Design and Implementation of an SMS Based Home Security System

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Abstract — The project presents a versatile security and alarm system which can be used by individuals, corporations and establishments which require a cheap but reliable security system. The idea behind this project is to provide its users with a simple, fast and reliable way to get help during emergency situations. The device can be placed at any remote location which can be easily accessed by the user. It uses a microcontroller for system control, GSM technology for communication and sends SMS containing the emergency message and the GPS location of the sender. The project consists of an 8-bit microcontroller ATmega16, GSM SIM900A module and two Android applications for user interface with the hardware. One of the application configures the device. On pressing the panic button, the emergency contact receives the emergency message along with the GPS location of the sender. The device has been made for less than 1300INR and it can be used anywhere irrespective of the place of deployment provided mobile network connectivity is available.

Keywords - Atmega16, GSM SIM900A, Android, GPS, microcontroller, security

NOMENCLATURE

SMS: Short Message Service GPS: Global Positioning System GSM: Global System for Mobile communication
RAM: Random Access Memory
EEPROM: Electrically Erasable Programmable Read Only Memory
CISC: Complex Instruction Set Computing
RISC: Reduced Instruction Set Computing
USART: Universal Synchronous Asynchronous Receiver Transmitter
GPIO: General Purpose Input Output LED: Light Emitting Diode INR: Indian Rupee

I. INTRODUCTION

This paper aims to build a hardware system capable of providing the services of the proverbial emergency button to an average user with a smartphone. The device can be used in a variety of situations in which triggering leads to a remedial action. The hardware system is always in the waiting mode, which means it is waiting to be triggered by the push of a button which signifies a state of emergency. On pressing the panic button, the device sends out an SMS containing a pre-saved message and its GPS location. Such a device can be used in variety of locations: Home (it can be used as an emergency button which can inform the police or a security guard about a threatening situation), Hospitals (it can be placed close to each patients bed and can be triggered by some biomedical sensor), Hotels (one of these can be put in each room and it can communicate with the reception on the press of a button). The system has been designed keeping in mind the requirements of an average man and will fulfil the purpose of a triggered-security system. In fact, this device can be used in many different ways like, the device can be triggered by a sensor, for example, a rain sensor, fire sensor or even a proximity sensor where a threshold value is selected, above which the device sends out information to the pre-specified number. It uses the GSM mobile communication network to transmit alarm signal and control instruction. The control and communication between the user and the proposed system are achieved through the SMS protocol available in the mobile phone.

The paper is organized in the following way: Section-II gives a brief literature review, Section-III describes the components of the system, Section-IV depicts the system operation, Section- V explains the design procedure and Section-VI gives the total expenditure involved in the hardware realisation of the system. Section-VII concludes the paper, followed by Section- VIII which lists the citations.

II. RELATED WORK

This section gives the work done earlier in this field. A GSM based home automation system has a very low cost of installation and maintenance [1]. It is also very flexible and durable. An advantage of such a system is that there is no risk of it being hacked since it involves only a mobile network [1]. However, these systems involve daily operation costs as the user has to pay for each SMS [1]. So, researchers are trying to simplify the systems and minimize costs of installation and maintenance. Several SMS based home security systems were developed in [1], [2], [3], [4]. In [1], microcontroller AT89C55 has been interfaced with GSM module through RS-232

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communication protocol for interaction between the users' mobile phone and the security system. Rozita, Walah, Chan and Mok in [2], developed a full control home based automation system using PIC16F887 microcontroller which was integrated with GSM module communicating at a baud rate of 9600 bps. Another such system was developed in [3], where a GSM module was interfaced with a desktop computer. Here, clients were connected to the computer through Wi-Fi access points and the home appliances have wired connection to the computer. Md. Shafiul Islam in [4] used PIC18F452 microcontroller to monitor doors and windows of a home which could be accessed only by entering the proper ID.

III. COMPONENTS

The overall system contains a lot of different functional units which combine together and interact with each other to provide the total functionality of a security system. These different components are combined as follows to provide the total functionality:

- Microcontroller and GSM Module are put in the same box called as device along with a push-button. They are wired together to be installed at the users preferred location and define the hardware of the system.
- Android Applications (Two in number) provide the software part of the system and are coded in Java.

Microcontroller:
An 8-bit microcontroller called ATMega16 has been used in this project. It is a low-power microcontroller based on AVR enhanced RISC architecture. It is a 40 pin microcontroller with 32 I/O (Input/output) pins divided into four 8-bit ports designated as PORTA, PORTB, PORTC and PORTD. ATmega16 has 16 KB programmable flash memory and static RAM of 1 KB. The AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.

