Server Room Monitoring System Capable of Remote Status Querying and Remote Administrating

D.M.D.D.P. Kumara, B. Thiruparan, H.H.E. Jayaweera and T.R. Ariyaratne
*Centre for Instrument Development, Department of Physics, University of Colombo,
Colombo 03, Sri Lanka.*

ABSTRACT

Development of a standalone device together with three application software in different platform for server room environment monitoring is reported. The developed hardware is connected to different sensor networks to detect/measure door opening, relative humidity, temperature, flood, power line status. User can define critical situation as a function of sensor inputs. In case, a critical situation is detected, the system produces warning messages to the stored phone numbers through short messaging service (SMS) and on-site audio visual warnings also produces. The hardware can be operated using the keypad and liquid crystal display (LCD) available on the hardware itself or using web application or using SMS. An application runs on a computer allows the hardware to connect to the internet. The data registered in the sensors are uploaded to a web database as a web based data log. A mobile application has been developed to make possible the remote administration through the mobile phone more user-friendly.User in the system can be given different credentials, such as operating device, adding new users and changing critical situation detection function. The system is capable of the authorizing user through password or using iButton (in case of on-site authorization). The main requirements to operate the hardware are power supply (which is battery backed up) and global system for mobile communication (GSM) coverage. The internet connectivity is optional, if connected additional functionalities are enabled.

MNEMONIC

EMI	Electro-magnetic interference
GPRS	General packet radio service
GSM	Global system for mobile communication
HSDPA	High-speed downlink packet access
Java ME	Java Platform, Micro Edition
Java SE	Java Standard Edition
LCD	Liquid crystal display
PCS	Personal communication system
RH	Relative humidity
SMS	Short messaging service
TCP/IP	Transmission control protocol/ Internet protocol
UPS	Uninterrupted power supply

1 INTRODUCTION

Client-server model is the widely used architecture for sharing services or resources in (credential based) more organized manner [1]. In this architecture, the service or resource iscentralized. Hence, updating and providing security becomes easier. However a major drawback of this architecture is a possible serve failure making the whole system useless [2]. In any system all possible measures should be taken for keeping the servers up and running.

Servers must be placed in a specific location where the external interrupts such as surges from power and data lines, power failures, physical damages due to people, animals or weather are minimal. Use of access controlling mechanisms, controlled environments, surge protectors and uninterrupted power supply arekey steps to get rid of external interferences. Monitoring of the functionality of such a system is also important, since, it allows providing warning signals to authorities in order for then to take necessary actions.

There are several automated systems that have been developed to monitor meteorological data of different situations such as automating traditional meteorological data gathering stations and green houses in which the climate is controlled[3,4,5,6]. Kuang et al (2008), have developed a remote flood monitoring system using optical fibres and electronics [7]. Solar irradiance and other weather parameters such as wind measurements are ofcrucially importance in renewable energy field [8,9,10]. Different wired and wireless techniques are used for remotely collecting the data from the monitoring stations. Internet is widely used in remote monitoring and controlling applications [11,12,13]. The advantages of the use of internet is ease of use and fast full-duplex communication, and the drawback are requirement of sophisticated equipment capable of connecting Transmission Control Protocol/ Internet Protocol (TCP/IP) and in case where internet connection is not approachable such as in most of the field experiments. Wireless sensors are commonly used in field experiments either with ad-hoc [14] or client-server architecture [3,4,7,12,13]. Advantage of wireless sensor systems are ease of use in the field for remote data gathering and drawbacks are the difficulty to transmit long distances, high power consumption, and high vulnerability to external electro-magnetic interference (EMI).

Global system for mobile communication (GSM) is the most widely deployed personal communication system (PCS) that has gained broad acceptance. Make use of existing GSM network is a better low cost reliable wireless data transmission approach [10,15,16]. As long as GSM coverage is available, this method can be use by interfacing basic GSM modem toa microcontroller for generating SMS messages, dialing and hanging up using Hayes command set.The objective of the project reported is to develop web/GSM based hybrid system for controlled room weather parameter monitoring and warning system capable of remote administrating through SMS or web based mobile phone/ computer application.

