An Elegant Home Automation System using GSM and ARM based architecture

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***Abstract*- in the recent years, every day new technologies are coming up in the field of electronics, and tremendous changes have taken place in the daily life of people in general. Especially, the home based environment has experienced an introduction of digital technology, supported by wireless communication and computer networks, that gives innovative and challenging opportunities to design intelligent systems for home automation. The research work presented in this paper focuses mainly on developing a smart and elegant home automation system using the ARM (Advanced RISC Machine) 'mbed' microcontroller (NXP LPC11U24), and the GSM (Global System for Mobile Communication). Several aspects of home automation such as knowing the status of devices, remote control of home appliances, alerts on fire, gas and smoke detection are explained here. The most widely used communication devices such as mobile phones are considered for remotely controlling the appliances by offering efficient architectures. The proposed system can be implemented using GSM by Attention commands. The GSM technology used in the proposed system can provide remote access to the user. Thus the system provides cost effective, handy and reliable solutions to the common difficulties experienced by a house owner in his daily life, and thus makes his life easier and safer.**

Keywords— Home appliances, Home automation, Microcontroller, Mobile Communication, Relays.

I. INTRODUCTION

Home automation systems have been developed in the past few years using different upcoming technologies, and it is not a new concept. Many designs have been proposed using different technologies such as the Internet, wireless networks, Bluetooth™, voice commands, and so on. The proposed research provides a cost effective system that helps us to know the status of different appliances in the house and also to control them. The technology used here is GSM, and the central processing unit of this system is the NXP LPC11U24 MCU (the ARM 'mbed' microcontroller), which is designed especially to prototype low cost Universal Serial Bus devices and other applications that are battery powered. The specific advantages of using SMS (Short Message Service) for intimating the user, over email or any Internet based messaging techniques are:

1. Text messages are immediately and also directly delivered to the user's mobile phone, which is carried by him/her almost at all times. As soon as a message is delivered, an acknowledgement indicating the same appears on the sender's mobile and thus provides assurance to the sender. In the case of an Internet based messaging technique, there exist latency problems of message delivery, problems of spam or other email filters which do not guarantee delivery of messages.

2. This system can be used in any environment and is free from geographical limitations. It can be used anywhere the GSM network is available. Though this is the same case with that of the Internet, the proposed system does not at all depend on an Internet connection, unlike other systems which require continuous connection, thus incurring more cost. This makes the proposed system more cost effective and universal, catering to the needs of any common man.

3. Another major advantage obtained by employing GSM technology in the field of home automation is that the GSM has a higher security infrastructure, or in other words, it provides maximum reliability as others cannot monitor the information sent or received. But this is not the case with Internet based messaging, as the network is vulnerable to attacks. Though there are some industry proven techniques of facing some of the threats, incorporating these into a home automation system makes it very complex and also adds up to the expenses.

Hence the research work provided here aims at studying the feasibility of implementing an SMS based control of home appliances using the GSM technology, without trying to have any access to other local networks. Also, it is affordable to all classes of people as the hardware used in it is inexpensive. Mobile phones are very common these days and almost everyone has a mobile phone and knows how to send an SMS. This makes the system a real time application.

II. Related Works

Many home automation systems have been developed previously, which are designed based on the concepts of wireless networks like Zigbee Modules, the Internet, voice commands, Infra-red rays etc.

Baris et al. have proposed a home automation system that makes use of communication through the GSM, Internet and Speech commands that are merged into a single system. This method involves communication between the home appliances using RFID (Radio Frequency Identification) communication.

The research work by Khusvinder et al. presents a home automation system based on Zigbee, where all the appliances of a house are connected to the network and a personal computer as an end user. This system requires an Internet enabled device with Java support to remotely control the home appliances.

