Multi-Zone Remote Monitoring and Display System Schematics

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***Abstract*-Multi-Zone Remote Monitoring and Display Systems Schematics is a general data acquisition and control system to monitor distributed zones while the user of the system is anywhere in the world. The system comprises of mobile client and server application. The mobile client was developed in J2ME (Java 2 MicroEdition) and the server application was developed in ASP.NET using C#.NET. The mobile client was deployed on the cellular phone interacts with the server application for real time monitoring and control of distributed zones while the server application was deployed on a windows based web server. The wireless mobile networks especially GSM (Global System for Mobile communication) based mobile networks are becoming very popular and due to competition in the GSM world, the cost of service and cellular phone is decreasing day by day while quality of both the service and devices has improved. The wireless cellular technology used in the system was GSM and GPRS (General Packet Radio Service) was used to monitor and control of distributed zones. This innovative technology was designed for the use in diverse fields of life including nuclear industry, chemical laboratories, manufacturing industry, automobiles and many others where real time data is required to be monitored and controlled. The system can be used in two modes that are on-site mode and off-site mode. Using the off-site mode, the user of the system can monitor and control the zones using the cell phone while the user is anywhere in the world.**

I. INTRODUCTION

The era of current cellular phones date backs to 1945 when first car based telephone, half duplex system consisting of a radio transmitter came into being. The same care based telephone system was named as mobile telephone system after some enhancements [1]. At the time no one knew that this minor invention will lead to the path to the present cellular technology due to which we are able to control and monitor things remotely. With the increasing development of cellular technology and increasing use of cellular phones made their access to common man on the globe.

The system, Multi-Zone Remote Monitoring and Display System Schematics is a system which focuses to use the cellular technology most effectively. New developments and enhancements are being done in the hardware as well as in the development softwares and tools and components in the wireless world. Now with the developments in new languages like J2ME [2] has enabled the development of applications intended to be run on mobile phones and new packages in J2ME are being introduced with the passage of time.

Using cellular technologies remote monitoring of different industry processes can be done. With every passing day the number of service providers is increasing around the globe covering maximum populated area. The cost of service is going down while increasing quality by virtue of improvements in the technology. In this paper, a brief summary of a "Multi-Zone Remote Monitoring and Display System Schematics" developed for communicating with remote monitoring devices is given.

This paper focuses on the use of mobile phone for data acquisition and transmission using the technique called GPRS [3]. For testing purposes, the temperatures of distributed zones were monitored and controlled on the cell phone while the user was at a remote location. The temperatures may also be monitored and controlled from the desktop system running on personal computer. The temperature history can be viewed on cell phone as well as on computer. Hence the system is very cost effective to use in many fields of life like chemical laboratories, nuclear industry, automobiles and many others.

Overall block diagram of system is shown in Fig. 1. The system has eight temperature sensors called LM35DZ to sense the temperatures of the distributed zones. The sensors are connected to analog to digital convertor which is interfaced to the microcontroller and eight bit microcontroller is interfaced with MAX232.

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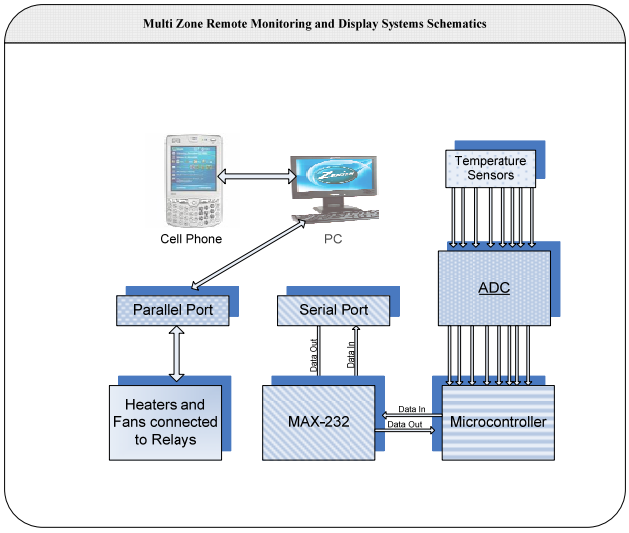

Fig. 1. MZRDSS System Block Diagram

The MAX232 provides TLL vlotage level. The MAX232 is interfaced with serial port of the computer. The zonal temperature data on the serial port is read by a program written in C#.NET which displays the real time temperatures as well as temperature history. Real time temperature values are stored in the database and the temperature history may be viewed from the stored temperature values of distributed zones in the database. On the computer there is web server running on which a web application is deployed to which mobile phone can be connected at any time. The web application reads the temperature values from the stored database. On the mobile side there is a mobile client developed in the J2ME [2] and mobile client is connected with the web application deployed on the web server. Hence all the zonal temperatures values which are viewed on the computer may also be viewed on the mobile phone.

