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Study and Implementation of Environmental Monitoring System (EMS) Using WSN

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Abstract: Wireless sensor networks are currently an active research area mainly due to the potential of their applications. A WSN consists of number of sensors spread across a geographical area. Each sensor has wireless communication capability and some level of intelligence for signal processing and networking of data. Sensor networks require technologies from three different research areas: sensing, communication and computing. Sensor Networks (SNs) facilitate the study of fundamental processes and the development of response systems. Various applications of WSN are animal habitat study, health monitoring, military applications, environmental monitoring, etc. Among these, environmental monitoring represents a class of sensor networks which facilitates the process of monitoring of the environmental variables such as temperature, humidity, light, etc. In agricultural sector, at present farmers are using conventional methods for environmental monitoring which has a problem of poor accuracy and efficiency. So, an effective environmental monitoring system is needed to provide an interface for collecting and analyzing the measured values from the agricultural field. In the proposed research, sensor nodes in a WSN professional kit sense temperature, light and humidity from their surroundings and send these parameters to the base station. The base station in turn sends to the interface called Mote view. Mote view interface is connected with postgre SQL and through web applications data is viewed and inserted in SQL. In Web applications client side data can be viewed by target audience. Its server tier provides data logging, database storage for forwarding sensor data from Mote gateway for further processing and analyzing. The maximum, minimum and average value of each parameter is analyzed. These are updated to server data base along with the given location and date for processing. In addition to the environmental monitoring of various parameters, the project also aims to provide an alert signal if the conditions are exceeding certain threshold level in a real-world environment.

Key words: WSN, EMS, MEMS, mote, SQL, India

INTRODUCTION

Wireless Sensor Network (WSN) consists of spatially distributed autonomous sensor nodes to monitor physical conditions such as temperature, sound, vibration, pressure, motion and pollutants (Zuo *et al*., 2011). Sensor networks provide endless opportunities but at the same time pose key challenges such as the fact that energy is a scarce and usually non-renewable resource. But recent advances in low power VLSI, embedded computing, communication hardware and in general, the convergence of computing and communications are making this emerging technology a reality. Also, advances in nanotechnology and Micro Electro-Mechanical Systems (MEMS) are pushing towards networks of tiny distributed sensors and actuators. Applications of sensor networks are wide ranging and can vary significantly in application requirements, modes of deployment, sensing modality or means of deployment.

A WSN usually consists of tens to thousands of sensor nodes that communicate through wireless channels for information sharing and cooperative processing (Rout *et al*., 2008). It is usually deployed densely over certain area in an ad hoc manner to provide accurate data. After initial deployment, sensor nodes are responsible for self-organizing an appropriate network infrastructure, often with multi-hop connections between sensor nodes. Sensor nodes collect information in continuous or event-driven mode.

The network is fault-tolerant because many nodes are sensing the same events (Giannopoulos *et al*., 2009). The two most important operations in a sensor network are data dissemination that is the propagation of data/queries throughout the network and data gathering that is the collection of observed data from the individual sensor nodes to a sink (base station). Sensor networks are data centric that is the queries in sensor networks are addressed to nodes which have data satisfying some conditions (Burri *et al*., 2005). A sink node acts as a gateway between WSN and internet (Fig. 1). Users can retrieve information of interest from a WSN by injecting queries and gathering results from sink node. Base

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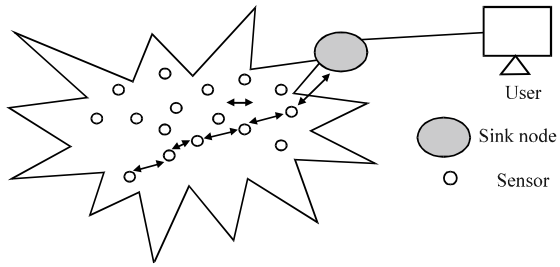

Fig. 1: Accessing WSNs through internet

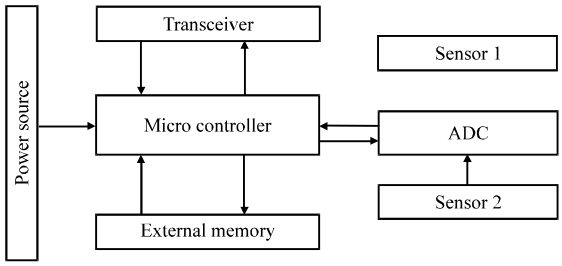

Fig. 2: Architecture of sensor node

stations have enhanced capabilities over simple sensor nodes since they must do complex data processing.