Al-Ali et al. have described a home automation system based on Java, wherein the all the appliances present in a house are connected to an embedded system board and the remote sensing of appliances is achieved using the Internet connection at the house. Felix et al. have offered a system based on the wireless Zigbee technology (based on radio frequency communications), where the transmitter communicates with every node present in the home. A GSM module is used to facilitate data flow between microcontroller and user. The user can send commands via SMS to the controller and thus achieve control of appliances.

Alkar et al. suggest a home automation system where every appliance is connected through a server to one central node and uses the Internet connection to achieve control of appliances. There are other communication protocols being used to control the devices.

III. System Hardware

The major hardware components in the proposed system are:

1. The NXP LPC11U24 microcontroller: Figure 1 shows the central processing unit of this system is the LPC11U24 microcontroller that is often referred to as the 'mbed' microcontroller. It is designed to prototype low cost USB (Universal Serial Bus) devices. It comes as a package that contains small DIP (Dual in-line package) form-factor and is used for prototyping with some of the devices such as through-hole Printed Circuit Boards, breadboard and the like, and in addition includes a built in USB FLASH programmer. It includes 32KB flash memory, 16KB RAM (Random Access Memory) and other interfaces like Serial Peripheral Interface (SPI), Analog to Digital Converter (ADC), and other input and output interfaces. Its specific features are the ability to run low on power ARM Cortex^{TM}-M0 Core. It runs at a speed of 48MHz and uses the I^2C (Inter Integrated Circuit) serial computer bus. It has an inbuilt USB drag and drop Flash programmer, to communicate with other devices mainly the computer. The prototyping form-factor is as follows: 40-pin 0.1" pitch DIP package, 5V USB, 4.5-9V supply or 2.4-3.3V battery.

2. GSM SIM 300 Module: The GSM module, shown in Figure 2, can accept the SIM (Subscriber's Identification Module) card of any network operator. It is similar to a cellular phone with a unique phone number. The main advantage of this module is the utilization of serial communication and the resultant development of applications based on embedded

systems. This modem can be directly connected to any microcontroller or directly to a personal computer. It can send/receive SMS and also make/receive phone calls. When used in GPRS (General Packet Radio Service) mode, it should be connected to the Internet and it can perform tasks like data transfer. Other applications include SMS control, remote control, data logging, security applications and sensor monitoring and highly reliability for continuous monitoring with a matched antenna. It is very simple to use and inexpensive. It also contains a Quad Band modem that supports all GSM operator SIM cards. We use Attention Commands (AT commands) to control the various operations of the GSM modem.

3. Four Channel Relay Board: Relays are special switches that are used to open and close electrical and electronic circuits, either electro-mechanically or just electronically. They are a kind of control devices which are used to control an electrical circuit, by maintaining or removing its contact with another circuit. When a relay contact is NO, i.e. normally open, there is no contact and when the relay contact is NC, i.e. normally closed, there is a contact maintained. In both cases, when electrical current is applied to the contacts, there is a change of state. Relays switch smaller currents present in a control circuit and do not in general control the devices that consume power, except for some small motors and a few solenoids that draw very less current. However, relays can regulate larger currents and voltages by amplification, because even a slight voltage applied to a relay, can affect in huge voltage standing switched by the relay contacts. To accomplish control of numerous appliances, we use an n-channel relay board, that contains in it LEDs (Light Emitting Diodes) that correspond to the status of appliances. In this work a four channel relay board, as shown in Figure 3, is considered.

4. Sensor Modules: Home automation not just includes the control of electrical appliances, but also detection of fire and the leakage of LPG (Liquid Petroleum Gas). For this purpose, we also use sensor modules like fire/smoke sensor and gas sensor, using which we can obtain the status of the house.