A. Major Parts

At a higher level, the system is divided into two parts that is mobile client running on the cellular phone and server application also called the web application running on the web server.

B. Client Application

The client application was developed in J2ME [2] because most of the GSM [4] cell phones in the market now a days are java enabled providing different types of libraries for developing applications for running on cell phones. The client application was deployed on the J2ME [2] enabled mobile phone to provide the user an environment to monitor the zonal temperatures. The mobile client application directly interacts with the server

Fig. 2. Mobile client user interface

application (web application) to get the real time zonal temperatures. The temperature history can also be viewed on the mobile phone.

The Fig. 2 shows the user interface to monitor and control the zonal temperatures from mobile phone. Clicking on full screen will show monitoring screen in full screen mode. Selecting the monitor button may monitor the zonal temperatures on the cellular phone, the temperatures are recursively displayed on the cell phone until the user interrupts the process. The temperature data is stored in the database and at the same time temperatures are transmitted to the cell phhone. Whenever the mobile user wants to monitor the zones, always latest information is delivered to the cell phone. During the monitoring process the user may also take some other action like controlling, whenever he sees some specific zone temperature increases some limit value he may start the cooling process from the cell phone. Similarly the system user may also turn ON or OFF some specific heaters present at different zones.

C. Server Application

Server application is further divided into two parts that is web application and data acquisition application. Client application does not interact with the data acquisition application directly. It requests for specific information about zonal temperatures to the web application and web application provides the response. Only the user who has the rights to monitor or control can be connected to web application.

D. Web Application

This application was developed in ASP.NET [5] using C#.NET [6]. The main purpose of this application

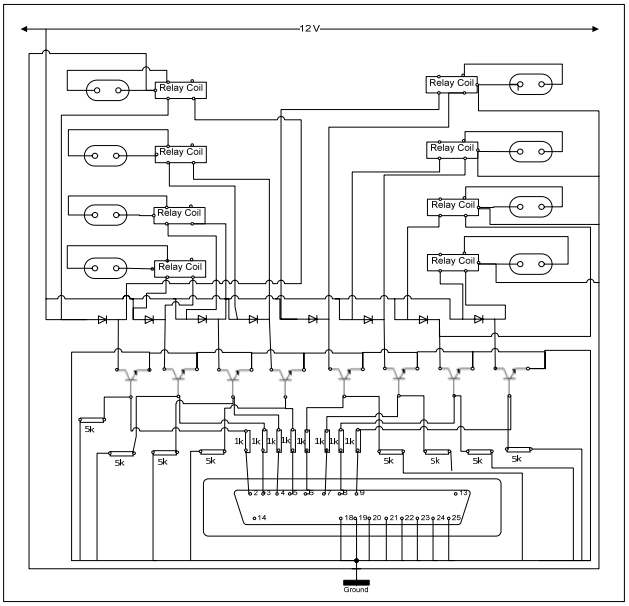

Fig. 3. Controller circuit diagram

is to provide the GSM cell phone real time zonal temperatures as well as temperature history depending on the request. The mobile phone will interact with the web application via GPRS [3] to fetch the real time zonal temperatures. The circuit related to controlling the zonal temperatures from mobile phone is shown in the Fig. 3 which shows relay based controlling mechanism.

E. Data Acquisition Application

The main purpose of this application is to read the data from the serial port of computer. The application stores the temperature information in the database and real time temperatures and temperature history is shown on the screen. This application was developed in C#.NET [6]. The zonal temperature data is acquired and stored locally for displaying the time history of temperature on the computer system. If the user of the system is at some remote location he may interact with the web application and the web application fulfills the request by delivering the latest values of zonal temperatures. The connection between the mobile client and the web application is established using the HTTP (Hyper Text Transfer Protocol). The circuit diagram corresponding to data acquisition is shown in the Fig. 4.

II. SYSTEM REQUIREMENTS

In order to execute the mobile client and server application, both the cellular phone and personal computer system should fulfill minimum hardware as well as software requirements.