SENSOR NODE ARCHITECTURE

Sensor node is small, light weight and portable one. Smart disposable micro sensor nodes can be deployed on the ground, in the air, under water, on bodies, in vehicles and inside buildings (Panayiotou *et al*., 2005). A typical architecture of a sensor node is shown in Fig. 2. Each wireless sensor node consists of following components.

Sensors: Sensors are hardware devices that produce a measurable response to a change in a physical condition like temperature or pressure. The analog signal produced by sensor is digitized by Analog to Digital Converter (ADC) and send to the controller for further processing. Sensor nodes consists of one or more sensors such as seismic, thermal, visual, infrared, etc. These sensors can be integrated using MEMS technology.

Micro controller: The controller performs tasks, processes data and controls the functionality of other components in the sensor node. A microcontroller is often used in many embedded systems such as sensor nodes because of its low cost, flexibility to connect to other devices, ease of programming and low power consumption.

Transceiver: Sensor nodes often make use of ISM band which gives free radio, spectrum allocation and global availability. Radio frequency based communication is the most relevant that fits most of the WSN applications. The functionality of both transmitter and receiver are combined into a single device know as transceivers. The operational states are transmit, receive, idle and sleep.

External memory: From an energy perspective, the most relevant kinds of memory are the on-chip memory of a microcontroller and Flash memory off-chip RAM is rarely if ever used. Flash memories are used due to their cost and storage capacity.

Power source: The sensor node consumes power for sensing, communicating and data processing. More energy is required for data communication than any other process. Batteries, both rechargeable and non-rechargeable are the main source of power supply for sensor nodes.

OBJECTIVES

- To create a real time monitoring wireless sensor system to solve the problem of poor accuracy and wastage of labor in the environmental parameter monitoring based on WSN
- To provide essential value using this device based on WSN in rural areas in the field of agriculture
- To develop a system to provide interface for collecting and analysing the measured values through Internet and sought suggestions/ recommendations from the expert group

PROPOSED SYSTEM

WSN have gained worldwide attention in recent years, particularly with the rapid progress in Micro-Electro-Mechanical Systems (MEMS) technology which has facilitated the development of smart sensors. These sensors are small with limited processing and computing resources and they are inexpensive compared to traditional sensors.

These sensor nodes can sense, measure and gather information from the environment and based on some local decision process, they can transmit the sensed data to the base station. The base station connected to server system receives the sensed data and sends to the proposed system which stores the data in the database. The proposed system provides the effective interface to the user so as to analyse the parameters conveniently.

Observing the parameters using such nodes is a simple process and it provides a flexible way of finding environmental conditions as fast as possible (Panchard, 2006). Another advantage of the proposed

system is efficient management of observed parameters. The measured readings are displayed to user accurately and consistently. The measured values will be sent to the server through which the administrator in research sector can get a clear idea of the external conditions.

The proposed system overcomes all the drawbacks of existing system as stated above. In addition to this it provides one more facility for research organizations related with the agriculture. That is an administrator from the research organization can able to view the environmental parameters conditions in the rural areas through internet. In short this system provides the accurate monitoring of parameters via internet WSN.

