GSM-Bluetooth based Remote Monitoring and Control System with Automatic Light Controller

Vini Madan
Research Scholar
IGIT, IP University
New Delhi

S.R.N Reddy
Associate Professor
IGIT, IP University
New Delhi

ABSTRACT
In past few years, home automation & remote control and monitoring systems have seen a rapid growth in terms of technology. This paper gives a review of these systems based on existing technologies and also proposes a GSM-Bluetooth based light controller and remote monitoring system. This system has simple features designed with the objective of minimum power consumption using infrared sensor for controlling lights, fans and other appliances which are controlled via SMS using a GSM module. A Bluetooth module is also interfaced with the main microcontroller chip. This Bluetooth module eliminates the usage charges by communicating with the appliances via Bluetooth when the application is in a limited range of few meters. The system informs user about any abnormal conditions like intrusion detection and temperature rise via SMS from the GSM module or by Bluetooth module to the user's mobile and actions are taken accordingly by the user.

General Terms
Remote Monitoring and Control Systems

Keywords
GSM, Bluetooth

1. INTRODUCTION
Embedded system is not a new concept. Embedded systems has become a buzz word in the last 15 years, but embedded systems and processors have been around for much longer than that. One only needs to look around to see embedded systems everywhere: cell phones, alarm clocks, personal data assistants (PDAs), automobile subsystems such as ABS and cruise control etc. These embedded systems are now commonly interfaced with Bluetooth and GSM (Global System for Mobile communication) modules to widen their scope and enhance the application areas to a greater extent. Although the GSM was initially designed for voice, it can be used to serve other purposes than talking. This idea is reinforced by the fact that the GSM infrastructure has been deployed in many countries. GSM can be used as the communication via to receive signals captured by machines in remote places, and also to send control signals to remote machines [1]. The installation of long wires to reach remote places (i.e. bridges, vending machines, etc.) is more expensive than the use of a mobile network that can perform the same task. Of course suitable sensors and actuators are needed for the mentioned examples and others. Some automatic GSM module is also needed, but long wired installation is not necessary. Furthermore, mobile telephone can also be used in remote systems, but in moving systems as well, such as vehicles and people. Also Bluetooth is a popular mechanism for short distance point to point or point to multi-point communication. The features include low cost, low power and small size. Also the robustness for the interferences has made Bluetooth a highly versatile and attractive technology among other short range wireless technologies. Operating over unlicensed, globally available frequency of 2.4GHz, it can link digital devices within a range of 10m to 100m at the speed of up to 3Mbps depending on the Bluetooth device class. This paper gives a review of remote control and monitoring systems based on existing technologies and a GSM-Bluetooth based remote control and monitoring system with automatic light controller is proposed. The design presented has the advantage of both GSM and Bluetooth technology and the appliances and devices are controlled by both by using Bluetooth when in a limited range with the appliances and using SMS for remote monitoring and control thereby reducing the usage charges of GSM.

The rest of the paper is organized as follows. Section II gives the classification of generic remote control systems based on technology and processors used and applications of the systems. Section III analyzes the existing systems, section IV describes the proposed system. Finally section V concludes the paper.

2. CLASSIFICATION OF GENERIC REMOTE CONTROL SYSTEMS
The idea of remotely controlling and monitoring of different devices and home appliances in a unified system is flourishing day by day with the use of latest technologies. There are many types of remote control and monitoring systems available. These systems are typically designed and installed for different purposes. Different technologies used for designing these remote control and monitoring systems have been studied [2] – [34]. From technical point of view these systems can be classified on the basis of Technology and applications & processors used. Table 1 shows the classification of existing systems based upon different criteria.

2.1 Technology Used and Applications
Al-Ali & Al-Rousan introduced a low cost Java-Based Home Automation systems [2] based on PC-based home server. Various devices are connected to the input/output ports of the microcontroller and their status is send to the server whether they are on or off. The monitoring and control software engine is based on the combination of Java Server Pages, JavaBeans, and Interactive C. The system is scalable and that is any number of devices can be added with no major changes to its design. Password protection is used to stop unauthorized users from accessing the appliances at home. If the Internet connection or the server is not working, the embedded system board still can control and operate the appliances locally.

