
Data Center Temperature Monitoring via Simulated Sensor Network



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Abstract

This research paper presents a temperature monitoring system of servers and active devices inside data center room via simulated sensor network. Continuous temperature monitoring in data center is very important for reliably operating the computing equipment and minimizing the required cooling energy. The presented system composed of three parts (part-1, part-2 and part-3) and it works based on the relationship among these three parts. Part-1 means simulated wireless sensors that created to represent data center's temperature. Part-2 is a SQL database server to receive sensors temperature data. Lastly, part-3 is the network administrator's monitoring tool that is installed on a personal digital assistance (PDA) or Tablet

Keywords: Data Center Monitoring, PDA, Temperature and Humidity, Alert Message, Simulated Sensors.

Introduction

The IT industry is one of the fastest growing sectors of the economy in terms of its energy consumption. According to the Environmental Protection Agency report, U.S. data centers alone consumed 61 billion kWh in one year — enough energy to power 5.8 million average households. Even under conservative estimates, IT energy consumption is projected to double by near future. Reducing data center energy consumption is a pressing issue for the entire IT industry now and into the future [1]. Furthermore the growth in cloud services is expected to increase consumption further. The large monetary cost and the environmental impact of this consumption have motivated operators to optimize data center management.

One of the underlying reasons for the low-energy utilization is the lack of visibility into a data center's highly dynamic operating conditions [6].

With these important considered notes, the successful operation of air-cooled data center (DC) requires an efficient cooling environment to ensure that the DC operator can provide its services to customers with maximum availability and reliability at minimum operational cost. An efficient cooling system guarantees that the temperatures at the inlets of all computing devices in the DC never exceed a given threshold value to prevent device overheating, and achieving this goal with minimum required cooling energy. However, most of the current DC's cooling energy is

wasted because they are operated at significantly lower temperature than actually necessary. This approach certainly reduce the potential risk of reacting too late to a harmful temperature increase the DC that might be caused by a sudden malfunction or replacement of a cooling or computing device, but leads to the consumptions of 3 to 5 % more cooling energy for each degree Celsius below the upper temperature limit. To encourage the operators to run their DC closer to the economically attractive upper limit, monitoring functions have to be incorporated into existing DC management tools that allow for continuous tracing and analyzing of the temperature distribution in the DC during its regular operation [3].

Wireless sensor networks promise to remove this veil of uncertainty by delivering large volumes of data collected at high spatial and temporal fidelities.

In the current High Tech, wireless communication place the major role which led us the innovative idea of using this new technology for many applications. A Wireless Sensor Network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to monitor physical or environmental conditions (i.e.; Data Center Temperature and Humidity Monitoring).

After around a decade of active research on wireless sensor network recent standards released are stimulating the development of commercial product [2, 6].

Unlike other models of Data Center Temperature Monitoring, in this paper a model of DC monitoring is proposed by utilizing simulated sensors.

This system composed of three main parts:

- Part-1 means simulated wireless sensors created to represent data center's temperature and humidity.
- Part-2 is a database server for receiving sensors temperature and humidity data.

- On the other hand, part-3 can be classified to network administrator PDA or Tablet device.

The current system works based on direct relationship among these three parts.

The Data Center Temperature Monitoring via Simulated Sensor Network which is shown in figure 1, has been developed using Visual Studio programming language utilizing some features like socket module with some Application Programming Interface (API), Microsoft ADODB and SQL server database. This application works under Microsoft Windows operating system environment.

The rest of this paper is organized as follows: In section II, related work and background have been discussed; section III, explains the design of the system software; section IV is devoted to the necessary steps in analysing system work flow. The system test, results and all relevant discussions are appeared in section V. Finally, the main conclusions and future work are summarized in section VI.



Fig. (1) Data Center Monitoring System via Simulated Sensor

II Related Work and Background

In the last decade, some Data Center Temperature Monitoring Systems by using different ways have been seen; they are concerned with developing systems to operate on different applications for different fields such as distributed transformer networks remote temperature monitoring system which have been proposed by **R. Pandey** [4]. Developed and constructed this system for monitor and records the parameters (i.e.;

temperature status, of a distribution transformer). Some of these monitoring sensors used in data centers are put inside servers and active devices or put outside; technical approaches for data collection and data center management sensing system have been presented by Jie et al [6]. On the other hand, temperature monitoring systems of conductors have been produced by Viswanatha et al [5]. This system is based on GSM SMS and Zigbee. It can be monitored in real-time, and some accidents caused by the increased temperature can be avoided.