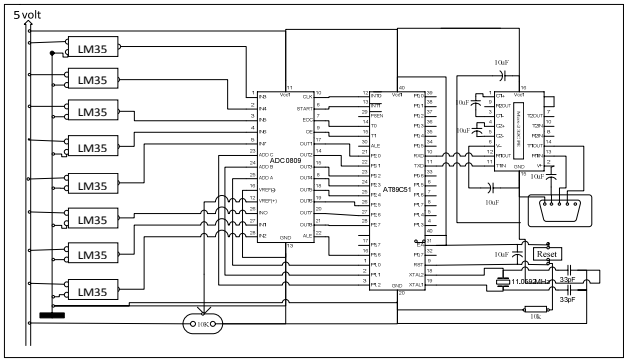

Fig. 4. Data acquisition circuit diagram

A. Operating Systems

Operating Systems are software platform on which other application can run utilizing the core features of operating system.

B. Microsoft platforms

The web application and data acquisition application can be run on Microsoft Windows Xp professional or higher operating system.

C. Mobile Operating System

At a lower scale than the computer system the main objective of mobile operating system is to provide the mobile related applications to be run on top of them. To be able to run the mobile client on the GSM cell phone it is necessary to select a GSM phone which has that operating system on which J2ME applications may be installed.

D. Software Requirements

The software requirements corresponds to soft wares which are either necessary for development or running the developed application.

E. Microsoft .NET Framework 2.0

A reusable class or component is called a software framework and Microsoft .NET Framework is a software framework which includes support programs and code libraries. It is pre-built with some operating systems while on others we may install it. A large library of pre-coded solutions to common programming problems, a runtime or virtual machine combines together to form a .NET Framework.

Most new applications can be developed using the existing code libraries of .NET Framework. On a higher scale the .NET Framework may be divided into class library and Common Language Runtime (CLR) [7]. Any

program or software targeted for .NET Framework executes in a software environment whose responsibility is to manage the program's runtime requirements parameters. This software environment is called the CLR. Any compiled program code targeted for .NET environment may run on any C.P.U. because compiled intermediate code is independent of C.P.U.

F. Java Runtime Environment

The Java Runtime Environment 1.6 was used which provides Java Virtual Machine and other required components and libraries. Any java compiled program needs Java Runtime Environment to execute the program.

G. Internet Information Services (IIS)

The web application part may be deployed on Internet Information Services (IIS) version 5.1 or higher that gives the highly reliable, manageable, and scalable web application deployment mechanism. Any web application can be quickly deployed on the web server.

III. HARDWARE REQUIREMENTS

There are minimum hardware requirements for both the cellular phone as well as computer system in order to run the mobile client on cellular phone and server application on the computer system.

A. Computer

The hardware requirements for installation of .NET Framework and ultimately the deployment of web application on web server and installation of data acquisition application is shown in Table 1.

B. Mobile

To be successfully running the client application to be deployed on the cell phone, the cell phone should be GSM based, and GPRS may be enabled on it and it should have minimum of 1 Mb of free space to be able to efficiently monitor the zonal temperatures. These are the minimum requirements, more enhanced is the hardware, more will be the data transmission rate.

IV. Wireless Data Communication Technologies

Transmission of data from one place to some distant place without wires is called wireless data communication. In the early era before 1980 when there were analog systems this was not very successful but the late 1980 evolution of GSM [4] and Personal Digital

TABLE 1
HARDWARE REQUIREMENTS

Type	Minimum	Recommended
Processor	400 MHz	800MHz or above
Memory	128 Mb	Greater than 128 Mb
Hard Disk Space(32 bit)	280 Mb	1Gb
Hard Disk Space(64 bit)	610 Mb	1Gb
Display	800X600 256 colors	1024X768 high color(16 bit)

Cellular devices started a new revolution in the wireless world. These wireless technologies can be used to monitor and control some process or location at a distant place. Currently for remote monitoring and control the following wireless technologies are available.

A. Wireless Local Area Networks

The linking of two or more computers or network nodes without wires comprises of wireless local area networks. They cover devices in a limited area using modulation technology based on radio waves. They can communicate up to hundreds of feet and provide greater data transmission rates. Group IEEE 802.11 corresponds to Wireless Ethernet standard with 2.4 GHz spectrum. All the wireless devices in the network are connected to access point across the Local Area Network.

B. Wide-area Wireless Data Systems

These systems provide low speed communication and cover large area. Initially they started to grow rapidly but rapid growth and popularity of mobile cellular phones stopped their growth. This kind of systems was developed by Motorola and Ericsson. After some time the standard for these systems evolved towards Cellular Digital Packet Data (CDPD) [11] which have data transmission rates up to 19.2 Kbps.