Studies in [3] [4] has some examples of web based automation systems. These systems are low cost and flexible with the

increasing variety of devices to be controlled. These systems can be controlled from anywhere in the world provided internet access is available.

Wijetunge et. al. [5] proposed remote controlled systems that can control home appliances from a PC using Bluetooth technology. In this work, a general purpose controlling module is designed which has the capability of controlling and sensing up to five devices simultaneously. The Bluetooth module can manage both analog and digital devices provided with suitable interfaces designed by the manufacturer. The server can communicate with many such modules simultaneously. Similar systems using Bluetooth technology are also explained in [6] [7]. These systems cannot be controlled by a cell phone.

To provide greater mobility R. Piyare and M.Tazil [8] proposed a Bluetooth based Home Automation System using Cell phone. This system is a low cost secure system in which the communication between mobile and home appliances is wireless. Appliances at home are connected to the Arduino BT board. Additional devices can be connected into the system by making little modifications. Since the cell phone script is written in Python, it is portable and can run on any mobile using Symbian Operating System platform. The users are expected to acquire password for the Arduino BT and the cell phone to access the home appliances. This adds a protection from unauthorized users.

A similar system for remote monitoring and control using cell phone is explained in [9]. Microcontroller system send signals through its ports to switch on/off appliances like AC, lights, fan, siren, etc when commands for the same are received from user cell phone . The sensors used in the system are microphone, temperature sensor and passive infrared (PIR) intrusion detector sensors. The system informs user about any abnormal condition through missed call or SMS using Bluetooth. However Bluetooth technology has been proved to be the cheapest technology, it has a limitation where distance is a concern. It can link devices within a range of 10m to 100m at the speed of up to 3Mbps depending on the Bluetooth device class so remote monitoring and control is not possible while using this technology.

Khushwinder Gill [10] proposed a Zigbee based Home Automation System. The system allows home owners to monitor and control connected devices in the home, through a variety of controls, including a ZigBee based remote control, and any Wi-Fi enabled device which supports Java. Additionally, users may remotely monitor and control their home devices using any Internet enabled device with Java support.

In [11] DTMF based Remote Control System is proposed. In this work, the teleremote system has been installed. The system uses DTMF tones. The decoder decodes the DTMF tones generated by the keypad of a commercial landline or mobile set. No PC is required for monitoring when using DTMF technology. However DTMF does not utilize the network resources efficiently as it takes several seconds to send instructions.

A mobile embedded system using RFID technology [12] has been proposed as aid in education system. The presented solution offers possibility for the students to go through the class material without guidance from the teacher and still receive help in their learning process. The system has four parts-touch sensitive LCD screen, RFID reader, Ethernet module and online database. The touch screen was used for easy interaction between the students and the electronic system. The RFID reader was used so the teachers could easily monitor the activities and attendances of the students. The Ethernet module forms the link between the electronic device and the database of the students. The database was installed into the system so the teachers could monitor the progress of every student. An RFID system consists of a tag, a chip, an antenna, and a reader. RFID has been used in many applications, such as tracking inventory and for automatic toll-road payment systems. Recently, RFID industry advocates have been promoting the use of RFID for tracking and monitoring students in schools. A similar RFID based hospital automation system is explained in [13]. These RFID based systems needs PC for monitoring purpose.
A monitoring system for the weather conditions using RF technology [14] consists of the monitoring unit having temperature, pressure and humidity sensors that are taken to the lower atmosphere using hydrogen balloon. The values measured by the sensors are processed and then transmitted to the control server using the RF transceiver. The control unit which is interfaced to a PC receives this data.

RF can also be used for remote monitoring and control of process control application as described in [15] and for wireless data transmission [16]. The limitation of both the systems is that they only allow for acquisition of data from a single remote monitoring unit with no control facility added to it.

A.Alheraish [17] proposed a design of Home Automation System based on GSM. To enable its use in several applications, this design integrates the device to be controlled, the microcontroller, and the GSM module. This paper implements a complete M2M (Machine to machine or man to machine system) over a GSM network. The controller processes the incoming data from RS-232 by running a visual C++ program, and sends data via M2M module to control any connected device. The M2M module GM47 is developed by Sony Ericsson. It is intended for use in 900/1800 and 850/1900 MHz GSM bands respectively. The module is used to make a connection to the GSM network and send and receive SMS and GPRS services and to make a voice calls as well.