2 MATERIALS AND METHODS

The whole system comprises of three major units: Hardware, Web Application and Mobile Application. Hardwareunit is connected to a global system for mobile communication (GSM) modem and a computer which is connected to the internet (see Figure 1).
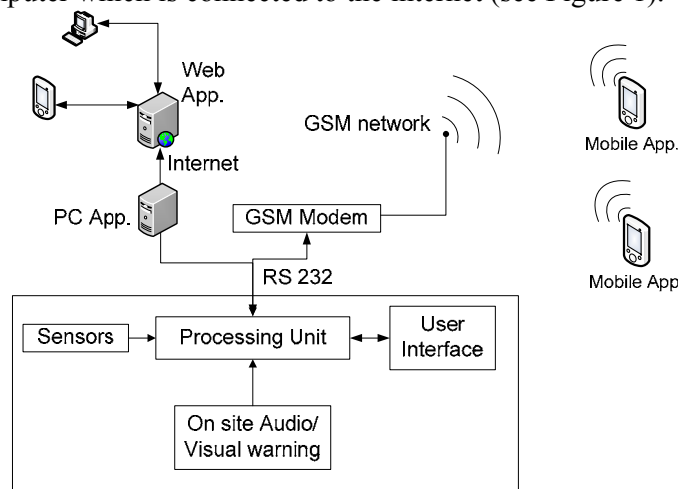

Figure 1- Systemoverview

2.1 Hardware

Microchip PIC 18F452 microcontroller is used for processing and controlling of the other units: sensing and user interacting units. The sensing unit is capable of sensing temperature, relative humidity (RH), flood, power line status, door lock, iButton and uninterrupted powerfully (UPS) status. Sensirion SHT75 sensor was used for measuring relative humidity since it comes with digitally interfaced, factory calibrated RH and temperature sensors [18].A unipolar type conductivity cell was used for detecting flooding in aroom. An industrial AC relay was used for power line status monitoring, and the door open was detected using a mechanical micro switch. An iButton reader was installed to authorize the door opening. Am array of Microchip PIC 16F84 were used to detect temperature in different locations of the room. The temperature sensor array was connected each other in parallel RS232 based request-response type network (Figure 2).The user interacting unit of the hardware was constructed of a liquid crystal display (LCD), a 4×4 matrix keypad, iButton reader and micro switch which detects the opening of the door. All the operations (adding phone numbers/users and changing passwords/parameters) can be done with the keypad and LCD. In addition to password based user authorization, an iButton based authorization has also been implemented for device to be more user-friendly.
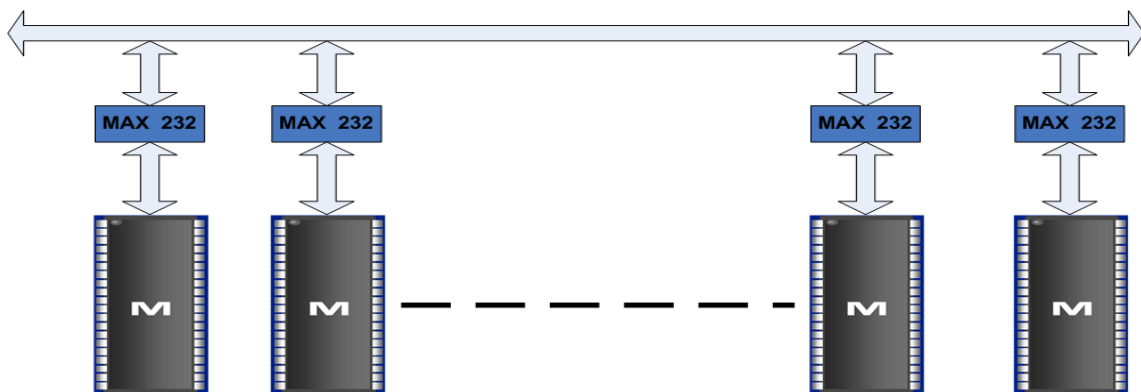

Figure 2 - Temperature sensor network

A GSM modem and a web application was used for communication with the external world other than the user interacting unit. Sony EricssonT630 has been used as the GSM modem to receive/send SMSes from/to mobile phones. An application was developed to run on the computer in order to upload/download information through the internet. Both, GSM modem and computer application communicates in RS232 protocol with the hardware.

