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MONITORING AND OPERATION OF INTELLIGENT HOME SYSTEM USING PASSWORD PROTECTED SMS SERVICE

AZID S.I.* AND KUMAR S.

School of Engineering and Physics, The University of the South Pacific, Suva, Fiji
Corresponding Author: Email- azid_s@usp.ac.fj

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Abstract- This paper presents a mobile phone based Intelligent home system equipped with motion sensor, smoke detector, temperature sensor, humidity sensor and light sensors. The sensors are controlled by a microprocessor PIC 18F4520 through the Short Message System (SMS) having password from the user or any mobile used for secure operation of the Intelligent home. The microprocessor after completing the required task contained in the SMS reads the sensor measurements of respective sensor and then feedback to the user by SMS in an average time of 20.3s. Intelligent home has been designed such that if there is any emergency, it will send an emergency SMS to the user in about 9.26s. The operation of the Intelligent home has been successfully tested on Vodafone- Fiji network and can work with other networks in the world.
Keywords- Intelligent Home, SMS, Microprocessor, Sensors, Automation

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Introduction

'Intelligent home' is alternatively referred to as Smart home or Automated home and several other terminologies have also been used [1]. The term Intelligent home simply indicates the automation of daily tasks with reference to the appliances used in the home. This could be the control of lights or more complex chore such as remote viewing of the house interiors for surveillance purposes. The Intelligent home networks are progressing bigger as a way to offer a comfortable, convenient, and safe environment for occupants [2].

The 21st century has been regarded as the information era. The penetration of internet connection that can be used for home automaton is the new dimension along which technologies continue to grow [3]. The Internet based automation is controlled by the server situated in the home. The wireless technology has some amazing achievements in automating home via Bluetooth [4], ZigBee [5-7], and Wi-Fi [5].

Furthermore, remote controlling and monitoring of a house using web internet requires a computer, which is large in size and heavy to carry around. Global System for Mobile Communication (GSM) module was then introduced for home automation [7]. The GSM module system are battery powered which made home automation system safer from internet hacks. home automation has further advanced in successfully merging communication technologies GSM module, internet, and speech recognition system [7]. The wireless automation reduces the cost of the system unit as well as it is much easier to install. The GSM module has advanced to automobiles. It can be interfaced with the car ignition system where the owner carries the mobile phone rather than to carry around the key [8]. Recent advances in the automation showed that the billing system for electricity, gas or water uses GSM module based SMS metering service rather than assigning person to visit each house and read the meter readings manually [9]. However, the GSM module has some drawbacks as it cannot behave like what the actual mobile does. GSM module users have to remove the SIM card for recharge top-up. There is more exposure in using the GSM network if only the mobile is interfaced rather than GSM module.

Mobile Phones have become one of the most popular communication devices amongst the people all over the world. At the present with the world population of around 6.7 billion peoples, 60% of the world population uses mobile phones which are about 4.1

billion mobile phone users. Since the GSM network started its operation in 1991, the SMS became popular as it provides cheap and convenient method of communication. SMS users are able to message over 160 (7 bit) word characters including the space using cellular network to almost anywhere in the world within seconds [10]. Unlike the Internet, the SMS is safe from network security threats and can be operational from anywhere in the world where there is a mobile network.

In this paper we present Mobile Phone based Intelligent home. This system interfaces the mobile phone with embedded microprocessor PIC18F4520 which is based in the home. Any mobile phone which supports Attention (AT) Command language is used to interface with microprocessor. The user can use SMS for monitoring and controlling lights, home appliances and security sensors and get feedback on the same mobile phone about the status of different appliances. The entire system is password protected which can only be changed by the user. The system is generic as it can work with any mobile network. The system designed has two way switching properties which means that the home 240V AC or 110VAC electrical appliances, lights and sensors system can be switched on and off by mobile phone and also by the manual switches.

Control and Management of the Intelligent Home System

The overall architecture design and networking of the Intelligent home system is shown in "Fig. (1)". The Intelligent home system is able to set up mobile phone SMS mode to text mode. First it checks battery charge level of the mobile phone every cycle of the coding, that is, about 15 seconds and turns on battery charger if battery level is below 30%. It then reads the message received by the mobile phone interfaced with the microprocessor. The microprocessor then stores the phone number from which the message is received for feedback purpose. If the message indicates low credit, it sends callback message to user indicating that credit is low (Callback message is free for Vodafone Fiji Network).