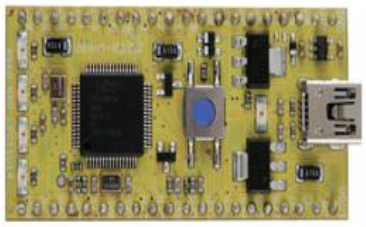

Figure 1. NXP LPC 11U24 Microcontroller

Figure 2. GSM SIM 300 Module

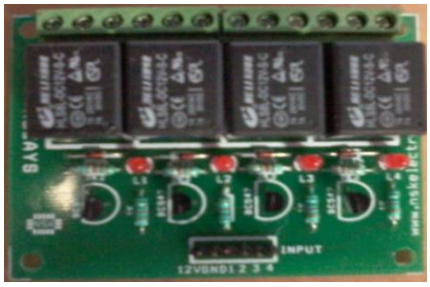

Figure 3. Four Channel Relay Board

IV. Circuit Description And Implementation

The circuitry of the proposed system is elucidated below. Appliances or devices in a house are connected to the 4-channel relay board. The relay board consists of 4 independent relays, mounted on a single board. Each relay is connected to one LED, which indicates the status of the appliance connected to it. There are 6 pins on the board, out of which one is for the power supply (12V), one is for the ground connection and the rest four are control pins for each of the four relays. This relay board is interfaced with the microcontroller. The control pins of the relay board are connected to the input and output ports of the microcontroller. The GSM SIM 300 modem is interfaced to the microcontroller by means of serial communication. The ground pin of SIM 300 is connected to the microcontroller's ground and the transmission and receiving

pins are connected to the receiving and transmitting pins respectively of the microcontroller. The sensor modules like temperature and humidity sensor, and LPG gas sensor are placed on the same board where the microcontroller is placed and are connected based on their pin configurations. The power supply is then given to the microcontroller, relay board and the SIM 300 module. The block diagram is shown in Figure 4 and the circuit connections are shown in Figure 5.

Once the circuit connections are made, a valid SIM card is put in the module and is authenticated. The user's mobile number is verified and set as default for sending SMS. When the user wants to turn on/off an appliance, a message is sent from the user mobile to the number placed in the module. This turns on/ turns off the device through the relay board. In addition to controlling the device, we can also know the status of each appliance, obtain information about the temperature, humidity of the place. The messages used for communication between the user and the system are summarized in Table 1, and the real implementation of switching on and off an appliance is shown in Figures 6 and 7 respectively. In situations like gas leakage or fire breakout, the sensors detect changes in the surroundings and intimate the user through the microcontroller interfaced GSM modem and the user can take necessary and timely action in order to avoid further damage.