GSM:
SIM900A evaluation board has been used, which is controlled by the microcontroller ATmega16. SIM900A evaluation board is used to make development process easier and faster. It interfaces the SIM900A directly with appropriate power supply, SIM card holder, RS232 serial port for connection with PC, antenna and all GPIO of the SIM900A. SIM900A module is controlled by ATmega16 that contains user application. The board contains SIM900A as its wireless module, which is ultracompact that can support voice, data, and fax at both 900 and 1800 MHz . This is also a low power device which has a tiny size- 24mm*24mm*3mm which helps in putting it with a microcontroller on a bread board in a small sized box to form our device.

Android Application:
Two applications have been made to support the software functionality for smartphone users. First one, SecureU, provides a way to turn ON and OFF the application, change the details and save it. Second one, SecureU Config, uses a text message to configure the hardware device remotely. So, the user can just change the settings and send it to the hardware device where it will be saved in EEPROM of ATMega16 and will be used in the next run of the code. This functionality is of paramount importance to the users where they can fit the device once and forget it. The only thing they need to care about is updating the setting/configuration whenever the need arises and the position of the panic-button, that is, the GPS location of the sender of the emergency message.

IV. SYSTEM DESCRIPTION

As mentioned earlier, our project is the sum total of the components: Microcontroller, GSM Module and two Android applications. The individual working of each components and their integration can be technically broken down into the following subtasks:

- The microcontroller and GSM module communicate with each other through USART communication.
- The microcontroller sends an SMS using the GSM module on occurrence of one of the two events: (a) when a button is pressed; (b) as an acknowledgement reply when the user is saving new configuration settings.
- The microcontroller receives SMS through the GSM module and retrieves the new configuration settings from the SMS and saves the same in the microcontrollers EEPROM.
- The android application named SecureU sends a Cry for help SMS containing the GPS Location (of the mobile in which it is installed) to a desired location for example, Police Station.
- The android application SecureU Config stores the new configuration from the user and sends them via SMS to our device in a format understood by the device.

V. DESIGN PROCEDURE

Microcontroller and GSM Module Interfacing:
The microcontroller Atmega16 and the GSM Module SIM900A are connected to intercommunicate via the USART device present in the Atmega16 chip. The Rx (PD0) and Tx(PD1) pins of Atmega16 are connected to the Tx and Rx of the GSM Module respectively.

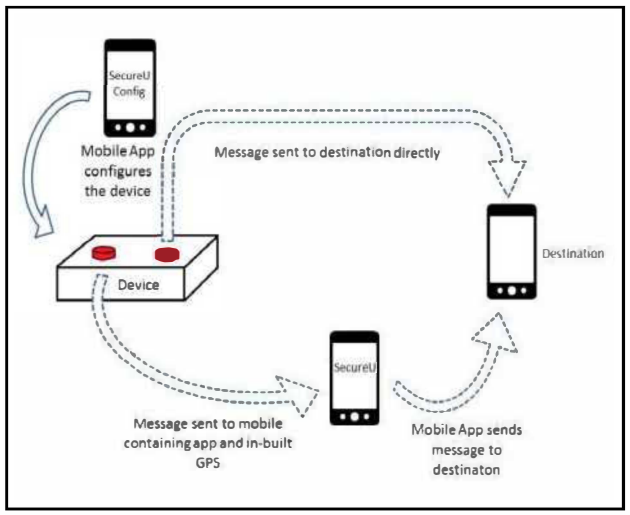

FIG. 1. WORKING OF THE SYSTEM

The GSM Module SIM900A can accept power supply in the range 9 to 15 volts. It is powered with a 12 volt dc adapter. The Atmega16 is powered with a 5V supply from the 5V power output pin in the GSM Module. The two buttons in our device are connected to the Atmega16 External Interrupt pins: INT0 and INT1 on one end, and the other end is grounded. The pull-up resistors in the interrupt pins are enabled in the coding. So, pins INT0 and INT1 are at 5 volt by default. When a button is pressed, the corresponding pin is grounded (0 volt).In addition two LEDs are connected to pins PORTB2 and PORTB6 of the Atmega16 for status indication. The USART has to be initialized before any communication can take place. The initialization process normally consists of setting the baud rate, setting frame format and enabling the Transmitter or the Receiver. Baud rate is set by writing the value of in the Baud Rate Registers: UBRRH and UBRRL.

$$[CPUfreq \div (16 \text{ x } baudrate)] — 1 \quad (1)$$

The USART Transmitter and Receiver are enabled by setting the Transmit Enable (TXEN) bit and setting the Receive Enable (RXEN) bit in the UCSRB Register to one. A frame format of 8 data bits and 1 stop bit is selected by setting the UCSZ1 and UCSZ0 flags to one and the USBS flag to zero in the UCSRC register.