Wael M El-Medany [18] et. al. proposed a GSM-Based Remote Sensing and Control System using FPGA. The system is based on designing and implementing an FPGA chip that is interfaced with a GSM modem to work together as a remote security and control system at the same time. The hardware of the chip has been designed using VHDL and has been tested using Xilinx FPGA. First a synthesizable VHDL code has been written and simulated using Xilinx ISE 6.2i tools, and then implemented on a Xilinx Spartan 3 FPGA. The design has been successfully simulated and tested for both sensing and controlling purposes at different frequencies (4800 KHz, 9600 KHz, and 19200 KHz). The system works as a remote sensing for the electrical appliances at home to check whether it is on or off, at the same time the user can control the electrical appliances at home by sending SMS. It also works as automatic and immediate reporting to the user in case of emergency for home security. The advantages of using FPGA as a controller is multi inputs/outputs and low cost, where the used FPGA chip has 256 inputs/outputs that achieve the multi inputs and outputs. Since many components can be integrated into the FPGA chip that has 200 k Logic Gate, a low cost is also achieved.

The system in [19] [20] [21] proposes Remote Monitoring and control Systems based on GSM. GSM network is a medium for

transmitting the remote signal and communication takes place between monitoring centre and remote monitoring station. The central monitoring station performs real time control, alarm and data processing and also manages database. Receiving and sending of the data in the central monitoring station is achieved by using the GSM wireless communications module TC35 in [19] - [21]. TC35 is introduced by SIEMENS which is a dedicated Modem. GSM module is interfaced using RS232 and accessed using AT commands.

A similar remote monitoring system based on fingerprint lock is explained in [22]. The system can accurately identify fingerprint, and sent unlock ID information, the illegal burglary information to the owner by the GSM network or to the monitoring center of property management office by the PSTN. The remote monitoring system consists of fingerprint recognition processing module, lock mechanical control component and phone communications. The fingerprint identification module of fingerprint lock consists of tactile sensors, CCD fingerprint collection system and ARM9 processors. Door lock control circuit uses a microcontroller PIC18. By UART MCU communicates with the fingerprint recognition module to complete the fingerprint input, delete, and identification. If pass validation will control motor of lock to open action.

Another approach using GSM technology to communicate with the remote devices via SMS is remote metering system [23]. This paper illustrates a technique for remotely reading electricity meter readings using SMS. Both postpaid and prepaid are feasible to implement using this architecture as SMS based data collection can be done very quickly and efficiently.

Work has also been done to design monitoring and control system for the home automation with three alternate control mechanisms: GSM, Internet and Speech [24]. PC is used as a monitoring station and consists of main control program, database and speech recognition program and home server. It communicates with the transceiver via a RS232 interface and the microcontroller in the transceiver then communicates with the devices. GSM modem is connected to the home automation server to receive the SMS from the control unit for controlling and checking the status of the various elements. The GSM and internet are used by the users when they would like to remotely access the devices in the house whereas the voice is used for communicating while they are inside the house. The speech module of this system is highly beneficial for physically impaired people. The system is secured using a login password authentication.

Wireless sensor networks in home are easy to establish without using cables and offers a greater coverage. There are a number of studies which says that Wireless sensor networks are a cost effective solution for collecting, receiving and transmitting data. A wireless-GSM based Home Security System is proposed in [25]. This system is a low-power consumption remote home security alarm system developed by applying WSN and GSM technology which has the ability of wirelessly sending and receiving data, and can send a SMS to the user's mobile when some dangerous condition has been detected. This system consists of the MCU-based home wireless control center, one WSN center node module, and several data collecting nodes, GSM module, GSM network and mobile phone. The WSN data collecting node modules are connected with pyroelectric infrared detector, temperature sensor, smoke detector and gas sensor separately. The system software is developed in C51 language. This system also has a practical value in other fields where remote monitoring is required such as irrigation, temperature measurement etc.

[26] [27] propose a Zigbee-GSM based Monitoring and Remote Control System. These systems use both Zigbee and GSM for communicating between user and devices. This system allows user to monitor and control devices in the home through a number of controls, including a Zigbee based remote control. Users may remotely monitor and control their home devices using GSM.