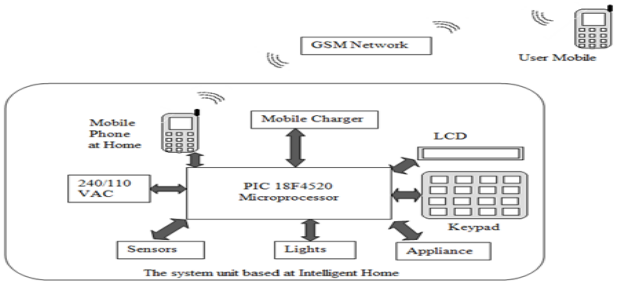

Fig. 1- Architecture of Intelligent Home system.

The system then looks for password in the message if password is wrong it replies to origin SMS indicating "incorrect password". If password matches then it searches for command to be done in the message, does the required task and then writes the feedback in form of message to reply to the sender. The user can activate any appliances, lights or sensors to check their status in the house via SMS using any mobile phone and from anywhere where there is mobile network. If the SMS sent to Intelligent home does not contain the password the Intelligent home will reply to the same number indicating "PASSWORD INCORRECT". This password can be only changed by the user from home. Once the SMS is received, the microprocessor (PIC 18F4520) reads it and performs the task directed by the user and replies the status of light and other sensors in the home. The system based at home is generic, thus any mobile phone which supports AT command will work with the microprocessor provided they are interfaced serially. To add on, it is not necessary that the user number be emergency number. The user can easily change the emergency number on the unit at home. The C language program controlling the microprocessor in the Intelligent home uses 706.5 KB of RAM and 16711.68 KB ROM. The AT command language is used to communicate with the microprocessor.

The smoke and motion sensor sends an interrupt to the microprocessor when triggered. As soon as the interrupt is detected the microprocessor halts and goes to the interrupt routine. It first detects the type of emergency and writes the SMS to the emergency mobile number stored. The sent message is a stored message stating the type of emergency and the location of the Intelligent home. For example "EMERGENCY Fire detected at 17 Port Denarau Rd, Nadi".

The microprocessor is programmed in C language to communicate with the sensors and the mobile phone. The programming is designed such that the C language can communicate with AT command language of the mobile phone. The AT commands are common to all mobile phones. The set of AT command used to develop the system is given in Table 1.

Table 1- AT Command Roles

ATE0	Test if phone supports AT command
AT+CMGF=1	Sets the mode to SMS text mode
AT+CBC	Checks the battery level
AT+CMGL= "REC UNREAD"	Reads unread messages
AT+CMGD	Deletes read Message
AT+CMGS	Writes and Sends Message

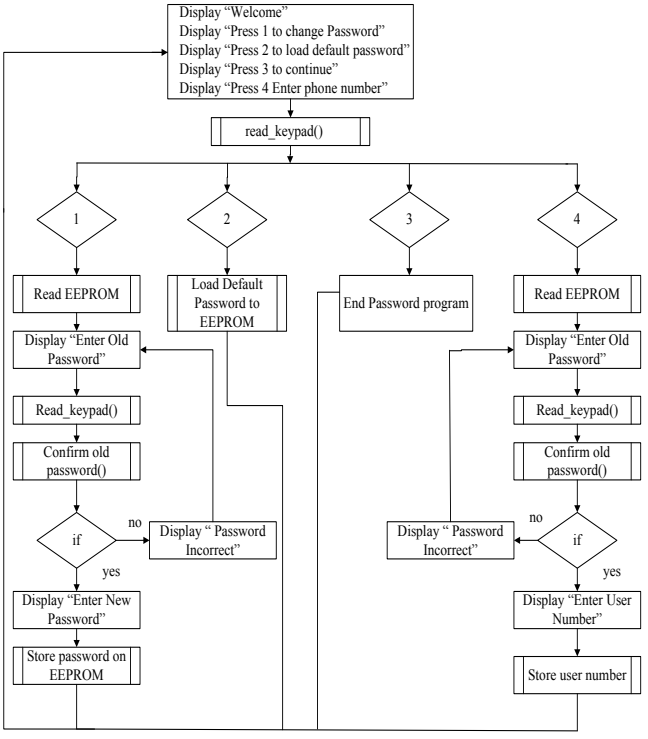

Fig. 2- Flowchart of the main menu showing the operation of the Intelligent Home.