Sending SMS via GSM Module:
The microcontroller sends an SMS in the following two events:

1. *When a button is pressed:* The buttons are connected to the INT0 (PD2) and INT1 (PD3) pins of Atmega16. When pressed, Interrupt Service Routines of external interrupts INT0 and INT1 are triggered. The initialization of interrupt is done as follows:
   - The pins PD2 and PD3 are configured as input ports by appropriately setting the DDRD register.
   - The pull up resistors for pins PD2 and PD3 are enabled by appropriately setting the PORTD register.
   - The INT0 and INT1 interrupts are enabled by setting the INT0 and INT1 flags of GICR register to one.
   - The interrupts are configured to be triggered at the rising edge by setting the ISC00, ISC01, ISC10 and ISC11 flags in MCUCR register to one.
   - The Global Interrupt flag in the SREG is set by calling the sei() function.

2. *Saving new settings:* When a user sends a message to save new settings in the device, the microcontroller is required to send an SMS to the user notifying that the new settings have been saved or that the pin in the message is incorrect*Receiving SMS from GSM Module and saving new settings in EEPROM:* In order to receive any data from the GSM Module, the RXC interrupt of the Atmega16 is used. The RXC flag in UCSRA register is set when the USART has already received a byte from the GSM Module. As soon as the RXC flag is set, the RXC interrupt is triggered and its

ISR is executed. In the ISR, the received byte is read from the UDR and written to a character array named URBuff. The RXC interrupt is enabled by setting the RXCIE flag in the UCSRB register. When a new SMS is received by GSM Module, it sends a new message indication to Atmega16. This message indication starts with +CMTI. In order to detect new SMS arrival, Atmega16 keeps on checking the URBuff length continually in an infinite while loop. If the length found to be non-zero, the array URBuff is checked for +CMTI. If found, it implies that a new message has arrived. Now the Atmega16 sends the AT+CMGR command to the GSM Modem. GSM Modem then sends a string of data to Atmega16 which contains the sender's number and the message body which are retrieved by Atmega16 by reading the buffer URBuff.

The number and message body is then passed onto a C function:

void SetConfig (char *number, char *message)

1) Functional Algorithm of SetConfig function: Steps of the algorithm are given below:

Step 1: Wait until a new message arrives.
Step 2: When a new message arrives, retrieve the sender's number and message body.
Step 3: Look for the sequence 'double-hash ABC' at the start of the message body.
- If found, go to Step 4.

- If not found, go to Step 1.

Step 4: Check the 4 digit pin enclosed within < and > in the message body.

- If pin received is incorrect, notify the sender.
- If pin received is correct, go to Step 5.

Step 5: Check for occurrence of tags <hash N> and <N hash> in the message body.
If found, save the destination number setting enclosed within these tags in EEPROM. Then go to Step 6.

- If not found, go to Step 6.

Step 6: Check for occurrence of tags <hash M> and <M hash> in the message body.
If found, save the message setting enclosed within these tags in EEPROM. Then go to Step 7.
If not found, go to Step 7.
Step 7: Check for occurrence of tags <hash G> and <G hash> in the message body.
If found, save the GPS Location number setting enclosed within these tags in EEPROM. Then go to Step 8.
If not found, go to Step 8.
Step 8: Check for occurrence of tags <hash P> and <P hash> in the message body.
If found, save the new pin setting enclosed within these tags in EEPROM. Then go to Step 9.
If not found, go to Step 9.
Step 9: If any of the above tags were found in the message body, notify the sender that new configurations have been saved. Then return to Step 1.

Android Application 1 (SecureU):

The android application designed for the project application acts as a communication interface between the senders side and the receivers side. It provides a very user friendly interface for all its controls and actions.

Working Principle:

- It senses every incoming SMS and check if it is from the desired sender number.
- On sensing a SMS from the desired sender it comes into action.
- It accesses the built-in GPS system of the mobile and collects the current location details (current latitude and longitude).