Yuan Jian et. al. [28] described the development of an e-Guardian for the single elderly or chronically ill patients. It communicates via Zigbee mesh network with the base station which is integrated to a GSM module. Vital signs and health status of the patients or elderly persons are sent in real time to caregivers' mobile phones via SMS.
A similar approach is given in [29] for home health care system with emotion recognition function.
Another approach for transmission of data is a wireless-GPRS based data acquisition system [30]. It is mainly composed of data acquisition, controller and data transmission module. The data acquisition part transmits signal to the controller through a transceiver. Controller processes the data and sends it to the monitoring station be it a mobile or a PC through the GPRS module.

A similar system for automatic meter reading is proposed in [31]. Another application using GPRS is given in [32]. A mobile-based approach is be used for efficiently collecting required data leading to accurate, low-cost, non-laboratory based early detection of CVD risk in Indian context. The design consists of three level architecture - A mobile client, central server (a medical record system) and a middle layer which connects the mobile client and the server so that mobile and server can communicate with each other efficiently. Collected data is buffered locally on the phone and uploaded, using GPRS, to the central server for further analysis, based on available cellular connectivity. GPRS possess many advantages such as wide coverage, High transmission rate, accuracy etc.

[33] Proposes a scalable water monitoring system capable of estimating water flow rate using wireless sensor network technology. The design combines the pre-installed inline flow meter with non-intrusive inexpensive vibration based sensors in order to provide an accurate per pipe flow rate.

Another application using wireless sensor network is given in [34]. The main contribution of this paper is the design of a sensor network optimized for rapid deployment during periods of volcanic unrest and provides real-time long term volcano monitoring.

Table 1. Classification of Existing Remote and Control Systems

References	Technology	Processor	Monitoring Station	Modules Interfaced	Tools	Programming Code
[2] [4]	Internet	8051 family	PC	None	Keil IDE	Java, Interactive C
[3]	Internet	PIC16	PC	None	MPLAB IDE	UML, C
[5]	Bluetooth	Atmega64	PC	TDK Blu2i	AVR Studio	C
[8]	Bluetooth	Atmega168	Mobile	Bluegiga WT11	AVR Studio, Symbian	Interactive C, Pythan
[9]	Bluetooth	Atmega32	Mobile	CBOEMSPA31 2	AVR studio, Eclipse 3.2.2	C, Java
[12]	RFID	Parallex P8X32A	PC	RFID Reader, ENC 28J60	Propeller tool, Spin compiler	Spin
[14]	RF	Atmega 48	PC	RDM-A4FZ	AVR Studio	C
[15] [16]	RF	8051 family	PC	nRF905, Si4421	Keil IDE	C51
[17]	GSM	8051 family	Mobile	Sony Ericsson GM47	Keil IDE	Visual C++
[18]	GSM-FPGA	8051	Mobile	MAXON MM-6854	Xilinx ISE 6.2i	VHDL
[19]	GSM	MSP430F149	PC	Siemens TC35	C430 IDE	C
[20]	GSM	ARM7	PC, Mobile	Siemens TC35	Flashmagic	C
[21] [22]	GSM-Internet	Atmega128, PIC18	PC, Mobile	Siemens TC35	AVR Studio, MPLAB IDE	C
[23]	GSM	8051 family	PC	Nokia FBUS	Keil IDE, Linux	C, Java
[24]	GSM-Internet-Speech	PIC16	Mobile	Siemens TC35	MPLAB	C
[25]	GSM-WSN	8051 family	PC, Mobile	Siemens TC35, CC1100	Keil IDE	C51
[27]	GSM-Zigbee	Atmega 128	Mobile	Sony Ericsson T290i, EM357	IDE & C compiler	C
[28]	GSM-Zigbee	8051	Mobile	GM862QUAD-PY, CC2430	Keil IDE, Symbian	C, Pythan

[29]	GSM-Zigbee	8051	PC/Mobile	Siemens TC35, CC2430	Keil IDE	C/C++
[30]	GPRS	ARM7	PC/Mobile	SIM700, nRF24E1	µC/OS-II	C
[31]	GPRS	8051 family	PC	SIM300, SN65LBC184	Keil IDE	Visual C
[33] [34]	RF	Atmega128, APXA271	PC	CC2420	AVR Studio, TinyOS	C
[34]	RF	APXA271	PC	CC2420	TinyOS	nesC

2.2 Processor Used

There is an exhaustive list of processors used in embedded systems. Different processors are used with different technologies and there are few systems where different processors are used for the same technology.

