WSN and GSM based Remote Home Security System

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ABSTRACT
In this paper, a sophisticated remote home security system designed by combining the advantages of wireless sensor networks and GSM technology is presented. It can detect intrusion, fire etc. and inform the user remotely about the incidence with distance playing no barrier. The hardware of the system includes wireless transceiver XBEE along with Atmega microcontrollers, real time clock DS1307, DTMF decoder HT9170, Voice recording and playback IC APR9600 and some other components. The system software is developed in C language on CVAVR platform.

General Terms
Wireless Sensor Networks, Home Security Systems.

Keywords
Wireless sensor network; global system for mobile communications; home security system; short messaging service; voice calls; intrusion alarms.

1. INTRODUCTION
Home Safety is one of the most important requirements for people. With the development of IT technology, network and automatic control technology, a remote home security monitoring and alarming system becomes more and more practicable today. By combining wireless sensor network (WSN) and GSM technology, we can design a remote home security monitoring and alarming system that can detect the theft, fire etc and send alarm message to the house owner's mobile phone. Wireless sensor network is composed of a number of wireless sensor nodes. By combining sensors and wireless communication, WSN can detect, collect and deal with the object information in its covering area, and send data to the observer. WSN technology has the advantages of wide covering area, able to remotely monitor, high monitoring precision, fast network establishment and reasonable cost. GSM network has the advantages of mature technology, wide covering area, long communication distance and so on [1]. The remote home security system presented in this paper combines the advantages of WSN and GSM technology. Firstly, wherever the users are, once some dangerous instance happens in home, such as fire or thief intruding, this system can call and send SMS to the users through GSM network immediately, informing people the possible dangerous circumstances in home. GSM increases the reliability in terms of user being informed about the intrusion immediately because today almost every person carries a mobile phone. Secondly, the wireless sensor network established in home has the features of ease establishment, without use of cable, and low-power consumption.

2. SYSTEM STRUCTURE AND WORKING PRINCIPLE
The system structure is illustrated in figure 1. It is composed of a base station/gateway, a dialer, a control panel, several sensor nodes and mobile phones. We can install sensor nodes e.g. door sensor, fire sensor at the location we want, without placing any wires. House is divided into different zones and each sensor node is placed in one of the zones. These sensor nodes detect abnormal situations and intrusions and then send this information to the gateway (also called as base station). The gateway has all the user configurable information e.g. what zones are enabled and what zones are disabled and what zone is delayed and system is armed or disarmed. Depending on all these configured options by the user, the gateway decides whether the zone data is to be treated as intrusion/abnormal situation or not. If it is an intrusion or abnormal situation and system is armed then dialer makes use of GSM module to start calling and sending the SMS containing intrusion log (e.g. which zone caused intrusion, time of intrusion, name and address of house owner) to the user. Since we are using GSM module for informing the user about the intrusion, distance of user is no longer a barrier and also since almost every person today carries a mobile phone, we increase the probability of user being informed about the intrusion immediately as compared to when we are using some technology other than GSM e.g. email through Internet. Using Control, user configures all the user configurable options. Our system can have a maximum of 15 mobile numbers on which intrusion/abnormal situation information is to be sent and our system instead of calling/SMS only once, does the same three times for increasing reliability. Our system also has the provision of remotely enabling and disabling it. At any point of time, user may call the GSM module fitted into the system and by pressing a secret code on his mobile phone; he may be granted access to arm/disarm the system remotely. System also informs owner using SMS whenever system is armed and disarmed so that even if trusted persons who know the secret code cannot tamper with the system without the knowledge of owner.

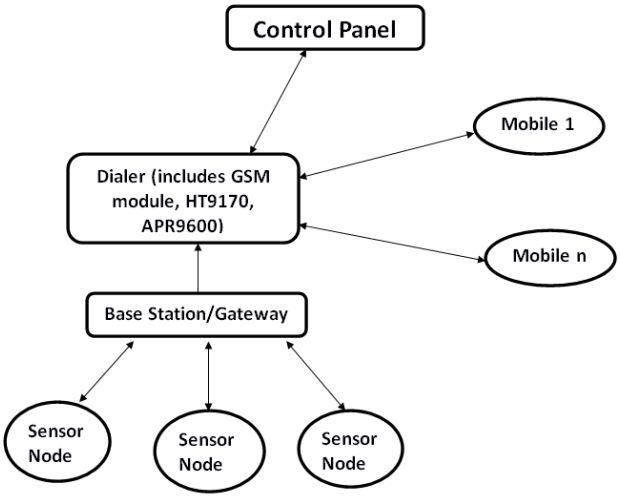

Fig 1: System Structural Diagram

3. SYSTEM FEATURES

The system has following features:

3.1 6+1 Zones

System supports maximum of 6 normal zones along with 1 tamper zone. Tamper zone is different from normal zones as; if this zone is tampered with, it causes security alert even when system is disarmed.

3.2 Delay Zone

One zone programmable as delay zone which after being activated causes the system to start calling and send SMS after delay interval. This zone is for the entry/exit door of the house.

3.3 Control Keypad

Control Keypad for controlling operation of the device such as controlling user configurable options.

3.4 Display

20x4 LCD display for displaying information to user.

3.5 Fifteen Telephone numbers for intrusion alarms

System supports a maximum of 15 numbers which can be stored in the system.

3.6 Time based auto disarming

System gets automatically disarmed everyday at a particular time stored in the system.

3.7 Night mode arming

In this mode delayed feature of delayed zone is disabled because at night there are usually no entries/exits from main door of house.

3.8 Remote Arming and disarming

System can be armed and disarmed remotely making use of DTMF tones.

3.9 Arm and Disarm Notification

System sends SMS to the first number stored in the system whenever system is armed and disarmed.

3.10 Intrusion log with time, name and address

Whenever any intrusion occurs, system sends SMS to the numbers stored in the system which contains zones under intrusion, time of intrusion, name and address of the owner.

3.11 Voice message recording and playback

System allows user to record voice message which can be used for providing information about intrusion and this message is played when system calls users about intrusion message and as soon as user attends the call, system start playing the recorded message.

3.12 User editable name and address for alarm SMS

User can edit the name and address information to be sent as intrusion log.

4. SYSTEM HARDWARE DESIGN

The complete system is composed of following parts

4.1 Sensor Nodes

These are the nodes which sense various kinds of parameters e.g. door sensors, fire sensors etc. Door sensors are attached to various doors and windows of the house from where chances of intrusion are there. Fire sensor can be placed at any location, preferably near kitchen. Whenever there is fire, intrusion or some other kind of abnormal situation, sensor node sends that data to the base station. It is composed of a sensing element, Atmega8 [2] microcontroller and XBEE [3] transceiver.

4.2 Base Station

Base station is made up of a radio transceiver XBEE and atmega8 microcontroller. This base station receives the data sent by sensor nodes and then sends the intrusion data to the dialer through one of its ports.

4.3 Control Panel

This is the user interaction part of the system. This is the part of the system using which user controls various aspects of the system. For example enabling and disabling zones, setting delayed zone, changing delay values, recording voice, playback voice etc. Atmega16 [4] microcontroller is used in the control panel. There is a keypad consisting of 16 buttons arranged in four rows and four columns. This arrangement allows multiplexing for taking input from the keypad and thus requiring only 8 pins of the microcontroller instead of 16. So numbers of pin required for taking input from the keypad have been reduced from 16 to 8. Control panel also contains a RTC (Real Time Clock) DS1307 [5] which is interfaced to Atmega16 microcontroller. Microcontroller once sets the time into the registers of this RTC, after that RTC always supplies the microcontroller the right clock time even if the system is powered off in-between because RTC has been given a battery backup. For the messages to be displayed to user, a 20x4 LCD has been interfaced to the microcontroller. 20x4 means LCD has 20 columns and 4 rows, so allowing a total of 80 characters to be displayed at a time on the LCD. There is one MAX232 [6] in the control panel using which is used for

converting between TTL logic serial data and RS232 serial data. Microcontroller works on TTL logic serial data but it doesn't have long distance communication range. As distance increases number of errors also increase. So RS232 is used for communication between control panel and dialer, because it has long distance communication range along with reduced number of errors.