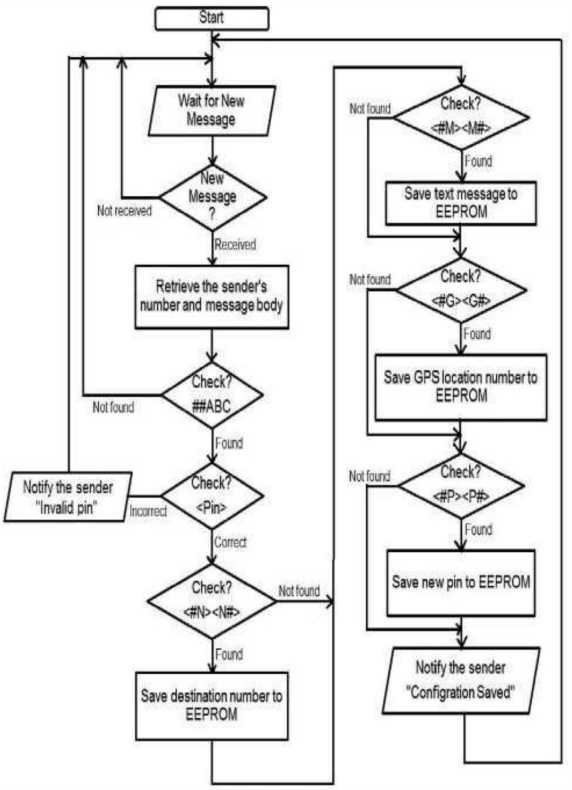

FIG. 2. FLOW CHART OF THE CONFIGURATION SAVING ALGORITHM

FIG. 3. HOME SCREEN OF SECUREU

FIG. 4. SETTINGS CONFIGURATION SCREEN

FIG. 5. SECUREU CONFIG HOME SCREEN

Application Description: The application basically consists of two screens for user interaction. The first screen, for SecureU, consists of three buttons namely START, STOP and CONFIGURE.

- START: Pressing of this button initiates the application by starting its services. It allows the application to run in background.
- STOP: This button terminates the application. It closes all the background activities of the application.
- CONFIGURE: This button leads the user to another screen consisting of three text fields where the user needs to feed the Device number(GSM module phone number), Destination number and a text message. The Save button keeps these feeds saved until it is changed again.
- On incomplete filling of the details, the application notifies the user at the start up to avoid malfunction.

Android Application 2 (SecureU Config)

SecureU Config is an android application designed to give the users a very simple-to-use experience in configuring the device.

1) Working Principle: The application allows the user to configure the following parameters:
Destination Number
SIM number of the mobile containing the SecureU application and in-built GPS
A text message to be sent to destination and
An authentication 4-digit PIN.

2)On clicking the Configure button:

- The received entries from the user input are logged and special prefixes and suffixes are added to all the fed details and are arranged in a format understandable by the microcontroller to be configured.
- The formatted string of text is sent to the SIM number of the Microcontroller device.
- When the PIN is to be replaced, a new PIN is entered in the NEW PIN field and the old PIN is filled as usual in the PIN box. The old PIN is then replaced by the new PIN inside the device and remains saved.

3) Application Description: The application displays a single screen consisting four text fields namely Destination Number, GPS Location Number, Message, 4 Digit PIN, Secure device number, PIN.

- Destination Number: The 10 Digit receivers contact number is fed into this field. Country code (0 or +91) may be entered as prefix.
- GPS Location Number: This field is to be filled with the mobile number where the SECUREU application is installed. This field is only use when GPS location is needed. Otherwise this is left blank.
- Message: This contains all the information in a simple text format that is sent to destination mobile number.

4) Digit Secure PIN: This field is filled only when the current authentication PIN needs to be changed with a new PIN. The new 4 digit PIN is entered here.

- SecureU Device Number: The SIM number of device to be configured is entered in this field.
- PIN: Current authentication 4 digit PIN is entered here.

TABLE I. COST

Sl. No.	Components	Quantity	Cost per	Total
1	ATmega16	1	175	175
2	GSM	1	900	900
3	Push Button	2	25	50
4	Breadboard	1	100	100
5	Miscellaneou			50
Total Cost: 1275				

- Configure: Button to save the entered PIN and send the message with the filled entry details.

VI. COST

The overall expenditure of the project is specified below. These include the cost for every physical component that was used.

VII. CONCLUSION

This paper successfully implements a triggered security system based on micro-controller and GSM. The device costs about 1300 INR and is used along with an android application to maintain security at any location through a panic-button. Hence, it can provide a cheap, quick and reliable security service for any user to be used at their homes. The cost of this device can be brought down to about 500INR with further development and much more functionality can be added by having different sensors as triggers.

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