[2] [7] [15] [17] [18] [23] [25] [28] [29] [31] have implemented their designs using 8-bit microcontrollers compatible with 8051 family. These processors do not have an ADC on chip so ADC is connected externally in these designs. The Operating voltage of 8051 family ranges between 2.7V-5.5V.

[4] [16] has used 8-bit processor compatible to 8051 family which has an 8-bit ADC and 2 12-bit DAC on chip. The operating voltage of this processor is 2.7V-5.25V.

[12] used a Parallex P8X32A 32-bit multiprocessor. It is called a multiprocessor because it has 8 processor cores called cogs. Its operating voltage is 2.7 V to 3.6V.

[3] [22] [24] [26] uses 8-bit PIC microcontrollers which have on chip ADC. PIC controllers also integrates a number of system level functions, this would significantly reduce the component count, board area and system cost. The operating voltage range is 1.8V-5.5V.

[5] [8] [9] [14] [21] [27] [33] have implemented their designs using 8-bit Atmega Series AVR processors with different size of programmable flash memory. It also has A/D converter inbuilt in the chip itself. Operating voltage range for all Atmega chips for any flash memory size is 4.5V-5.5V.

[19] uses a 16-bit MSP (mixed signal processing) microcontroller. Its peripheral circuits include Liquid crystal display, keyboard functions, A/D converter and so on and it is suitable for usage fields needing extremely low power consumptions. Operating voltage for MSP processor is 2.5V-5.5V.

[20] [30] have used 32 bit ARM7 processors which have a 10-bit ADC on chip. The operating voltage range for ARM7 processor is 3.0V-3.6V.

[34] used a 32-bit ARM processor which has 16-bit A/D converter on chip. Its operating voltage is 0.85V.

The classification of different technologies used for remote control and monitoring systems is briefly given in fig 1 so that the beginners or hobbyists who want to implement their designs for remote control and monitoring in embedded systems might get an idea on what technology is suitable for them as per their requirements.

3. ANALYSIS OF EXISTING SYSTEMS

All these systems [2]-[34] are well suited for remote control and monitoring depending upon the requirements. PC based technology is explained in [2] [3] [4]. In this system, PC is the remote monitoring station and microcontroller is the controlling device. Although one can monitor and control devices remotely from any part of the world provided internet access is available, this system incurs additional cost due to the requirement of a computer. Special hardware and software installation is required to control the devices. Also in case of power failure, it is difficult to monitor and control the status of devices unless you have a battery backup which is an additional cost.

Bluetooth based solutions are also used for this purpose [5] - [9]. Although Bluetooth eliminates the usage cost of the network to a great extent, its range of operation is limited to a few meters. One cannot remotely monitor and control devices using this technology. Also it is desirable for each home device to have a dedicated Bluetooth module but due to the fiscal expense of this type of implementation, a single module is shared by several devices which have a disadvantage of access delay. Interference is also a problem when using this technology. Also the remote systems can be accessed using any telephone that supports dual tone multiple frequency (DTMF) [11]. In this technology all communication occurs over a fixed phone and internet is not required. But users are not provided with a graphical user interface, users have to remember access codes and they have to memorize which button is to be pressed to control which device. Moreover it takes many seconds to send instructions so it is not a very efficient technology.