C. Satellite-based Mobile Systems

These systems cover very large area having adequate data transfer speed. They are most effective in the rural areas but they limit coverage in most populated areas because the transmission is shadowed there.

D. Paging systems

Most of the early paging systems worked in simplex mode but modern paging systems also work in half duplex mode. They are the simpler system which is the advantage and cover large area due to single powerful transmitter. The message length is up to 60 characters. The cost of both the device and service is low but there is no such powerful development environment by which we may develop our application for remote monitoring and control.

E. Digital mobile cellular systems

Digital mobile cellular systems are widely used now-a-days and they are not standardized yet but the widely used standard is Global System for Mobile communication (GSM) [4]. Digital mobile cellular systems are very common now-a-days and they are cheap too due to competition in the cellular industry.

In 1989, European Telecommunication Standard Institute (ETSI) took the responsibility to develop a standard for wireless networks and in 1980 GSM specifications were published. Finally in 1991 GSM network was launched by Radiolinja in Finland with joint technical help from Ericsson and now GSM is the most widely used standard around the globe for mobile phones.

Its ubiquity makes it possible for its users to have international roaming in maximum populated locations of the world. In GSM both speech and signal channels are digital. GSM provides many features like voice calls, data services and short message services or text message services. Remote monitoring may also be done using either short message service or using some features of network services. We may divide the GSM network into the following divisions.

1. Base Station Subsystem.
2. The Network Subsystem
3. The GPRS Core Network.

Newer and most enhanced versions of GSM are being introduced which are back compatible with the older versions. GSM release 97 added some feature of packet data capabilities by adding General Packet Radio Service (GPRS) and then in 1999 release 99 added Enhanced Data Rates for GSM Evolution (EDGE) features which have higher data transmission rates of up to 380 Kbps and still new features are being introduced.

V. Alternative Techniques for Data Communication

There are basically three techniques to communicate data from one place to remote location namely Short Message Service (SMS), Unstructured Supplementary Service Data (USSD) and General Packet Radio Service (GPRS).

A. Short Message Service

It is a stored and forward method of communication having character length of 160 in a message. The message is delivered to the recipient only when the resources are available until then it is stored in the pending queue. We may send SMS from one cellular phone to other and using the method may monitor and control the remote locations. Sometimes messages are not delivered instantaneously; hence it is not a reliable method for data communication.

B. Unstructured Supplementary Service Data

It is session based method of communication having character length of 182 characters in a message. It is faster than SMS and message is normally delivered in a predictable response time. In this method the two communication devices establish a virtual connection over GSM [11] system and start communicating with each other.

C. The General Packet Radio Service

When we are required to transfer data at a higher speed, the only intended technique is the GPRS [11]. It has the theoretical maximum speed of 171 Kbps having fast connection. Data is transferred from source to the destination in packets resulting in higher speed. The data converted into packets at the source side is delivered and at the destination it is reassembled and the complete and original information is received at the destination side. We can achieve higher data transmission rates using Enhanced Data Rates for GSM Evolution (EDGE) features.

VI. Proposed Technology and Technique

In the last two sections different wireless technologies and techniques were discussed. In this section optimal technology and technique from one of the technologies and techniques will be decided which will be used for remote monitoring and control. Although satellite based system has moderate data rates but it is the most expensive one and it will not results in a cost effective solution related to remote monitoring and control of zones. Wireless Local Area Networks have high data transmission rates and lower cost than digital cellular systems but they cannot be used because they have limited range which cannot be used to monitor and control the remote locations which are more than 200 feet apart. Similarly Bluetooth also cannot be used because it has limited range.The ranges of different wireless systems are shown in the Table 2.

To fulfill the required objective of Multi-Zone Remote Monitoring and Display System Schematics while considering the cost effective and optimal solution,

TABLE 2

RANGE AND DATA RATES OF DIFFERENT WIRELESS SYSTEMS

Wireless System	Range(ft)	Data Rates(Mbps)
WiFi – IEEE 802.11	100-150	802.11b(11),802.11g (54)
Bluetooth™ – IEEE 802.15.1	33	1.5
Zigbee – IEEE 802.15.4	30-300	< .25
WiMax – IEEE 802.16	26400-158400	45-75
Cell Phone(GSM)	114829	GPRS(.030-.080) EDGE(.16-.236)

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the only possible technology is Digital Mobile Cellular System which has unlimited range because using this technology we may monitor and control while we are anywhere in the world. In Digital Mobile Cellular System or GSM system the three techniques already discussed are the candidate techniques but from the three the optimal one is GPRS [11] which has higher data transmission rates, always on connection, robust and provides the required features.

