Home Appliance Automation using Mobile SMS in Bangladesh

D. M. S. SULTAN, A.H.M. Saiful Islam
Department of Computer Science and Engineering, University Of Development Alternative
Dhanmondi, Dhaka, Bangladesh.
szebon@yahoo.com,tamim_saif@yahoo.com

Abstract

In this paper, it is tried to introduce the latest home appliance automation system in respect of Bangladesh. Widely spread cellular network in all over the country brings a new horizon at centralize controlling. In this instance, automated home appliance implementation using mobile SMS is the right step of Bangladesh of today. Besides this, it highlights the aforementioned issues and offers of ways to overcome the need of remote controlling by employing the most widely used features of today's mobile SMS technology that will act as a bridge in between human and fully automated buildings.

Keywords: Automation, Mobile SMS, Mounted Circuit, Wide cellular coverage Area, Home appliance.

1.0 Introduction

Bangladesh has already developed different communication systems throughout the country as PSTN, Internet etc. But Cellular communication is the most successful among them since it provides the widest coverage area in our country. Besides this, it has even connected the people of such remote places where electricity has not been reached yet. Hence, the cellular communication system will be the right choice for applying our proposed home appliance automation system among all current ICT infrastructures of Bangladesh.

SMS based home appliance automation has already implemented through the most of developed countries. Even two years before, we were not capable enough to use such technology in our ICT infrastructure framework but now this scenario has changed. And we believe that it is the high time to take challenges of implementing such home appliance automation system.

Before going to the depth of such automation system, we need to have the knowledge about SMS. Short Messages are two-way alphanumeric and binary messages that can be sent and received by GSM modems/modules or servers equipment with Short Message Service (SMS) capabilities. The SMS is provided by the Global System for Mobile Communications (GSM). Short messages are stored and forwarded by the Short Message Service Centre (SMSC) [4]. Due to the fact that nowadays GSM networks are available through out the world, turning SMS is one of the cheapest ways of remote communication. The usage of SMS has been emphasized in this paper to act as a bridge between "commander" (human) and "receiver" (building's automated-system).

The installation of this automation system takes the advantage of using microcontrollers which is the most popular in the industrial fabrication because of its easy usage. A number of devices, such as lamp, motion detector, alarm system and 3-speed fan (as a symbol of any type of motors used in any organization), have added in order to visualize the capabilities of the automated system that will be discussed afterward in details.

In later section of this paper, an overview of the system as well as the software details and hardware specifications will be discussed also. One should note that the software in this project consist of two parts. One acts as an interpreter and commander while providing a Graphical User Interface (GUI) and the other drives the microcontroller.

Basically, This Home Appliance Automation System recommends its usage to every building and organization as it provides an inexpensive way to conquer automation without limitation of their security issues

2.0 Why is this proposed system suitable in Bangladesh's current infrastructure?

The recent growth of the phone subscribers in Bangladesh is apparent in Figure 1.1[1]

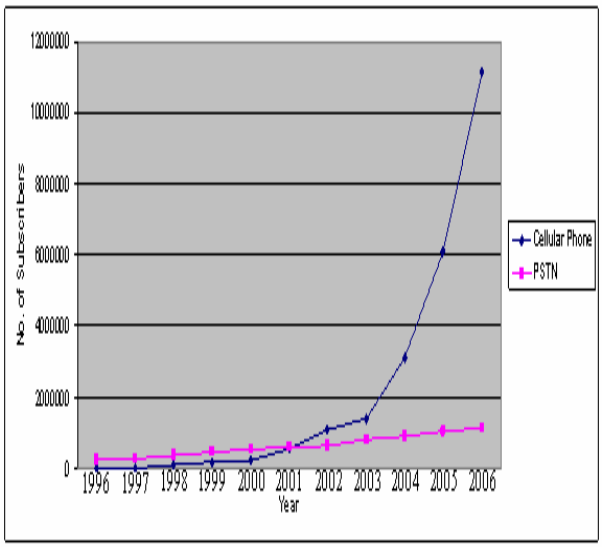

Figure: 1.1 the recent growth of the phone subscribers in Bangladesh

From the above figure, it can clearly be stated that mobile subscribers' number is the largest among all users of other communication systems. People of our country can easily utilize such network due to its control wideness. In this instance, the current status of computer and Internet infrastructure of Bangladesh at summarized form is given in Table-3 [2]:

No. of ISPs	**219(80% ISPs are located in Dhaka)**
Number of Internet Users	**0.3 million**
Internet Users	**19.04(per 10000 inhabitants)**
Computer Ownership	**0.782(per 100 inhabitants)**
No. of Active Cyber Café / Internet Kiosks	**500**
Cyber Café's / Internet Kiosks	**0.19(per 10000 inhabitants)**
Bandwidth Provided by Cyber Cafes	**32 kbps – 4Mbps**
National Bandwidth within the Country	**68 Mbps(Data)**
National Bandwidth to and from the Country	**112 Mbps**
National Highest Bandwidth of link	**10Mbps**

Table-3: Computer and Internet Infrastructure

According to the table, the ISP's coverage is so limited in terms of total area of Bangladesh and its usage cost is also high for our country since Bangladesh is one of the poorest nations where nearly half of its 140 million populations are surviving on less than a dollar day.

Considering both cellular and internet infrastructure of Bangladesh, It can be stated that E-mail or internet based system is not the optimum solution for home appliance automation on recent ICT context. Whereas, the mobile SMS based home appliance will be revolutionary solution. Since, the total number of mobile users in the country is now about 14.7 million and expected to reach nearly 18 million by the end of the year. And within three years (Bangladesh) it will be triple the number of subscribers to 45-50 million users, or about 30 percent penetration of whole nation [14]. This utmost rising of mobile users shows the feasibility of deploying such home appliance automation system in current ICT infrastructure of Bangladesh.

In provisos of cost, it is also feasible as a SMS charges only 2 BDT per SMS which is marginal enough to introduce such SMS based automation system in Bangladesh. Besides this, the initial cost is also very low. For establishing such Home Automation Appliance only a pc and circuitry will be needed and it can easily be implemented initially within 15000 BDT for once only.

3.0 Full-Framework Overview

In the following, a general overview as well as a detailed performance explanation of the system will be investigated.

3.1 Principle Revision

The controlling process of desired devices is done through a command which is carried by an SMS to the system. Once a command is sent, sophisticated software (discussed later in this paper) that runs on a computer (a desktop or a notebook) retrieves the message by accessing the memory of a SIM card (inserted in a SIM holder) which is connected to its serial port. After the new message is retrieved, the software executes a number of algorithms on the content of the message and compares it to a user-defined database and sends an appropriate data to a controller unit that is connected to the PC via either

the serial port or the parallel port. Since the controller module is in interaction with mounted appliances on the system, the desired action will take place accordingly. The following block diagram illustrates the whole process.

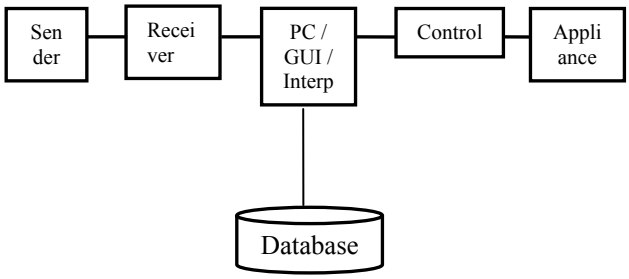

Figure 3.1 General block diagram of the system.

As Figure 3.1 shows, the message sent by the user through a message generator (sender) is retrieved by a PC where it is being compared to a database. A corresponding user-defined command is then sent to a controller module. The controller module consequently makes a decision and takes an appropriate action. This procedure is demonstrated in Figure 3.2 in more details. As the figure illustrates most of this process is bidirectional, the user can receive or redirect messages containing confirmation reports, requested status reports and automatic status reports (generated in critical cases) for a desired appliances.