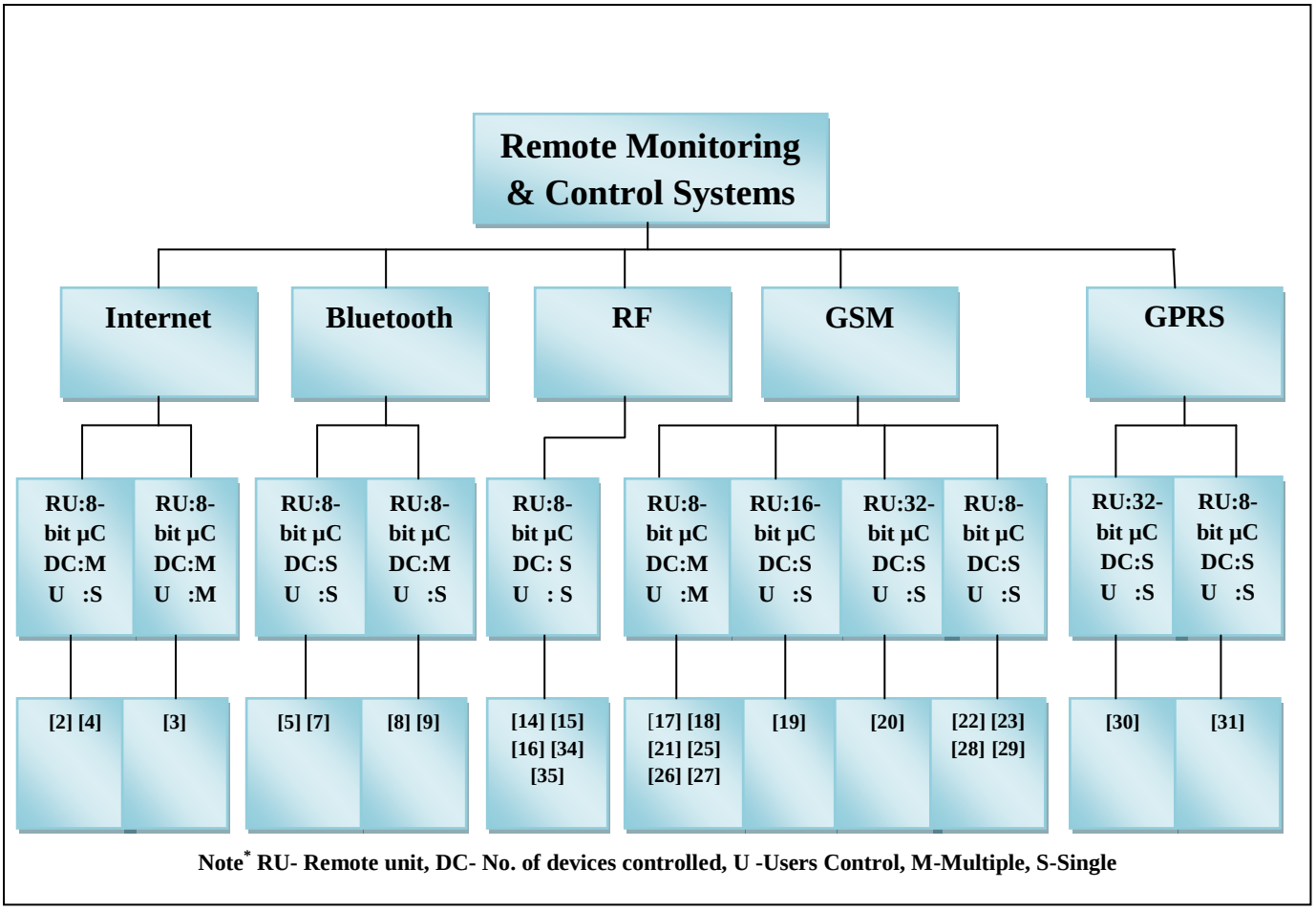

Fig. 1 Classification of Existing System based on different Parameters

RF Connectivity [14] [15] [16] [24] [33] and [34] has the advantage of low cost, ease of installation and maintenance. But they can be used only in situations where the distance between the remote and the central station is limited to a few hundred meters. It is better than Bluetooth is terms of cost and distance. However, RF module is less reliable and Transmission Bit error rate is quite high restricting its use to systems where the amount of data to be transferred is less. SMS based approach of remotely monitoring and controlling devices using GSM network is studied in [17] [18]. The main advantage of using SMS is that even if the network is busy or the user is outside the coverage area continuous effort of delivery is made. When the SMS is delivered, the acknowledgement for the same is sent to the sender of the SMS. Although GSM provides great network coverage and reduces the cost of implementation by eliminating the requirement of wires and cables, it does not provide real time monitoring when one needs data in the form of video as an example. [19] [23] are examples of GSM based remote monitoring and control systems where the monitoring and control unit is PC. It can provide the real time data and information with the help of internet access but again requirement of PC incurs additional implementation cost and it also restricts the mobility of the user. The systems where both PC and Mobile act as monitoring and control unit are given in [20] [21] [22] and [25]. PC acts as home monitoring station and mobile controls everything remotely. Although these systems eliminates one of the drawback of real time monitoring using internet and WSN but again increased fiscal cost due to PC is again a drawback. Another GSM based technology used for these remote monitoring and control systems is Zigbee protocol [26] - [28]. Zigbee communication provides easy wireless installation of sensors at a lower cost and also increases reliability using mesh networks. Although Zigbee has a capability of 250kbps which is more than enough for SMS, it is not intended for voice and data streaming because it consumes too much bandwidth and drains power quickly, thereby making it unsuitable for real time applications. Also is difficult to develop with limited coverage and cost of implementation is also quite high. GPRS based data acquisition systems are studied in [30] - [32]. These systems are small in size, have low power consumption and strong scalability. Real time data acquisition and high data rate are the special features of GPRS based systems but the usage cost is high as compared to other technologies which is a major disadvantage of using these systems.

From the above discussion it is concluded that designing a remote monitoring and control system that satisfies all the parameters simultaneously is a complicated task. Each proposed methodology has its own merits and demerits. However, there is still a possibility of designing a cost effective system which has an improved performance in most of the respects that will work optimally in many different applications. A new GSM-Bluetooth