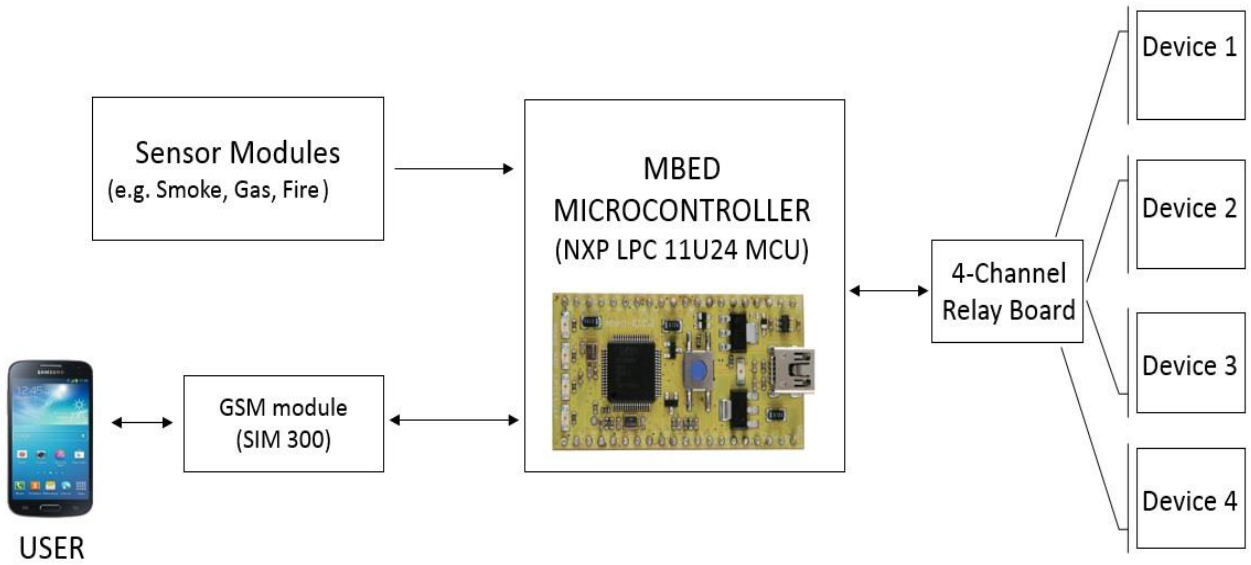

Figure 4. Block Diagram of the proposed work

V. SOFTWARE USED

The online 'mbed' development platform (www.mbed.org) is used for the implementation of this system. It provides free software libraries, the required hardware designs and other necessary online tools for professional prototyping of the microcontroller. The platform includes an open source Software Development Kit (SDK), based on C/C++ for rapid project development, and is licensed under the Apache 2.0. The SDK is designed so as to provide enough hardware abstraction to build powerful and complicated projects. A cookbook of hundreds of reusable peripheral device module libraries is provided, in addition to RTOS (Real Time Operating System), USB and Networking libraries. A Hardware Development Kit (HDK) that provides full support for microcontroller subsystem designs, is also provided for building the development boards and other products that make use of the development platform. The HDK gives us all components and circuits that support the mbed microcontroller. A simple drag and drop USB Flash programmer is provided to make the

programming of the microcontroller very easy. An online compiler is also available for the programming of the microcontroller, which relies on the ARM standard C/C++ compiler, and is configured to test and compile the code efficiently. A main advantage of the compiler is its private workspace feature, though it still provides access to the developer website. A snapshot of the online compiler is shown in Figure 8.