3.2 SMS-based Remote Access

The user can communicate with the devices by using mobile phone SMS service which is considered as a very cheap but efficient communicating tool through out the world. And we may easily take the advantage of GSM networks providing an SMS based control system. The user can control over building devices from any place around the world.

It is noticeable that while the messages are sent through different Service Providers, the SMS format may vary. This Home Appliance Automation system is completely compatible with most of these formats.

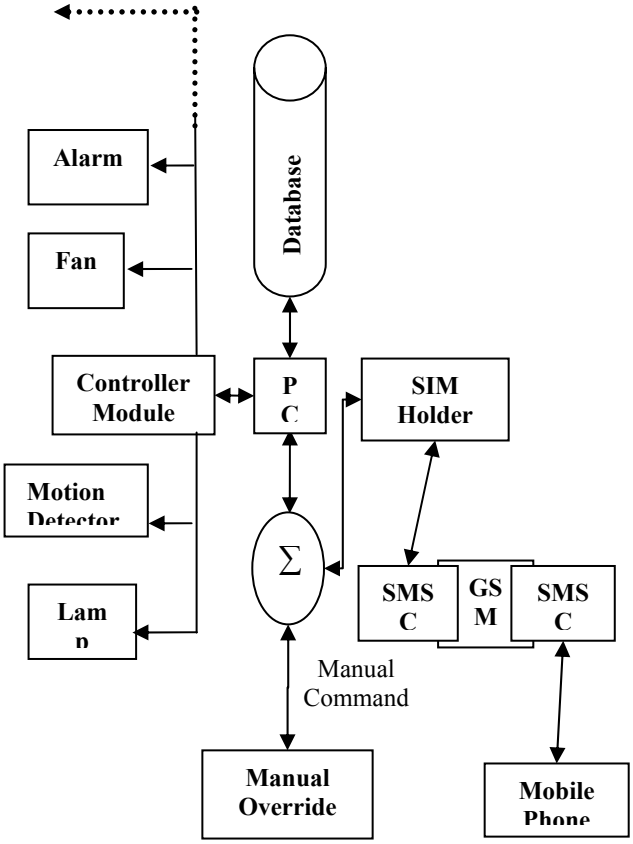

Figure 3.2 Block diagram of SMS based Home Automation Appliance

An SMS can be sent using a mobile phone with any SIM card provider to the GSM network where the corresponding SMSC holds and redirects it to a target SMSC. Consequently the target SMSC forwards the message to the SIM holder (any mobile phone with integrated modem or a GSM modem), which is based at the automated building. Since the installed System (software) is in constant interaction with this SIM holder, an appropriate action will take place after retrieving the SMS from its SIM card. An SMS (Confirmation Report) indicates that the command has been received and executed by the system is then sent back to the user or to any number specified by the user.

A Status Report containing the names of the commanded devices is sent to the user (or any specified number) once by an SMS with a specified phrase for user inquiry. In addition, the system sends an Automatic Status Report generated in emergency and critical cases such as errors and malfunctioning to the user or any specified number by SMS.

The aforementioned methods are obviously used when the message receiver is a SIM holder connected to the PC at the target automated building and the System (software) itself does not have an access to the internet in order to employ e-mail as the carrier of the commands sent by the user.

4.0 Implementation of SMS Controlled Home Automation

Implementation of such system contains basically two parts: Software (controlling algorithm) and Hardware (application board)

4.1 Software (Controlling Algorithm)

The system will retrieve the message from the first memory location of the SIM card, processes and compares it to a user-defined database. If a relevant command is found the system will send a corresponding data to the controller board and the message itself will be saved into the database. When the data has been sent to the controller successfully, a confirmation report is sent back to the user or any specified number. However, if the content of the message is a specific user-defined identifier phrase, (which differs from those defined in the database) a status report will be sent to the user. This status report contains a number of statistics (such as battery statuses of PC and GSM module – if applicable – whether or not the system is locked by the user and the total number of executed commands per session) as well as the list of commanded devices in the respective session.