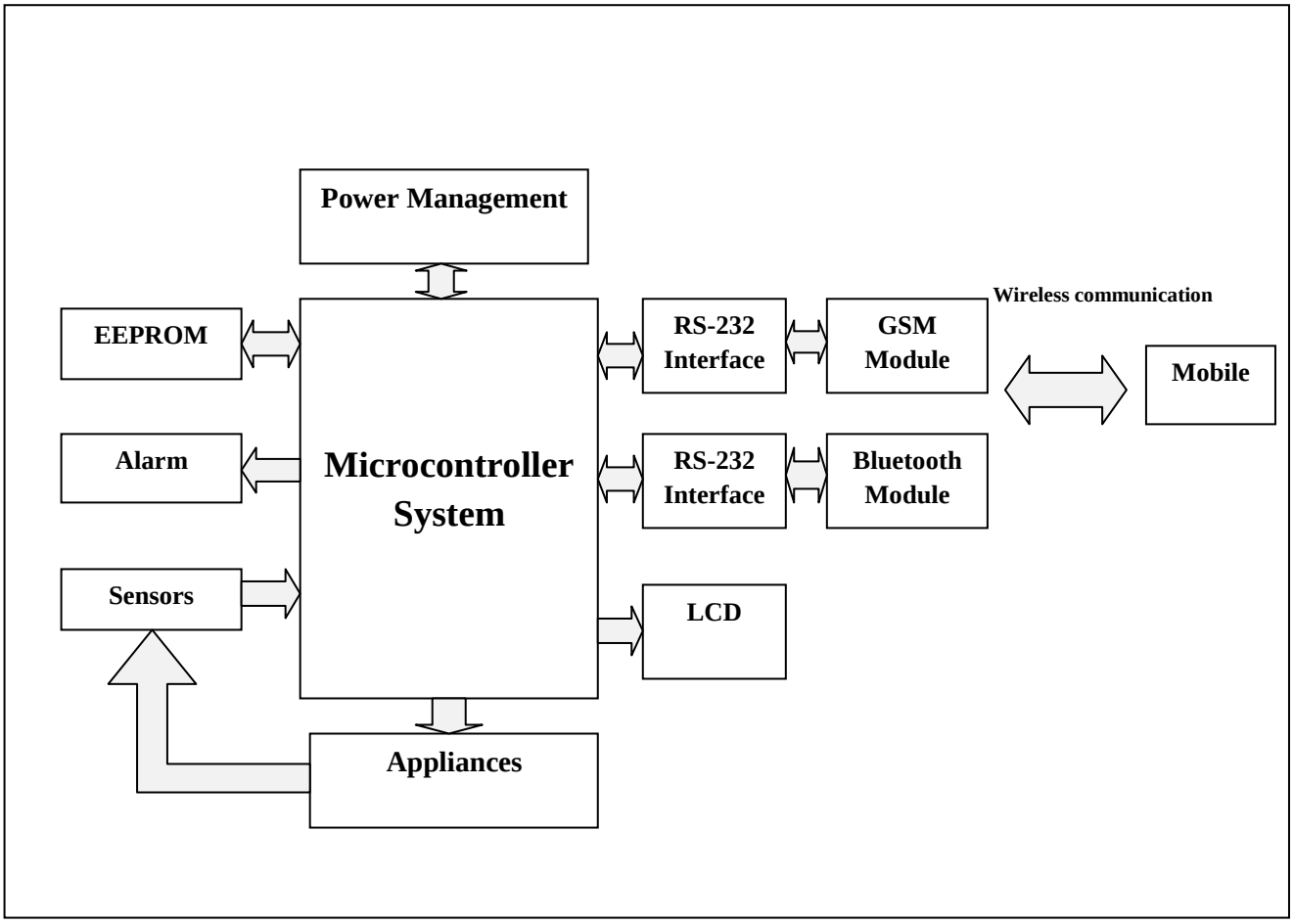

Fig 2 Block Diagram of GSM-Bluetooth based Remote Monitoring and Control System with Automatic Light Controller

based Remote Monitoring and Control System with Automatic Light Controller is proposed in this paper. Although this system will incur some additional cost due to the Bluetooth module interfaced to it, but it will eliminate the usage cost of network when in a range of few meters with the controlled devices by using Bluetooth module along with GSM. Next section explains the design of the proposed system.

4. PROPOSED SYSTEM

The block diagram of the proposed GSM-Bluetooth based system is given in fig. 2. In this system both GSM and Bluetooth modules are interfaced with the main controller chip. GSM is used for remotely monitoring and controlling the devices via a mobile phone by sending and receiving SMS via GSM network. Bluetooth is used for the same purpose but within a range of few meters, say when user is inside the periphery of the building where the system is installed, Bluetooth can be used for communicating with the devices thereby eliminating the network usage cost. This is an important merit of the proposed system. The lights and fans of the building are controlled automatically using IR (infrared) sensor and the other appliances are controlled by Bluetooth or GSM network via SMS. The system informs user about any abnormal conditions like intrusion detection and temperature rise via SMS from the GSM module to the user's mobile and actions are taken accordingly by the user. This leads to efficient utilization of power.

5. SYSTEM ARCHITECTURE

The hardware of the system mainly includes an 8-bit microcontroller chip, a GSM module, a Bluetooth module and RS232 interfaces. The microcontroller is interfaced with different sensors for controlling different applications. IR sensor is used to automatically control the lights, Temperature sensor detects the temperature and PIR (passive infrared) sensor detects for any unauthorized intrusion. The analog data from temperature sensor is converted to digital using A/D converter. EEPROM