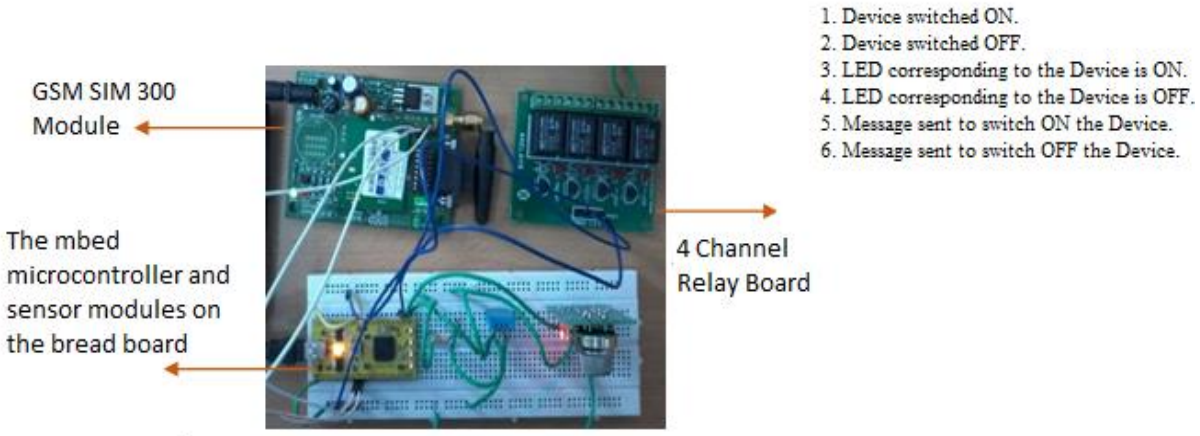

Figure 5. Circuit Connections

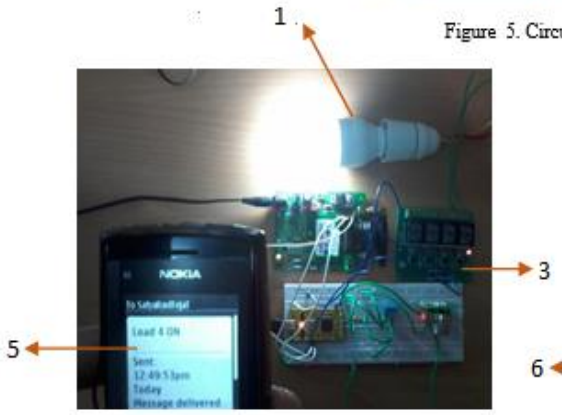

Figure 6. Turn ON any Device

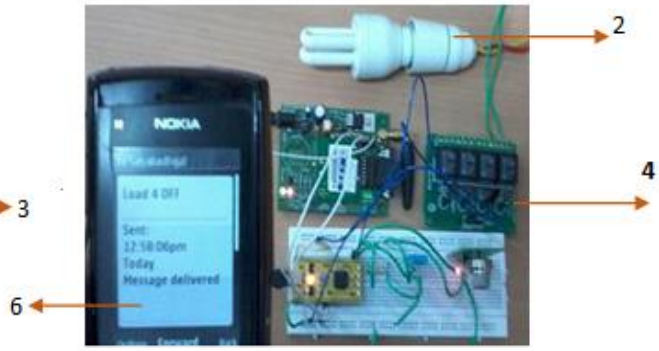

Figure 7. Turn OFF any Device

VI. Future Enhancements

Future improvisations include the implementation of home automation using a cloud, where the home automation technology can be extended with a central server for each house that monitors each and every connected node in the home. Also, an Ethernet connection to home appliances can be established and the audio/video devices can be added to the already established network and thus control can be achieved (e.g. playing music, video, and so forth.). This provides a higher level of automation, while also incurring expenses.