2.2 GSM network connectivity

Short messaging service (SMS) is the major remote communication system of the hardware with the users. Predefined formats are used in sending messages to the users and also hardware responds to the messages receivedin the defined format.

Message formats:

Send status/thresholds/warning/test : `<flag : W – warning, S – status only, T – test, P – power is back > AT <deviceID> ON <time & date in hh:mm:dd:MM format> RH <RH value> T <temperature values> P <power status [1 0]> F <Flood [1 0]> L <door lock [1 0]> END`

Message format query: `<user phone number><password>`

Query status: `<phone number><password> STATUS`

Add new user: `<admin phone no><admin password>ADDUSER<new user phone no><new user password>`

Delete user: `<admin phone no><admin password>DELUSER <phone no to be deleted>DELUSER <admin password>`

Change password: `<phone no><current password>CHANGEPASS<new password>`

As it is annoying to remember all SMS commands for a user,a mobile phone application was developed in order to make the remote query and the remote admin tasks more user-friendly using Java Micro Edition.

2.3   Internet connectivity

Since the hardware is to protect server room, it is much easier to get connected to the internet through a computer. An application has been developed using Java Standard Edition to communicate with the hardware and upload the status to a database (say PC application). A web application is developed to retrieve the logged data and change the configuration of the hardware. Once a user changes the configuration setting in the web application it is saved in the database. When the application runs on the computer connectedto the database for uploading data, it automatically downloads the configuration settings and then transmits those setting to the hardware. When the new settings are downloaded to the hardware, user authorization and the other operations are performed by the hardware itself.

3 OPERATION

At the first run of the device, there is no user accounts are added. At the beginning, at least one administrator account should be created using the built –in keypad. Every username should be a phone number. User accounts with administrative powers should always be created using the built-in keypad and the other user accounts can be created through SMS (see section 2.2) or using the keypad by an administrator.

Operation of the hardware is illustrated in the flow chart given in Figure 3: Left. Other than the normal operation, when door-open event is detected, interrupt routines are called and on site warnings and SMS warnings are sent if authorization user is unable to input authorization information through the keypad or using iButton. Once user is authorized, keypad is activated for configuring mode and allows user to make the changes in the settings and user information. An administrator can set threshold values for temperature and humidity. Critical event is defined as a Boolean function of sensor inputs.

$$C = \bigcup_i \left(S_i > S_i^{Tresh}\right) \cup S_{Flood} \cup S_{Power} \cup \left(S_{DoorOpen} \cap \overline{UserAuthorization}\right) \quad ....(1)$$

Where, S_0 is RH reading from the sensor and S_i (i≠0) is the reading from the ith temperature sensor; S_i^{Tresh} is the threshold value defined by the user for the ith sensor. Variable$S$ with indices, *Flood, Power* and *DoorOpen*are Boolean variables and represent trigger of flood detection sensor, trigger of power failure detector and trigger of door opening detector, respectively. Boolean variable, *UserAuthorization* represents the event user had entered correct password or touched an authorized iButton to the iButton reader.In a situation, where a critical event is detected, the hardware sends SMSes to the user following the format given in section 2.2.