"Fig. 2" describes the flowchart structure of the password programming. The password entered by the user is stored in the EEPROM of the microprocessor; therefore, it is not erasable even if the power goes off. The second option is to enter default password if the user forgets the password. This option is hidden from view once the program starts running. The third option is to enter the user's phone number for emergency purposes. If motion or fire is detected, then Intelligent home unit will send an emergency SMS to the mobile number entered here. The mobile number can be either local or an International number. The forth option is to continue with the main program.

The Intelligent home proposed in this work has been checked for its operation using the Vodafone Fiji network. If the Vodafone SIM credit goes low a SMS is sent to the user by their service number 116 in this case.

The microprocessors as well as the mobile phone are both Data Circuit Equipment (DCE) devices. It will not be possible to connect both of them as they conflict. As shown in "fig (3)" Signal Ground is connected such that both grounds are common to each computer. The Data Terminal Ready (DTR) is looped back to Data Set Ready (DSR) and Carrier Detect (CD) on the mobile phone side. When the DTR is asserted active, then the DSR and CD immediately become active. At this point the mobile phone senses that it is ready to detect the carrier of the microprocessor. As the mobile phone and the microprocessor communicate together at the same speed the flow control is not needed thus these two lines are also linked together. When the mobile phone needs to send data, it asserts the Request to Send (RTS) high and as it is hooked together with the Clear to Send (CTS), it immediately gets a reply that it is okay to communicate.

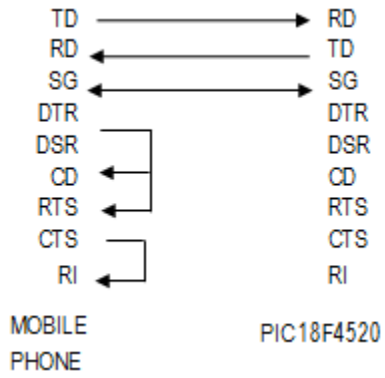

Fig. 3- Serial communication design

The lights and other appliances controlled in the Intelligent home have two way switching system. One of the sides of the switching is manual and the other side is controlled by the microprocessor. Single Pole Double Throw (SPDT) relay is used to fulfill the two way switching from the microprocessor side. For the two way switching system, the light and appliances can be turned on or off from any side of the switch as shown in "fig (4)".

The current from the microprocessor is not enough to switch the relays. Darlington array is used to boost the current supply to the relays as shown in "fig (4)". Each channel for is rated at 500 mA and can withstand peak currents of 600 mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite to the outputs to simplify the board layout.

The microcontroller output is 5V which drives the relays to control the 240V AC. When the relay switches, the counter electromotive force is generated that can freeze the microcontroller. An Opto-coupler is used to solve the counter electromotive force problem by creating a wireless zone between the transmitter and the receiver sides in the Opto-coupler. Infrared transmitter and receiver have been used to design the Opto-coupler.

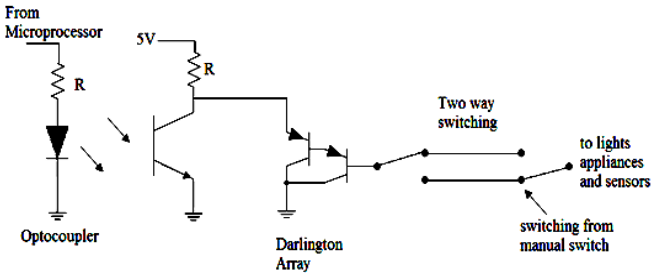

Fig. 4- Switching from low voltage to high voltage.

The Operation of Sensors at the Intelligent Home

The Intelligent home presented here consists of smoke detector, motion sensor, temperature sensor, humidity sensor, and light sensors mounted at appropriate locations. [13, Azid and Kumar] have presented the detailed analysis on the performance of sensor used in this Intelligent Home system. However a brief description of sensors are given as follows.

The smoke detector used for smoke and fire detection is mounted on the ceiling as the smoke is hot and lighter so rises up in the room. The smoke detector used in Intelligent home uses low power CMOS ionization smoke detector IC which triggers an alarm via an external piezoelectric transducer and internal drivers. The pin which activates the alarm is connected to the interrupt pin of the microprocessor.