is used for recording the data provided by the sensors. It provides this data to the microcontroller for analysis when requested and an alarm is raised in emergency conditions depending upon this data and an SMS is send to the user's mobile. The measured values and the state of the devices are displayed on the LCD. The GSM and Bluetooth modules which are the most important part of this system are interfaced with the microcontroller using RS232. The modules act like an interface between the controller and GSM network. The GSM module must have a SIM (Subscriber Identity Module) card to make the network identify the user. The microcontroller communicates with the GSM module using the

AT commands. These AT commands are used to send and receive SMS. The programming code for the microcontroller is written in some high level language. When a user sends an SMS requesting the status of devices and measured value by the sensors, the GSM module sends the data stored in EEPROM as a response via SMS. The use of a mobile as a monitoring and control station provides for mobility in the proposed system which is a major drawback of all the existing internet based systems.

6. CONCLUSION AND FUTURE WORK

Detail survey of various remote monitoring and control systems have been presented along with the classification based on various parameters and the design of a GSM- Bluetooth based remote monitoring and control system with Automatic light controller has been proposed. This system has an advantage of using both GSM and Bluetooth technology which thereby eliminates the cost of network usage to a great extent by using Bluetooth when in the range of few meters with the devices. The system is scalable and allows any number of different devices to be added with no major changes in its core. But it is not efficient in situations which have strong real time requirements. The system has its application in situations where the amount of data to be transferred is not tremendous. The implementation details and results will be presented in future work.

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