In each process cycle (Figure 3), hardware sends the readings of the different sensors to the the PCapplication. The PC application averages the values for 5 minutes time and upload them to the database in every 5 minutes together with the events such as user access to the system.
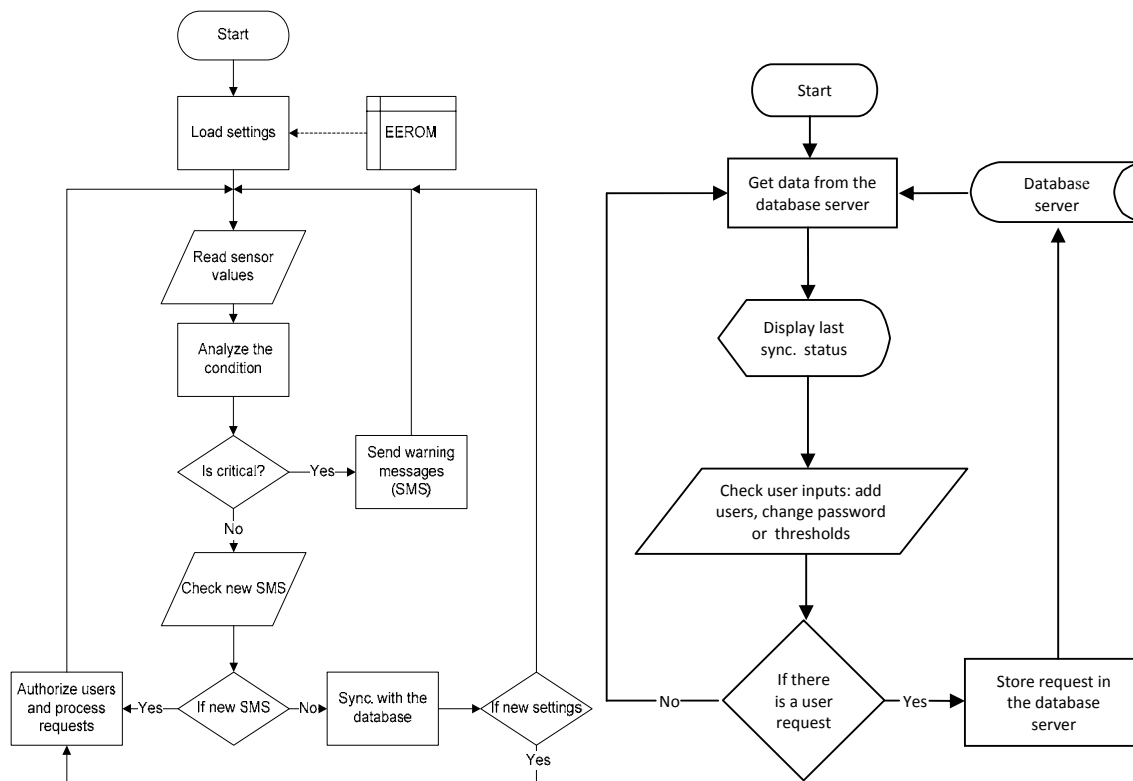

Figure 3–Left: Operation of the hardware, right: operation of the web application

Users can operate the device remotely either using web application or using SMSes. As long as user phone number password combination is remembered, user can use any mobile phone to control device with use of the SMSes. Use of SMS is littletricky, since, the user needs to send messages following the formats described in the section 2.2. User can use message format query feature, just by sending an SMS to the device with user phone number and password. If user sends a wrong formatted SMS, as long as the user phone number and password are correct, message format query feature is activated and user isreplied with the formats. Mobile application avoids the difficulty of formatting SMSes in proper way.

The web application allows users to retrieve event log and sensor value history. Moreover, it allows users to control the device through internet. Once, user sends request to change some settings, that information will be downloaded to the hardware within 5 minutes if the PC Application is connected to the internet at that time.

4 DISCUSSION AND CONCLUSIONS

A novel, low cost yet reliable and flexible method have been introduced to monitor temperature. Since a microcontroller itself was used as a temperature sensor it can be used to transfer data in any format such as I2C, SPI, RS232, etc. When the steel conductivity cells are used in unipolar configuration there is a danger of getting corroded, yet the low relative humidity and temperature makes it less vulnerable for corrosion. Providing cathodicprotection is a better way to protect the cell rather than using alternative polarity configuration, since the system is supposed to operate using batteries too. The industrial relay

used for power line monitoring provides the information whether the power is available or not. In some cases such as the situations where voltage fluctuations are occurred, the system does not respond. Hence, getting voltage monitoring signals from the UPSes is a better technique.

Internet based system is an optional add on for the system and cannot be relied on that since the internet connectivity can easily be disturbed in critical situation such as a power failure. Make use of GSM modem based internet connectivity method such as GPRS or HSDPA would be a better solution. Also, the web based remote administration system does not directly communicate with the hardware. Instead, the request made through web applications is stored in a database and when the device is connected to the database it downloads the settings and updates the parameters in the hardware. Data logged on the web database can be analyzed in order to find out the potentialissues/trends with of the environment such as temperature increment in localized area that may be due to block in the ventilation system. SMSes are delayed in the operator's end and it can be eliminated by getting priority service from the operator. Although SMS does not provide high speed communication, it has many advantages over other data delivering schemes such as GPRS and HSDPA, like being inexpensive and can operate concurrently with voice services. Also, it employs signaling channels only, hence requires less radio resources resulting less signaling traffic.