4.4 Dialer

Dialer is the that part of the system which makes calls and sends SMS to users whenever there is some intrusion/fire or any other abnormal condition. Dialer comprises Atmega162 [7] microcontroller, GSM module SIM300 [8], HT9170 [9] DTMF decoder, APR9600 [10] Voice recording and playback IC, 16x2 LCD and MAX232. Atmega162 was chosen because we needed two UARTs - one for communication with GSM module and other for communication with the control panel through MAX232. This MAX232 simply performs conversion between TTL serial data and RS232 serial data. HT9170 performs the DTMF decoding for sending data to the system remotely using mobile phone [9]. This is the part which allows us to enter the secret code remotely and enabling and disabling the system remotely. LCD is used just for debugging here. APR9600 is voice record and playback IC and allows around 30 seconds of recording and playback [10]. From base station, Atmega162 gets the data whether there is some abnormal condition/intrusion or not. Whenever central controller detects that there is an intrusion using the data sent by base station; it sends the zone information to Control Panel and asks control panel for the current time so that it can send alarm messages to users. Then it starts calling and sending SMS to the numbers stored in the system using the AT commands [11] for the GSM module SIM300. Whenever user attends the call, it starts playing a prerecorded message for the user to listen to which gives some information about the intrusion. Along with that it also allows remote arming/disarming of the system. For this DTMF decoder's valid pin is connected to the interrupt pin of the microcontroller and whenever a valid code is entered, along with arm/disarm option; central controller sends that information to the control panel. Now control panel controls the complete system arming/disarming.

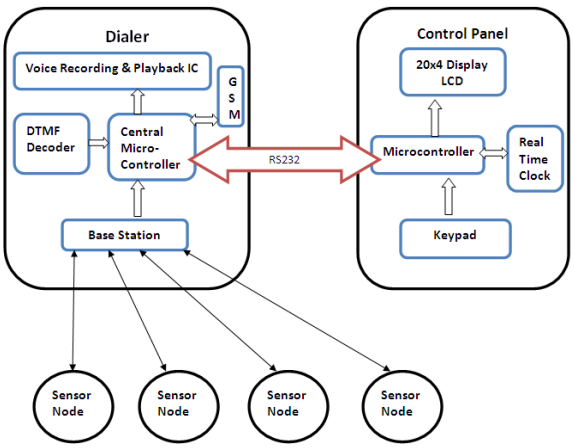

Fig 2: Overall System Design

5. SYSTEM SOFTWARE DESIGN

Software flow for various system components are given below.

5.1 Software Module for WSN Node Communication

In our system, the communication protocol is divided into three layers. The first layer is physical layer whose function has been implemented by XBEE module itself. The second layer is network layer which applies TEEN (threshold sensitive energy efficient sensor network) protocol. The data will be transmitted by the node only when there is a significant change. [12] The third layer is application layer. In this layer, the system's application software is divided into two modules, base station software module and sensor node software module. The former is responsible for wirelessly collecting sensor data and send that data to the dialer. The latter is responsible for sensing various parameters and whenever there is significant change; transmit that data wirelessly to base station. The software flow of base station node is illustrated in Fig. 3. And software flow of sensor node is illustrated in Fig. 4.