I. Software Design

The software of the proposed system is composed of part-1 and part-2 interfaces. Part-1 (i.e.; Simulated Temperature Sensors Interface) consists of textboxes (i.e.; temperature and humidity values) and communication sockets. Part-2 (i.e.; Main Software Interface) has socket communication with part-1 to transfer measured data, and GSM communication to transfer alert message with part-3. The dataflow in this system depends on direct relation among three main parts. Part-1 is designed to represent temperature sensors usually supposed to put on the server body or on the rack inside data centers. Figure 2 depicts the interface of the simulated temperature sensors.



Fig. (2) Simulated Temperature Sensors Interface

Part-2 is the computer system that hosts the software connected, which hosts the main part of the software connected to SQL database used for collecting temperature and humidity data in data centers; this server has physically connection to wireless and GSM network through attached GSM module. It utilizes wireless network to connect to part-1 for getting continuous temperature and humidity values and it utilizes GSM network to connect to part-3 to send alert messages in case of critical temperature values inside data center. Figure 3 illustrates the main software interface.

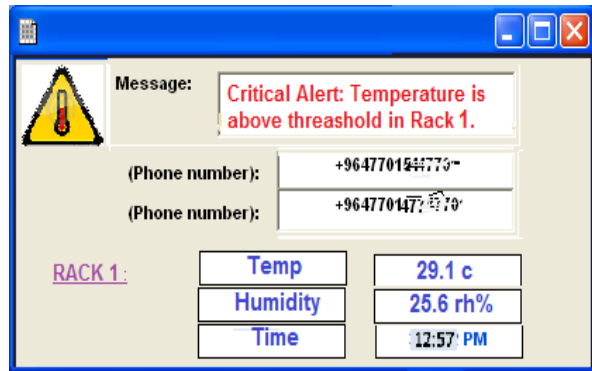


Fig. (3) Main Software Interface.

Part-3 can be classified into administrators: PDA or Tablets. For creating connection and performing data communication among all parts, the system uses network facility, (i.e.; socket and Global System for Mobile Communication alert message). Using different networks for data communication guarantee the availability and reliability for this system.

IV System Work Flow

Part-1 has a continuous connection with part-2; based on this relation, part-1 produces controlled range random temperature and humidity data, and then sends them to part-2 through the wireless network.

Part-2 in turn, accepts part-1 data in order to collect, analyze, and process it. In case of

getting the critical data by part-2 (i.e.; Temperature value above 26 °C), then part-2 notifies part-3, (i.e.; remote administrators) via alert messages and tell them about the temperature situation inside data center. Ultimately, it sends this data through GSM networks to part-3. This notification allows administrators to react and control the critical case within short time (i.e.; rescue data center). System work flow is depicted in figure 4 system flowchart.

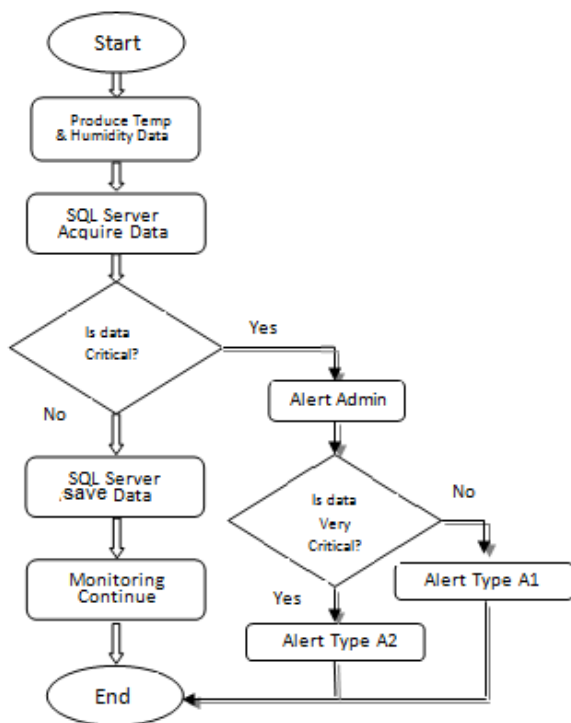


Fig. (4): System Flowchart

V Test and Result

In order to ensure the safe operation of the devices and equipments, there are a lot of remote wireless networking temperature monitoring of several equipment scattered in various locations of organization and enterprise [8]. To collect temperature and humidity data throughout the data center, sensors need to be widely and densely

distributed [7]. In this system, simulated sensors supposed to be on the body of the server and the active devices racks. This system has been designed and the network connection for the current system has been created between part-1 and part-2, also part-2 and part-3 in order to make a direct communication between each pair. The first test that has been done is explained as follows:

At the beginning, part-1 starts to generate temperature data (i.e.; first rack temp=20.9 °C) then it sends this data to the part-2 (i.e.; SQL server) through available wireless network. The server in turn takes the data; analyzes it then by depending on the threshold value (i.e.; normal temperature value is between 18 °C and 25 °C) it decides what the necessary reaction is. If the resulted value is below the threshold, value then its normal value,

If 18 °C < Temp value < 25 °C Then OK no alert

Afterword, it goes to the next record to proceed and so on. Otherwise if the temperature data above the threshold it means temperature of this rack is very high and starts to alert remote administrators by giving critical alerts through GSM network (i.e.; **Critical Alert: Temperature above the threshold in rack 1**).

If 25 °C < Temp value < 28 °C Then alert type A1

If Temp value => 29 °C Then alert type A2

Figure (3) Main Software Interface shows a case that the system gets very high temperature value (i.e.; in rack 1 temperature= 29.1 °C **alert type A2**)

This system has been tested many times to check its response, performance, reliability, and knowing when the DC temperature reaches a critical case. Table 1 explains the series of records which have been saved in SQL database in rack 1 and rack 2 for both

temperature and humidity values. As it appears during this test 10 records are acquired. The first 6 records values are normal; the system doesn't have alarms for remote administrators while the last 4 records have values above the threshold. This led the system to decide to send critical alarm messages to administrator exactly in last value where the temperature appears very high (i.e.; **alert type A2**).

Table 1: Critical Alarm

Seq.	Time	Server Rack Sensor (Temperature C)	Switch Rack Sensor (Temperature C)	Datacenter Sensor (Humidity Rh %)	Alert Type
177	10:12	20.9	20.8	33.5	Null
178	10:17	21.1	21.0	33.5	Null
179	10:22	21.4	21.1	33.2	Null
180	10:27	21.5	21.1	33.0	Null
181	10:32	21.6	21.4	33.1	Null
182	10:37	22.9	22.6	31.9	Null
183	12:42	26.2	26.0	28.0	A1
184	12:47	28.5	26.9	26.3	A1
185	12:52	28.5	27.5	25.8	A1
186	12:57	29.1	28.1	25.6	A2

Depending on table 1, server rack sensor values have been showed as a chart in figure 5. Here one can see clearly this curve gives good view to DC administrators for future use and decision.

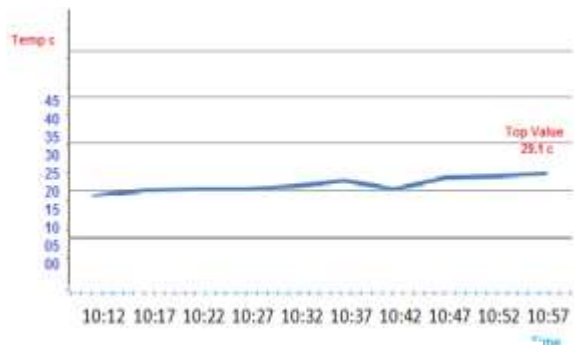


Fig. (5): Temperature Chart

II. Conclusions and Future Work

In the result some important points concluded. If the working simulated sensor changed to physical sensor, then the system can be used for automated data center monitoring and can be considered as a dependable system during emergency events. Proposed system can be used for unsafe temperature and humidity data values detection; also it gives a vision to administrators about how they spend cooling system energy inside data centers. In comparison to other works referenced in this field, this system can be considered as a good system with respect to the cost and usability. Furthermore; this system gives advantages of mobility for administrators. As well as it automatically sends alerts to network monitor and administrators (i.e.; using alert message to notify the network administrator's Tablet and PDA) and as soon as possible it makes them to react and return the DC to safe side. It prevents critical cases (i.e.; by using such system DC always remains in safe side) through early detection of the situation by continuously monitoring and informing administrators.

Further work can be done by adding other channels for communications such as sending critical messages to administrators e-mail for future use like DC statistics or for enhancing cooling system inside DCs. From figure 5, another feature which can be added to this system is sending curve (i.e.; chart value) to administrator PDA and tablet that gives better view of data value.

These features can be utilized but with the expense of adding cost to the system.

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