Passive Infrared (PIR) sensor is used for motion detection. The sensor is mounted between 1.1 to 3 meters of height for the best detection range. 12V DC is given to the PIR sensor to power up the sensor. It motion is detected, the microprocessor reads it as "Interrupt" and as a result a SMS is sent to the emergency number.

The Light Dependent Resistor (LDR) is chosen for light sensing as it is the cost effective light sensor of all and it does the task successfully. 5V DC is supplied to the LDR and the output analog voltage is read by the microprocessor. The microprocessor will read in full light if the light is above 300 lumens.

The temperature and humidity sensor is used for the temperature measurements. 5V DC is given to power this sensor which after powering up requires a time of about 11ms to reach the operating state [11]. No command should be sent before that time. Power supply pins (VDD, GND) are decoupled with a 100 nF capacitor. The serial clock input is used to synchronize the communication between the microcontroller and the Temperature and Humidity sensor. Since the interface consists of fully static logic, there is no minimum Serial Clock Input (SCK) frequency. The DATA pin is used to transfer data in and out of the device. DATA changes after the falling edge and is valid on the rising edge of the serial clock input. During the transmission the DATA line is required to remain stable while serial clock input is high.

Performance of the Intelligent Home System

The requirements of a home security system include low cost, low power consumption, easy installation and fast response. The proposed Intelligent home design utilizes a PIC 18F4520 microprocessor which acts as the brain of the Intelligent home [12]. (Azid and Kumar [12] have studied the performances of sensors used in this system for their feasibility and tested for 24 hour period of a day before installation in the Intelligent home). The results obtained with all the sensors showed that they are suitable for the Intelligent home requirements [12]. The sensors were appropriately installed and wired for security and safety requirements, such that the user would get an instant SMS in case of any emergency. The 240V AC lights and appliances are controlled by two way switching system that we designed specifically such that it can be controlled by SMS and the and also manual switch located at home have made the system user friendly.

A set of 25 SMS were sent from the user using Vodafone Fiji Network to same and different mobile network (Digicel Fiji) to activate and deactivate the lights, switches and sensors in the Intelligent home. The experiment showed that it takes about 18 to 22 seconds for the Intelligent home to process the information and send feedback to user. Another experiment was designed to get the time taken of 25 samples for the Intelligent home to send an emergency SMS to the user and appropriate civil authority using the same mobile network which took about 8 to10s, hence the Intelligent home takes an average time of 9.26s to alert the user in case of any emergency and an average of 20.36s for the Intelligent home to respond to the message sent by the user's mobile and for the mobile phone based in the Intelligent home to give feedback to the user. "Fig (5)" shows that both feedback and emergency response a message within the same network and with different network has almost same average response time in seconds.

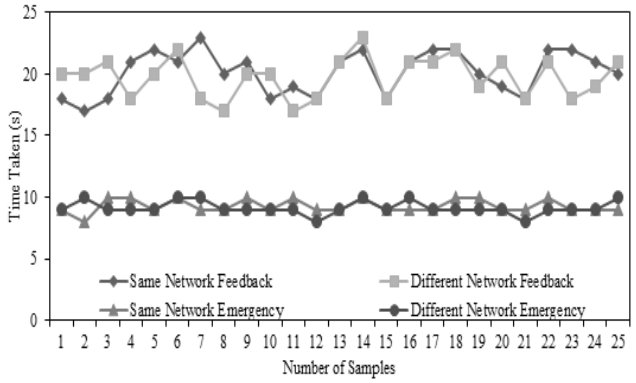

Fig. 5- The Time taken by samples between same network and different mobile network for Feedback and Emergency response

Summary and Future Works

A cost effective and SMS operated Intelligent home system presented here has been successfully demonstrated. The SMS contains the password and system operated only when password is correct. The AT commands have been used that provide a flexible way to control and explore the services of mobile. The communication with the Intelligent home is solely through SMS which can be sent using any mobile and network in the world. The system is self-contained and automatically checks the battery level of the mobile attached to the microprocessor and can charge when battery level goes below the 30 percentage.

The proposed Intelligent home system can be extended to the third or fourth generation mobile networks. This will initiate interfacing video surveillance cameras in the Intelligent homes. In case of an emergency the Intelligent home can send live video streaming of the emergency event to the user. Furthermore, voice recognition system can also be introduced to control the Intelligent home. The program should be able to detect the users voice as the password and able to recognize what the user is saying for the Intelligent home to respond.

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