Wireless sensor nodes: The measurement of temperature, light and pressure by the use of Crossbow sensor kit in which there are different nodes/motes placed at different locations. These nodes with different identification will sense the temperature and light of the reference environment and send it to the base station node. In turn it is connected through USB port to the computer by the use of Mote View and MoteConfig environment. The sensor boards are MTS400CA and MTS310 which are connected with A MICAZ node. MICAZ node uses the Chipcon CC2420, IEEE 802.15.4 compliant, ZigBee radio frequency transceiver integrated with an Atmega128L micro-controller.

Base station: Base station is composed of gateway MIB520 and MICAZ node and they are connected by 51-pin expansion connector. Gateway MIB520 connects to server through USB port which is used for communicating and programming online. The USB port is converted to two virtual serial ports in server. Gateway MIB520 has an on-board processor and can run MICA processor/RF board.

Software requirements:

- Operating System: Windows professional
- Mote View 2.0: To interface with sensor nodes
- Front End: J2EE (JSP and Servlet)
- Back End: MS-Access Database (as Server Database, PostgreSql (as Base Station's Database)

Mote view: The Mote view is designed to be an interface between a user and a deployed WSN. Motes are programmed with XMesh/TinyOS firmware (application) to perform a specific task: e.g., microclimate monitoring, agricultural crop tracking, etc. The second layer or server tier provides data logging and database services. Mote-view is a client tier application designed to provide users of wireless sensor networks an interface for end to end management and supervision of a deployment. The sensor readings arrive at the base station (e.g., MIB510, MIB520) and are stored on a server. The third part is the client tier where software tools provide visualization, monitoring and analysis tools to display and interpret sensor data. The mote tier comprises any embedded software that runs on the mote hardware including a tiny micro threaded operating system (such as Tiny OS), Firmware applications and sensor board drivers. Such embedded software is written specifically for the hardware in a language designed for resource constrained devices such as nesC, C or assembly (Appendix 1).

The server tier provides data logging, database storage and services for forwarding sensor data coming from the mote gateway. Cross-platform portability is important in the server tier since the hardware may be a PC running Windows or a dedicated appliance running Linux. This portability requirement encourages the use of high-level languages such as Java or C++ within the server tier. The client tier provides a Graphical User Interface (GUI) for managing and visualizing the server and mote tier and is typically designed to run well on an end-user platform of choice: a personal computer or a handheld Personal Digital Assistant (PDA).

ENVIRONMENTAL MONITORING SYSTEM (EMS) USING WSN-IMPLEMENTATION

The environmental monitoring process is implemented with the monitoring devices based on the WSN. WSN consists of various sensor nodes to sense and gather data and the base station to receive data from sensor nodes and then to send the data to the system. These devices adopt temperature, humidity, true-light sensors, infrared-based presence sensors (PIR sensor) and chemical sensors are useful for in-door environmental monitoring systems. In the study, the WSN devices adopt MICAZ node produced by Crossbow company. This system is implemented using the J2EE technology (JSP). The portability requirement in the Mote view encourages the use of high-level languages such as Java or C++ within the server tier. Java Server Pages provides the feature of user friendly interface with consistent business logic. Hence, change in interface does not affect the business logic and vice versa.

Data stored in MS-Access is available for detailed analysis turning into useful information. A Web Application is developed enabling users to access the WSN data over the internet. This interface is written in JSP to allow users interactively choose desired parameters and plot the results. Figure 3 shows the proposed EMS

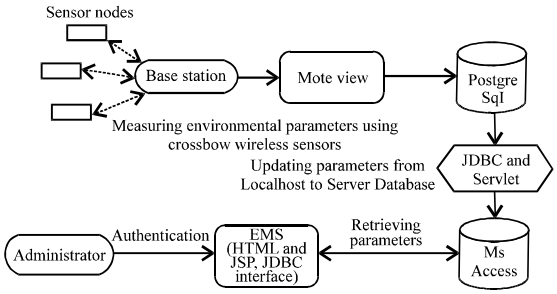

Fig. 3: EMS implementation architecture

Architecture for the typical application. After measuring the environmental parameters the user enters into the updating module. Here, user gives the date on which the readings are taken and the city, location where the measurement is done. With the above details user finishes the update module. Then, the system passes the query to the PostgreSql database where all the measurements are stored and the PostgreSql returns all the readings measures on the given date (Appendix 1).

