing calls to the police station and also sending SMS to the desired number. Fig. 8 shows the software simulation of the PIC microcontroller and the GPRS modem direct interface done using PROTEUS and its Virtual terminal outputs shown in Fig. 7 contain the AT Commands needed for the GPRS Modem to function.

Figure 5. AT Commands received in Virtual Terminal

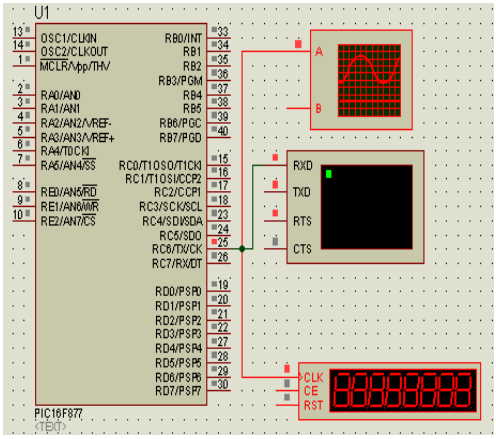

Figure 6. Software Simulation of PIC – GPRS Modem direct interface

VII. Experimental Results

The transmitter voltage has a range of 2 to 12 volts. The transmitter voltage was varied and the different ranges of reception obtained were plotted. TABLE 1 shows the different set of voltages used and the corresponding ranges of reception obtained and plotted as per Fig. 9.

TABLE I. TRANSMISSION VOLTAGE VS RECEPTION RANGE

Transmitter Voltage in Volts (V)	Reception Range in meters (m)
2.5	24
4	37
6	52
8	68
10	79
12	103

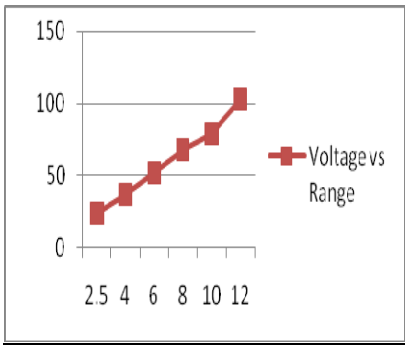

Figure 7. Transmission Voltage vs Reception Range

IWHSS was made a Low Power Consumption System by making use of the Sleep Mode in PIC microcontroller and other power saving techniques. Table II shows the Power comparison of PIC microcontroller when our system works for different number of people in 1 hour (60 minutes). Table III, IV, V shows the Power Comparison of various devices included in IWHSS. The system is in Power Save Mode by default. It is assumed that the system gets into active mode for 5 minutes for each person and again switches back to Power Save Mode.

TABLE II.. POWER CONSUMPTION OF PIC16F877A AT V_{DD} = 5V, FOSC = 4 MHZ

Number of people	1	5	10
Sleep Mode Power Consumption (W)	0.01607	0.0830	0.1667
Active Mode Power Consumption (W)	0.2	0.2	0.2

TABLE III.. POWER CONSUMPTION OF WAVECOM GPRS MODEM.

Number of people	1	5	10
Power Consumption (W) in Power Save Mode	0.1667	8.3	16.67
Active Mode Power Consumption	20	20	20

(W)			

TABLE IV.. POWER CONSUMPTION OF TWS A RF TRANSCEIVERS, HT-12 E ENCODER, HT-12D DECODER IC'S

Number of people	1	5	10
Power Consumption (W) in Power Save Mode	$66.67x10^{-3}$	$333.33x10^{-3}$	$666.66x10^{-3}$
Active Mode Power Consumption (W)	$860x10^{-3}$	$860x10^{-3}$	$860x10^{-3}$

TABLE V. POWER CONSUMPTION OF TLCLEARCAMII CAMERA AND LCD SCREEN

Number of people	1	5	10
Power Consumption (W) in Power Save Mode	3.66	9.07	16.66
Active Mode Power Consumption (W)	19	19	19

TABLE VI. TOTAL POWER CONSUMPTION OF IWHSS

Number of people	1	5	10
Power Consumption (W) in Power Save Mode	3.41	17.78	34.16
Active Mode Power Consumption (W)	40.06	40.06	40.06

Table VI compares the Overall Power Consumption of IWHSS when it is in Power Save Mode and in Active Mode. The tables II to VI are tabulated based on the assumption that at least one person (may be a stranger or a person who lives in the house) trying to get into the house every hour and at most 10 persons, every hour. Whenever a person is at the door, IWHSS gets activated and is in active mode for five minutes. Otherwise the system will be in sleep mode. From Table VI, it can be seen that 91.6% power is saved if only one person happens to come in one hour's time. 55.6% Power is saved if five persons happen to come in one hour's time and 14.73% power being saved for an extreme case of ten persons.

VIII. FUTURE WORK

In the proposed system, the Person Identification Function (PIDF) can be implemented by using wireless camera which makes use of the Wi-Fi technology. The camera can be placed outside the house and the authentication can be provided by the elderly person sitting inside the house. This Wi-Fi technology makes use of the IEEE 802.11 standard protocol for its functioning.

IX. CONCLUSION

The home security system discussed can be deployed at the homes where elders live. This can also be installed at all homes where there is threat from robbery. This system automatically sends an SMS or calls the police if the doors or windows are opened by an external person. The door breakage module informs the GPRS modem about the theft attempt through a wireless interface. The GPRS modem calls for necessary help spotting the location. Through PIDF which is part of IWHSS, the elders can monitor the people outside the house and also talk with them through the intercom provided. Through this cost effective setup, the life of many elders can be saved even though they are living alone and their lives will not be in anymore danger.

ACKNOWLEDGEMENT

We gratefully acknowledge the Almighty GOD who gave us strength and health to successfully complete this venture. The authors wish to thank Amrita Vishwa Vidyapeetham, in particular the VLSI lab and Power Electronics lab, for access for completing the project.

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