The process of communicating with the GSM module is done through a number of "AT Commands" (the commands with which an application can communicate with modems). When a specific AT command is sent to the GSM module requesting the arrived SMS available on the memory of the SIM card, the GSM modem sends the entire message to the system. The system is designed in such a way that it is compatible with different types of GSM modems since only a few brands support sending the SMS in text mode, while nearly every brand supports sending the data in what is known as Protocol Description Unit (PDU) format. Dealing with PDU format is not an easy task to perform. PDU translation requires a non-linear algorithm which is described as the follows.

A PDU string is a mixture of hex-decimal octets or decimal semi-octets data format while the message itself is in octet base format, therefore, in order for it to be process-able by the system, it should be translated into septet. For instance, the message "CD 32 39 4D 2F CB E5 61 77 39 EC 06 00" ("Mediterranean" consists of 13 characters, called septets when represented by 7 bits each). These octets need to be transformed into septets for the SMS transfer. The first septet (h) is obtained by fetching and inserting the MSB of the first octet in between the LSB of the second octet (32) and MSB of the third octet (9B). The second septet (e) is then obtained by fetching and inserting the first **two** MSBs of the second octet (32) in between the LSB of the third octet (9B) and MSB of the fourth one (FD). Obviously for the third septet **three** MSBs of the third octet are needed. This process goes on and on in this manner until the number of fetched bits reaches 7 which itself represent a septet. At this stage the whole process is repeated from the beginning.

After a valid command is received and executed (sent to the controller module), a confirmation message will be translated from text back into PDU format and sent to the GSM modem via an AT command which then the GSM module will be forced to send the SMS to a specified number. The password of the System is created and encrypted using an algorithm known as Hash Algorithm. This method increases security since the password is not stored anywhere on the computer; rather a randomized equivalent of it is stored in an unreachable place, and therefore making it extremely hard to crack. This password is used for login and security-lock purposes. Therefore, this method of authentication, as explained before, as well as user-defined identifier phrases have been employed to ensure that only the user has the commanding access to the system. One should also note that all the commands sent through SMS can be overridden by the Manual Override section of the System.

4.2 Hardware (Application Board)

The hardware used in the system consists of a

controller board, connection lines and a number of appliances with mounted circuitries. As discussed before, the system is designed in such a way that the complexity of the software improves the simplicity of the hardware. This, on the other hand, reduces the total costs of the system which can reach a great amount in large scale productions.

The controller module consists of a Micro Controller Unit (MCU), a regulator, an inverter, a number of resistors, transistors, indication LEDs and serial and parallel interfacing components. As a MCU a microchip PIC of 16F family has been used in the system. PIC 16F877 is a 40-pin 8-bit CMOS Flash microcontroller. Ease of use and, at the same time, exclusive properties, has made PIC microcontrollers extremely popular. There are 5 I/O ports available on a single chip providing 33 I/O pins. This relatively high number of data ports has been a strong reason to choose this chip as the core of the controller module. It is important to emphasize that Motorola's 68HC family is often used for somewhat more complex tasks than PICs, but tends to be more difficult to buy. The smaller [Atmel] AVRs are much like the PICs in price and performance [11]. If a higher number of I/O pin is required (to hook up more devices to the system), a PIC 18F8722 (with the cost of about 9$ and total 72 I/O pins) can be a reasonable replacement. Instead, obviously, a network of MCUs can also be used. The PIC has been programmed in C language using PICCLite compiler from Hi-Tech Corporation. Other programming languages such as assembly, PIC Basic, JAL, etc. can also be used.