Then, the given system calculates the peak, lower and normal conditioning for the parameters and stores these values in the MS-Access database. To perform these transactions JDBC and Servlet technology are used because it is concerned only with the business logic. The update module is implemented using Servlet. All other modules are implemented using the JSP technology which integrates the user interface and the business logic.

Only the update module deals with two databases at a time. PostgreSql act as a BS database and Ms Access act as a Server Database for the Monitoring system. In order to ensure that only authorized person can access. Enforced via AES algorithm. Session management is efficiently implemented in the project so that after getting logout no can gain access to this system unless doing login again.

CASE STUDY

Climate monitoring is most important to the operation in green houses and quality of the collected information data has a major influence on the precision and accuracy and control result. The WSN Provisional kit test bed has been used to collect various parameters such as temperature, pressure and humidity from various green houses climate condition prevailed in around Coimbatore. The experimental set up shown in Fig. 4. Generally the green house micro climate is combination of physical processes such as heat, humidity, pressure, etc. The crop growth is mainly influenced by the surrounding environmental climate. In the case study, temperature and

Fig. 4: Experimental setup

humidity values have been taken from the WSN nodes and the data set values transfer to base station in wireless way. Subsequently, the data set is processed and stored in server. Now the authenticate user can able to access the stored data and monitored the status of various parameters in green houses. Here, if any abnormality found I green houses alert signal has been generated. Now end user has privilege of taking some suitable control action so has to maintain a better micro climatic condition green houses.

CONCLUSION

The applications for WSNs are plenty and are used in commercial and industrial applications. WSN's are used to monitor data that would be difficult or expensive to monitor using wired networks. So, an application of WSN for environmental monitoring system is proposed in this paper. It provides the accurate monitoring of environmental parameters such as temperature, humidity and pressure. Furthermore, it is necessary to provide an efficient way of processing the data (preferably in a decentralized manner) and turn them into meaningful information as needed to take control actions.

In this study, researchers proposed a preliminary design on the real-deployment of WSN for environmental monitoring. The system focused on new design architecture to cater the most important and critical issue in today's WSN monitoring. Besides this system provides an effective interface so that enhancements in the environmental control measures can be done in an effective and efficient way.