The developed system can easily be customized to use in different other applications, where the amount of data to be transferred is less and GSM network connectivity is available. Since, the power consumption is very little, it can be used in mobile applications, such as temperature monitoring in food (milk, fish, ice cream, etc.) transporting vehicles. Also, there is a potential that the system can be used in the applications ofdeveloping monitoring systems to detect water flow in rivers and predict the risks of food in low lying areas.

Standalone operation, battery backed up power supply and necessity of other infrastructure except GSM coverage make the device robust. Device produces warning messages through SMS to the mobile phone numbers stored in the system, if a critical situation is detected. Device is capable ofadministering remote and status requesting through any mobile phone. Web application, mobile application and PC applications were developed using freeware, so that there will be no additional cost involved in developing software tools.

5 ACKNOWLEDGMENT

6 REFERENCES

1. G. Reese, Database Programming with JDBC and Java (Second edition), (O'Reilly & Associates, 2000), pp. 127-132
2. Client-server model, http://en.wikipedia.org/wiki/Client-server, retrieved on 18/10/2010
3. M. Benghanem, *A low cost wireless data acquisition system for weather station monitoring*, Renewable Energy 35 (2010) 862–872
4. M. Hautefeuille, C. O'Mahony, B. O'Flynn, K. Khalfi, F. Peters, *A MEMS-based wireless multisensor module for environmental monitoring*, Microelectronics Reliability 48 (2008) 906–910
5. S. Rosiek, F.J. Batlles, *A microcontroller-based data-acquisition system for meteorological station monitoring*, Energy Conversion and Management 49 (2008) 3746–3754

6. S. Ameur, M. Laghrouche, A. Adane, *Monitoring a greenhouse using a microcontroller-based meteorological data acquisition system*, Renewable Energy 24 (2001) 19–30

7. K. S. C. Kuang, S. T. Quek and M. Maalej, *Remote flood monitoring system based on plastic optical fibres and wireless motes*, Sensors and Actuators A 147 (2008) 449–455

8. R.Mukaro and X. F.Carelse, *A Microcontroller-Based Data Acquisition System for Solar Radiation and Environmental Monitoring*, IEEE transactions on instrumentation and measurement, vol. 48, no. 6, December 1999

9. K. Kalaitzakis, E. Koutroulis and V. Vlachos, *Development of a data acquisition system for remote monitoring of renewable energy systems*,Measurement 34 (2003) 75–83

10. M. Gagliarducci, D. A. Lampasi, L. Podesta, *GSM-based monitoring and control of photovoltaic power generation*, Measurement 40 (2007) 314–321

11. M. C.Filibeli, O.Ozkasap and M. RehaCivanlar, *Embedded web server-based home appliance networks*, J. of Netw. and Comp. App.30 (2007) 499–514

12. W. Jang, W. M. Healy and M. J. Skibniewski, *Wireless sensor networks as part of a web-based building environmental monitoring system*, Automation in Construction 17 (2008) 729–736

13. W. Chunga, S. Ohb, *Remote monitoring system with wireless sensors module for room environment,* Sensors and Actuators B 113 (2006) 64–70

14. Y.Leea and W. Chung, *Wireless sensor network based wearable smart shirt for ubiquitous health andactivity monitoring*, Sensors and Actuators B 140 (2009) 390–395

15. J. Jianga, C. Tsengb, F. Lua, E. Yangc, Z. Wua, C. Chena, S. Lina, K. Linb, C. Liaob, *A GSM-based remote wireless automatic monitoring systemfor field information: A case study for ecological monitoringof the oriental fruit fly, Bactroceradorsalis (Hendel)*, comp. and elect. in agri.62 (2008) 243–259

16. S. C. Watthage and R.Lelwala,*Field Programmable Electronic Vehicle Security System,* Proceedings of the Technical Sessions of the Institute of Physics, Sri Lanka, session 26, (2010)

17. D. M. K. D.Dissanayake and R. Lelwala,*Construction of an SMS Operable LED Display Panel,* Proceedings of the Technical Sessions of the Institute of Physics, Sri Lanka, session 26, (2010)

18. SHT75 - Digital Humidity Sensor (RH&T). Sensirion - the sensor company. [Online] [Cited: March 10, 2010.] http://www.sensirion.com.