As shown in Figure 4.1, a crystal oscillator of 4MHz has been used in order to run the clock of the MCU (which can be replaced with higher values – up to 20MHz for PIC16F877 – for time sensitive applications). In addition, every input pins of the MCU is also connected to the GND via a 10kΩ resistor. This is because of the capacitive characteristics of the MCU which causes disturbance in inputting data (a time delay occurs between the reset of the input signal and the reset of the MCU's pin). Therefore resistors are connected in order to pull down the logic quicker. One can notice that the current going to the GND through the 10k resistors are negligible when the logic state of the input pin is 1.

$$\mathbf{I = 5 / 10k = 0.5\ mA}$$

The system is designed to have the ability to interact with both serial and parallel ports of the PC (hence giving the user the flexibility to replace the entire MCU-based controller module with, for instance, a Programmable Logic Controller (PLC)). However, one should note that the serial communication is extremely sensitive and unreliable. Therefore a low speed (baud rate of 1200) has been chosen for this matter which can be changed to any rates desired by the user through re-programming the PIC. Moreover, implementing the circuit on a PCB ensures a higher accuracy.

A 7805 regulator is used in order to step down the 12V supply voltage to the supported 5V.
In order to make the serial port communication signals, sent from the computer, compatible with the RX pin of the MCU a 74HC244 IC has been employed. Since the magnitude of output voltage level of PC's RS232 is approximately 15 (9 in some cases), as well as being inverted (negative in sign), this chip is used in order to re-invert the voltage and shrink it down to 5V supported by the microcontroller.

Each device in the system has a mounted circuitry which only consists of a relay and a diode. The relay is used to act as a switch while providing a complete isolation between the mains (high voltage) and the control circuit (low voltage). Since this isolation is realized magnetically, having a relay to perform the switching actions is a very reliable choice (TRIAC can be an alternative choice).
The coil rating of the relays used in the system is 12 VDC with 300 Ω internal resistance which in return requires a current of,

$$\mathbf{I_c = (V_{CC} - V_{CE}) / R_L = (12 - 0.2) / 300 \approx 40mA}$$

Since the MCU's maximum output sink current is about 25mA [9] a transistor has been used to amplify and provide the necessary amount of current to drive the relays (instead a ULN2003 could have been used). The transistors employed in the controller circuit are BC547 (low-power NPN BJT) which have a max collector current of 100mA, amplification factor of $h_{FE} \approx 300$ and max total power of 500mW (can be replaced by BC107B [10]).

Hence, in order to push the BJT into saturation the base current should be about 1.3mA;

$$I_B = I_{Csat} / h_{FE} = 40m/300 = 0.13mA$$

With an overdrive factor of 10, this yields in a resistor of value

$$R_B >= (5 – 0.7) / 1.3m = 3.3k\Omega$$

to be connected between the MCU and the base of BJT (4.7kΩ is used in the system). Once the output pin is reset, the transistor enters into cut-off region and does not conduct any current which causes the relay to act as an open switch.
In order to avoid the effect of back-emf (caused by the relays' winding) on the controller module, protection diodes (known as free-wheeling diodes) have been mounted across the coil of the relays (on the appliance side).

There are a number of devices (Such as a lamp, a three speed fan, a motion detector and an alarm system) hooked up in the system in order to demonstrate its application in real life. The control of these devices is done through simple ON/OFF states. However, more complex operations can be, easily, performed by modifying the controller module and the MCU's program.

As mentioned earlier, a simple circuitry must be mounted on each appliance in order to be installed in the system. For instance, since the output of the employed motion detector is 240VAC, an AC to DC inverter and a step-down concept are needed to turn the AC voltage into the supported 5 VDC value. This is realized by using a transformer of ratio 10:1 which would step-down the voltage level into almost 20VAC while providing some sort of isolation for the control circuits. In order to convert the ac voltage into a dc value, a half-bridge peak rectifier has been used employing 2M ohms of resistance and a high rated 2.2uF capacitance. This would make an RC value of almost 4.5 seconds! (Implementing a full-bridge rectifier would be a more preferable choice). The output of the rectifier is then regulated using LM7805 and fed into the microcontroller for demonstration of support for feedback (see Figure 4.1).

The AC motor (fan) used in the system is an induction motor with three different sets of windings in order to produce three speed levels. This is because of rather expensive solutions of speed control using frequency or voltage or any other alternatives. Therefore a simple switching concept has been used to control the speed of this device, connecting the mains to each winding. However a better solution would be a frequency converter which can be realized through the usage of Pulse Width Modulation (PWM) made available by PIC 16F877 and can be implemented easily. Else as an alternative a resistance based speed control can be employed. This is done through the usage of a digital potentiometer.