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APPENDIX 1

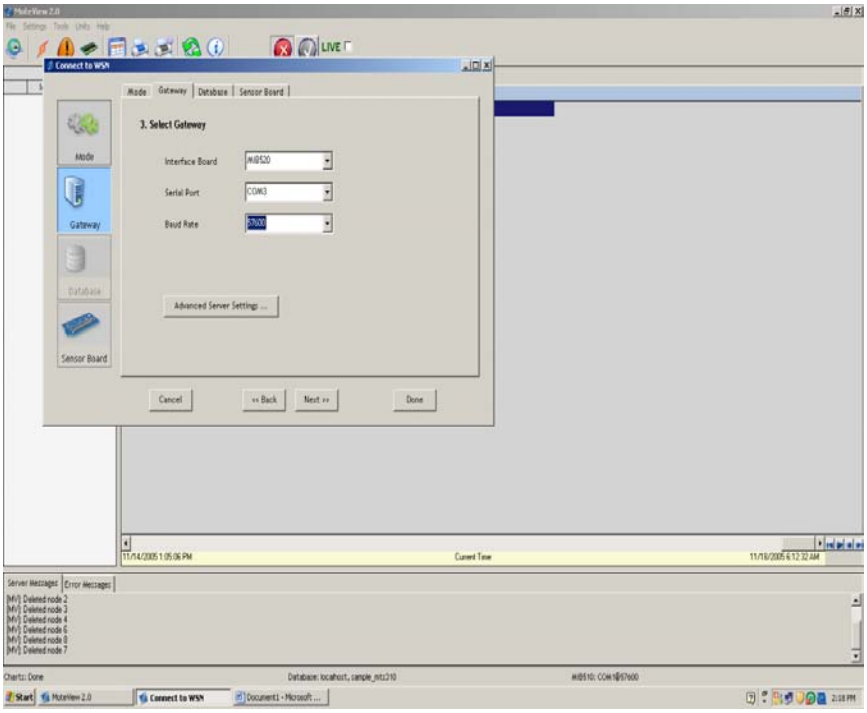

Fig. A1: Mote view configuration for WSN

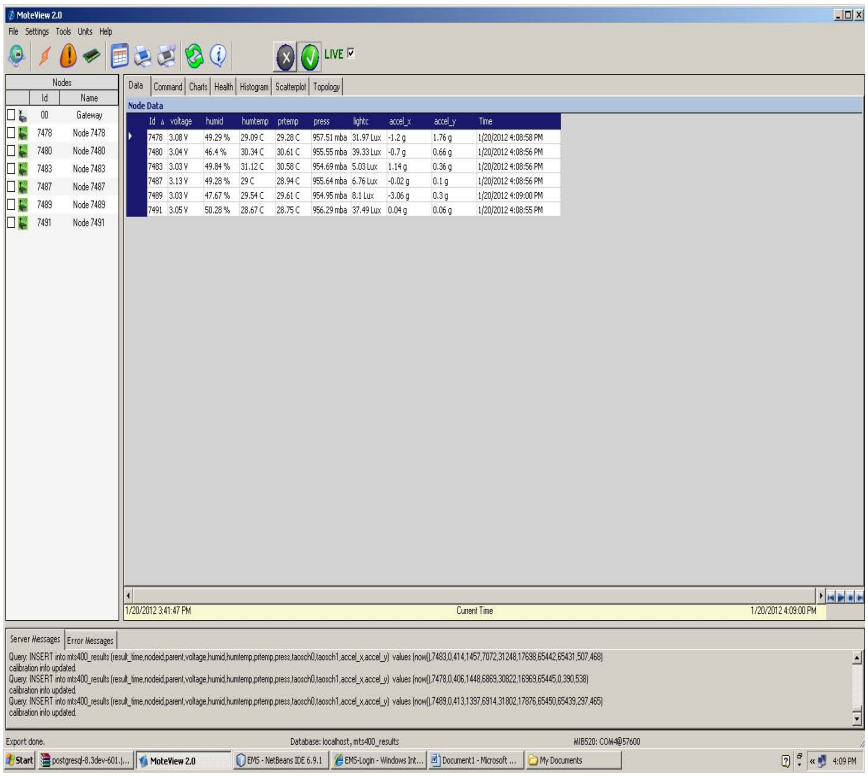

Fig. A2: Mote view 2.0-parameters measuring