Using GSM based cell phone and GPRS we can monitor and control any real world industry process efficiently and remotely. The GSM based intended technology and technique is adequate for data transmission rate that monitoring and controlling can be done remotely**.**

VII. Results and Discussion

The system can be used in two modes that are local monitoring and control and remote monitoring and control. Regarding local monitoring and control the system only needs to run the data acquisition application.

The Table 3 shows the recorded temperature history while running the system in off-line mode. The Table 3 shows the temperatures that were recorded while first four zones were at room temperatures and for the next four zones the heaters were turned on. There is an error of 1 degree. The error was induced due to noise as well as the environment because room was not at constant temperature. When the heaters at the zones from five to eight were turned on, the temperatures gradually increased shown in Table 3.

When the system was run in online mode that is monitoring and control was performed from the mobile phone the zonal information for the last four zones is shown in the Table 4.

The Table 4 shows that there is a delay of approximately 1 second. This delay is due to the fact that there is information flow from local computer to cellular phone using GPRS [11] and there is network overhead involved in that and this is expected and this delay will always be greater than 0 second but it may be minimized using EDGE enabled mobile phone and if monitoring is performed in EDGE hot spot which has greater data transmission and reception rate compared with that of GPRS based mobile phone. Now-a-days the EDGE enabled cellular phones are becoming very popular and in the next few years they will be economical too. Hence the efficiency of the system can be improved using EDGE enabled cell phone.

VIII. Conclusion

Multi-Zone Remote Monitoring and Display System Schematics has wide range of global applications. It is a general system and with some minor modifications to the system monitoring and control of some other process may be performed instead of temperature monitoring and control. The system with some modifications in the front end can be used for the flood detection system, earthquake monitoring system, monitoring the patients remotely, control and monitoring of industry processes, monitoring and control of radiation affected areas where humans cannot go, monitoring radiations levels, leakage detection in mines, home security system, remote power controller and surveillance system.

Hence the system has wide range of globally remote monitoring and control applications and the system is especially useful in nuclear industry because in nuclear industry there are a lot of activities which involve radiations and some radiations are hazardous to human beings, so they cannot directly interact with the radiations. The remote monitoring and control system can be used easily in those areas.

TABLE 3
TEMPERATURE HISTORY

Sr. No	Date and Time	Zone 1	Zone 2	Zone3	Zone 4	Zone 5	Zone6	Zone 7	Zone8
1	9/2/2008 12:01:08	26	26	27	26	27	28	27	28
2	9/2/2008 12:01:39	26	26	27	26	27	28	27	28
3	9/2/2008 12:01:50	27	26	26	26	29	28	29	29
4	9/2/2008 12:01:51	26	26	26	26	30	30	30	29
5	9/2/2008 12:01:53	27	26	26	26	31	31	31	31
6	9/2/2008 12:01:54	25	26	26	26	32	32	33	32
7	9/2/2008 12:01:55	27	26	26	26	33	33	33	33
8	9/2/2008 12:01:57	26	26	26	26	34	34	35	34
9	9/2/2008 12:02:00	26	25	26	26	35	35	35	34
10	9/2/2008 12:02:02	27	26	26	26	36	35	36	36

TABLE 3
DATA TRANSMISSION DELAY

Sr.No.	Date and Time when temperatures transmitted	Date and Time when received on mobile	Zone 1	Zone2	Zone 3	Zone 4
1	9/2/2008 12:01:08	9/2/2008 12:01:12	27	28	27	28
2	9/2/2008 12:01:09	9/2/2008 12:01:13	27	28	27	28
3	9/2/2008 12:01:10	9/2/2008 12:01:13	29	28	29	29
4	9/2/2008 12:01:11	9/2/2008 12:01:15	30	30	30	29
5	9/2/2008 12:01:12	9/2/2008 12:02:16	31	31	31	31
6	9/2/2008 12:01:13	9/2/2008 12:01:16	32	32	33	32
7	9/2/2008 12:01:14	9/2/2008 12:02:16	33	33	33	33
8	9/2/2008 12:01:15	9/2/2008 12:02:18	34	34	35	34
9	9/2/2008 12:02:16	9/2/2008 12:02:18	35	35	35	34
10	9/2/2008 12:02:17	9/2/2008 12:02:18	36	35	36	36

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