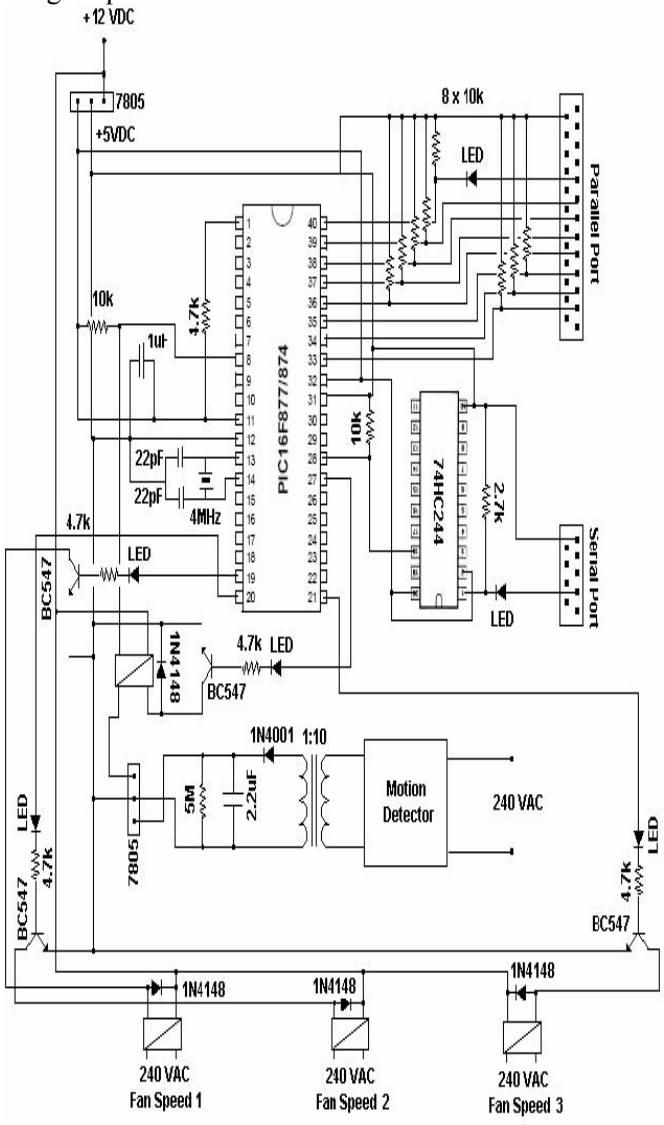

Figure 4.1 Controller module & mounted cct of two devices.

In addition, the speed level of the fan is demonstrated on a seven segment LED mounted on the device. This circuit uses the already mounted relays in order to determine the speed.

The lamp installed in the system uses a similar

switching strategy. On the other hand, the alarm system gets activated whenever the motion detector sends a signal to the microcontroller. This action could be well-completed by alerting the user an SMS. In such a case using a MAX232 (or any equivalent such as TCL232) in place of 74HC244 is of necessity.

5.0 Conclusion

This paper has focused the remote controlling system of buildings by suggesting a revolutionary solutions as well as demonstrating the functionality and performance of the "Home Appliance Automation via mobile SMS" system. An overview of the system including the relevant conceptual issues has been discussed. A detailed software and hardware requirements and realizations of the system has been described, offering an economical and rather simple, yet reliable, way to overcome the needs of automation of any building. And it is the appropriate remote controlling solution in the current ICT infrastructural context of Bangladesh.

It is important to mention that the system can perform more complex tasks by applying simple modifications on the designed hardware (and the MCU's firmware). For instance, mounting different sensors in the system which would inform the user of any changes in the behavior of the appliances by sending a SMS would make a proper feedback system. Hence, flexibility and efficiency issues, security concerns and economical matters yield to the necessity of having this system installed in every building, from residential houses to business environments.

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