Fig. A3: Updating parameters

Fig. A4: EMS view page with query type

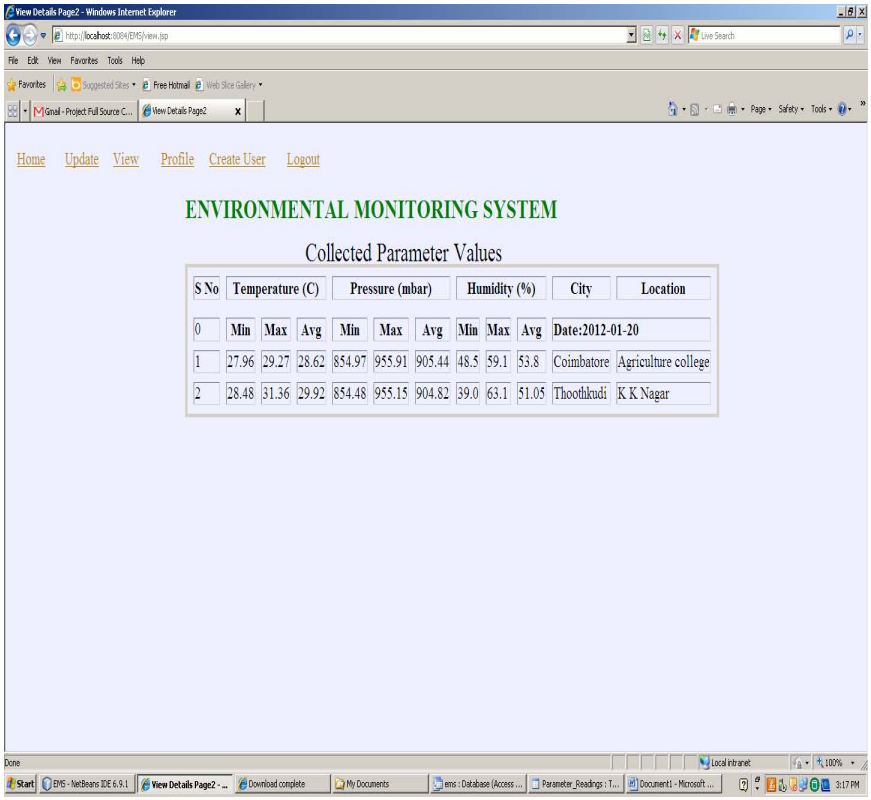

Fig. A5: Query type 1 result

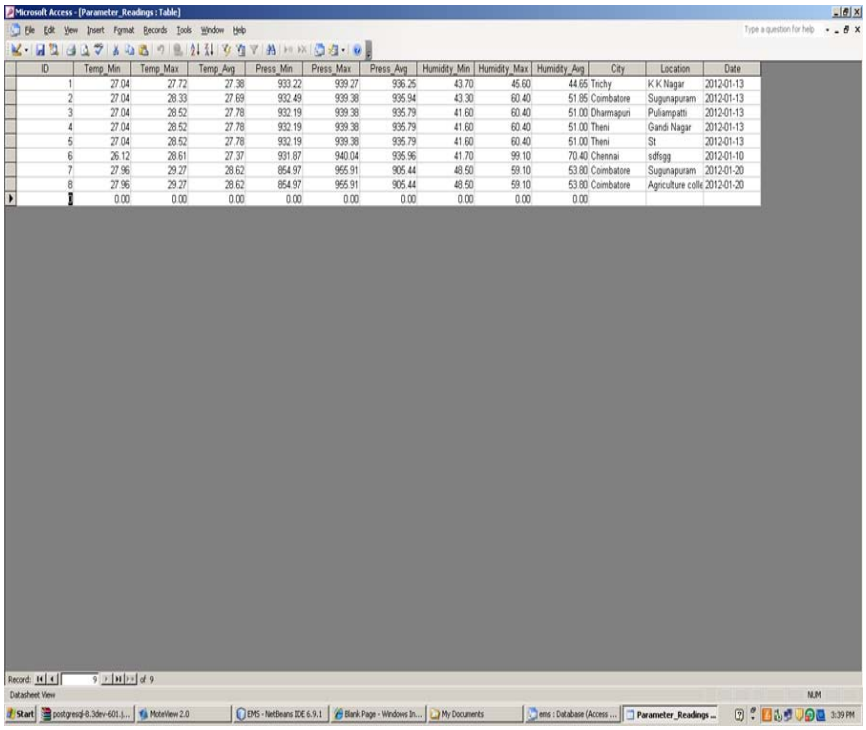