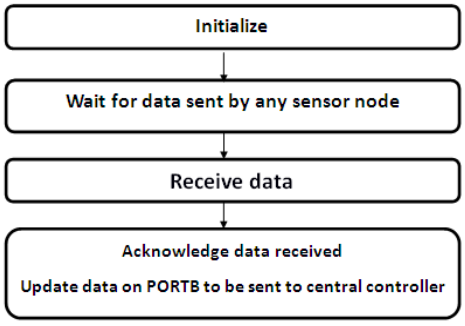

Fig 3: Software flow for base station node

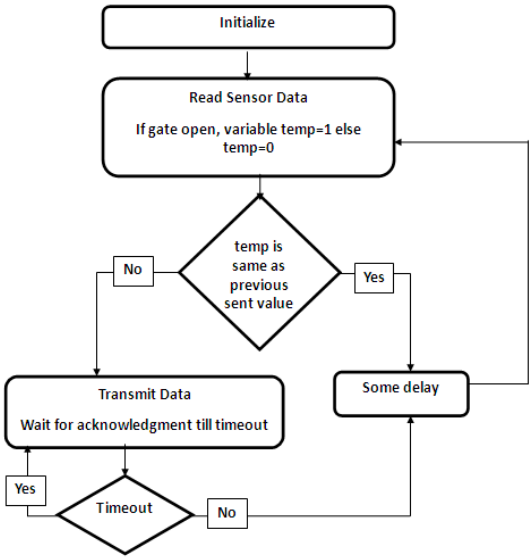

Fig 4: Software flow for sensor node

5.2 Software Module for Dialer

Whenever the central microcontroller in dialer receives abnormal data from base station through one of its ports, it asks control panel for the current time for the intrusion log. Then it asks GSM module SIM300 to start calling the numbers stored in its EEPROM. Along with voice calls, it also sends messages containing the intrusion information such as time, zone, name and address of owner etc. to the numbers

Table 1. AT Commands used in the system

Command	Description
ATA	Answer an incoming call
ATD	Dial a number
ATH	Hang up call
AT+COLP	Connected line identification presentation
AT+VTS	DTMF and Tone generation
AT+CMGF	Select SMS message format
AT+CMGS	Send SMS message

stored in the EEPROM of the system. The software flow of dialer is illustrated in Fig. 5.

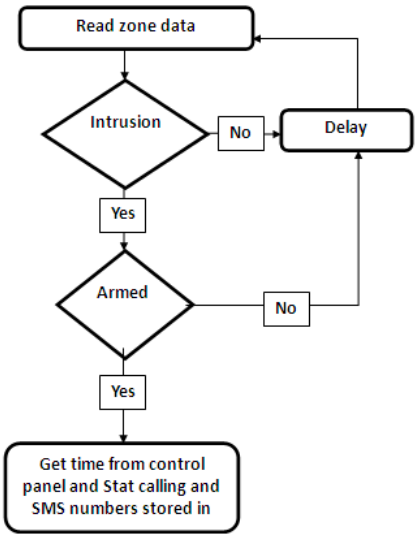

Fig 5: Software flow for dialer

5.3 Software Module for Control Panel

This is the user interaction part of the system. This is the part of the system using which user controls various aspects of the system. This part continuously waits for user input and any control character received from the dialer and depending upon the input, it performs further operations. The software flow for control panel is illustrated in figure 6.

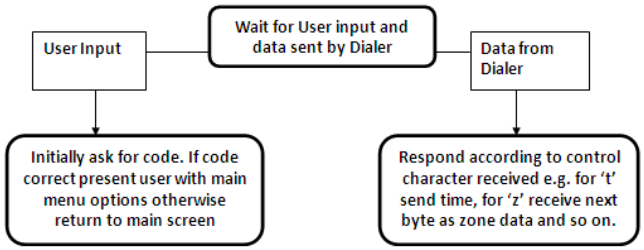

Fig 6: Software flow for control panel

6. Set Up A Prototype And Test

According to Fig.1, we set up a sample prototype system in our lab. We used LM35 [13] as the temperature sensor that can detect the room temperature. We used a jumper as door sensor. After hardware connection, installed the appropriate software developed with CVAVR on all the microcontrollers in the system. Then, we started the test with this prototype system by changing the preset temperature threshold for creating the effect of temperature raise because of fire and opened the jumper for creating the effect of opening the door. When the actual room temperature exceeded the preset temperature threshold or some gate opened, the base station sent abnormal data to dialer, which immediately triggered SIM300 GSM module to make calls and send SMS containing intrusion log to all the numbers stored in the system. Throughout the test process, this prototype system operated successfully and effectively.

7. Conclusion

This project presents one solution for establishing a low power consumption remote home security alarm system. The system, based on WSN and GSM technology, can detect intrusion, fire etc and send alarm message remotely and also can let user listen the prerecorded voice messages which convey some information about intrusion. Along with that system can be remotely armed and disarmed as well. The hardware of this system includes the radio transceiver XBEE, microcontrollers Atmega8, Atmega16 and Atmega162, SIM300 GSM module etc. The system software developed in C language on CVAVR compiler has the ability of collecting, wireless receiving and transmitting data, and can send a piece of alarm short message and calls to the 15 numbers stored in the system when some dangerous condition has been detected. With the advantages of reliability, easy usage, complement wireless, and low power consumption, the system also has practical value in other fields.

8. ACKNOWLEDGMENT

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