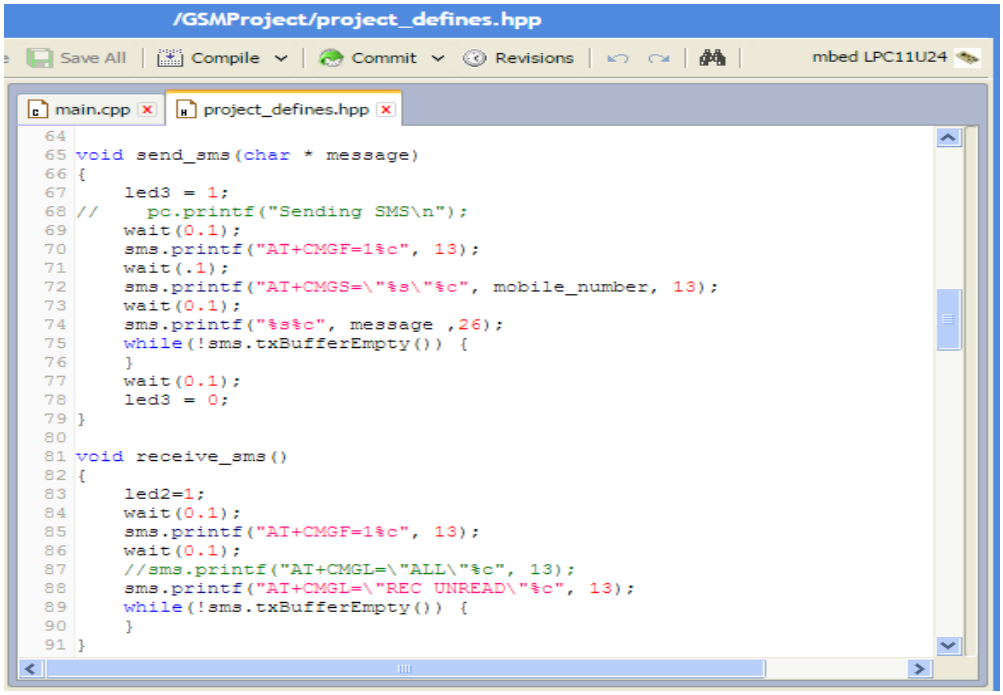

Figure 8. Online Compiler for programming the microcontroller

TABLE 1. List of Messages sent and corresponding actions

S.No.	Message Sent	Action
1.	**Status**	Returns the Status of the appliances
2.	**Load 1 OFF**	Turns off the device connected to position 1 on the 4 channel relay board.
3.	**Load 2 OFF**	Turns off the device connected to position 2 on the 4 channel relay board.
4.	**Load 3 OFF**	Turns off the device connected to position 3 on the 4 channel relay board.
5.	**Load 4 OFF**	Turns off the device connected to position 4 on the 4 channel relay board.
6.	**Load 1 ON**	Turns on the device connected to position 1 on the 4 channel relay board.
7.	**Load 2 ON**	Turns on the device connected to position 2 on the 4 channel relay board.
8.	**Load 3 ON**	Turns on the device connected to position 3 on the 4 channel relay board.
9.	**Load 4 ON**	Turns on the device connected to position 4 on the 4 channel relay board.

VII. Comparative Study

The details mentioned in Table 2, provide information for comparative study of home automation systems that are currently in use and the proposed system. The key feature here is the microcontroller used, the ARM mbed LPC11U24, the characteristics of which, such as the facility for up to 32kB on-chip FLASH memory, up to 4kB on chip Data EEPROM, low working voltage range of 1.8 – 3.6 V, wide operating frequency range of 1MHz to 25MHz etc., provide additional advantages to the proposed architecture. The full details are listed in the table below.

TABLE 2. Comparison of Existing System vs. Proposed System (as specified in Product Data Sheets)

S.No.	Characteristic	Existing Systems	Proposed System
1.	**Microcontroller used**	8051, PIC and Arduino	NXP LPC 11U24
2.	**Software Flexibility**	No online support available for software execution	Free, portable online compiler and open source Software Development Kit
3.	**Peripheral Devices used**	Usage of additional components for serial communication like MAX232.	A simple, built-in drag and drop USB Flash Programmer is provided for communication, without any need for additional components
4.	**Area Occupied**	The space occupied by the home automation units is fairly high	Requires less space due to small and simple circuitry
5.	**Cost Effectiveness**	Usage of wireless networks (e.g. Zigbee) and Internet is costly	Usage of a GSM module, and a simple mobile phone makes it cost effective, reliable and used by general public
6.	**Memory Management**	Up to 256 bytes of Data EEPROM and external FLASH memory provision	Up to 32kB on-chip FLASH program memory and up to 4kB on-chip EEPROM Data memory, along with 10kB SRAM data memory
7.	**Power Consumption**	2.0 – 5.5 V	1.8 – 3.6 V
8.	**Clock Generation**	Up to 10MHz	Wide operating range of 1MHz to 25MHz
9.	**Code Security**	No provision for code security	Uses Code Read Protection (CRP) mode so that the access to the on-chip flash can be restricted

VIII. CONCLUSION

The feasibility of an SMS based control of home appliances using the GSM technology was examined in this work. The conceivable challenges in the practical implementation of it could be packaging the hardware into a single unit and to make it a commercial product. Besides this, if the system were to be installed at a place which receives poor or no signal, the performance of the system might get affected, but GSM signal boosters could be set up at the home place so as to enhance the signal for the GSM module and thus increase the performance. Thus the controlling of home appliances using wireless GSM technology can have a great impact and can revolutionize the life style of people, translating them to a safe and secure way of life. The technique used in the proposed system is very simple and just by using the inexpensive GSM technology and mobile phones, which are easily available and known to the people in general, a real time application can be achieved.

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