Fig. A6: Parameter readings table

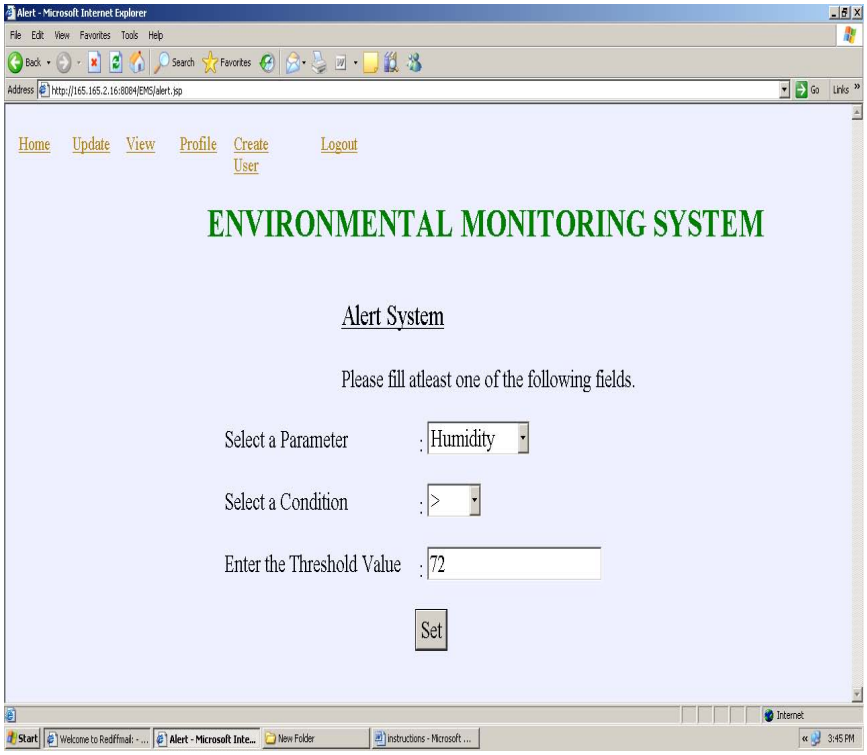

Fig. A7: Alert checking

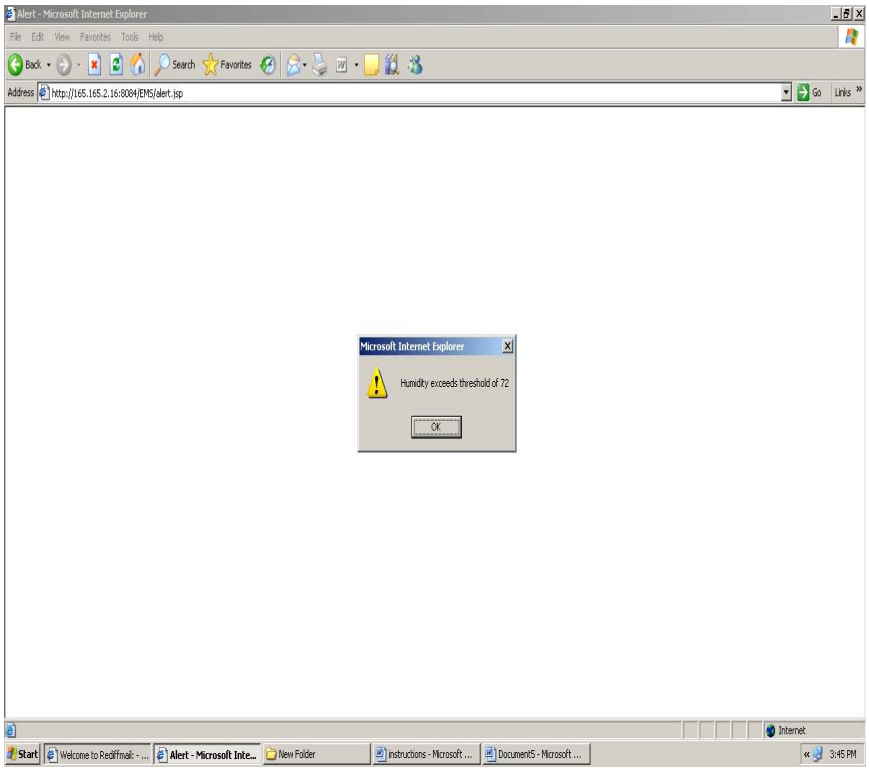

Fig. A8: Alert message

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