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Analysis of Cooling Process for Data Center's At Africa

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***Abstract:** Among the most popular cyber centers, there are few problems that generally interrupts the process of complete automation and cooling process. Modern data centers are generally keen to a lot of neatness's the industry consumes a lot of heat by consuming a huge amount of heat. So, for that, a substantial cooling process is required. This paper is basically a survey on the cooling process and also the human-automation on cyber centers and also a prototype networking software that helps cyber owners to forget their worries about the login and logout time of their customers. This system supports all types of human activities and also provides security and reliability. This paper based on the literature survey finds that Africa is lagging behind this scenario. It is based on Research and process for selecting the best location to build data centers for cloud providers in West Africa. This paper studies this problem by taking main considerations on Network performance, costs, and submarine cables.*

***Keywords:** Server Rooms, Energy Efficiency, IEC 61499 Standard, Cooling System, Data Center.*

I.INTRODUCTION

Modern data centers are accounted for 1% of the world's energy consumption. As the number of data centers is growing fast, it is expected that soon this figure will grow up to 2%, which is equal to the current percentage of energy consumption of data centers in the US. Currently, 50% of the total data centers energy consumption in the US is used for cooling the server rooms and this figure is around 30% of total energy consumption of the data centers in the world scale. Therefore, it is apparently very important to exploit cooling systems with better energy efficiency in the modern data centers in order to reduce the rapidly increasing amount of energy consumption in this new and fast growing industry.

Since cooling systems of buildings, in general, are considered as part of Building Automation Systems (BAS), enhancing cooling system implies enhancement of the existing BASs. BAS is a special type of industrial automation systems, which has been tailored to control Heating, Cooling, Airconditioning and Ventilation (HVAC) and lighting systems. Although in recent years BAS has been successfully utilized for reducing total energy usage of buildings, it is still not very suitable for more complex buildings such as data centers. Existing BASs are built on the base of traditional industrial automation systems and therefore is suffering from rigidity. In current large data centers cooling systems operate based on the maximum capacity of fans and load of servers. In this approach excessive energy is used in case of changes in environment conditions, such as volatile computing load, changing weather conditions, or reduced power supply.

A more adaptable control of ventilation could bring energy savings. To investigate this possibility, we consider heterogeneous ventilation architecture of a server room, which includes smaller fans for ventilation of individual server racks and blades, along with the main ventilation of aisles. This creates the opportunity for finding a more optimal balance of activity of smaller and large fans most appropriate for a particular situation. We will attempt finding the adaptation of ventilation to changing conditions using cyber-physical automation approach. Main features of this approach are distributed control architecture and simulation environment of the physical system used for validation of the control architecture.

In our proposed simulation tool, we have utilized several equations for modeling different aspects of server room's thermal behavior as well as energy consumption. Equations (1,2) adapted from are utilized to model the CPU's thermal evolution.

$T_{CPU} = \{P_{CPU} - 1/R(T_{CPU} - T_{in})\} / C_{CPU}$ -----------------------------(1)

$Tout = (1 - 1/(C_p.f_{rg}) . 1/R)T_{in} + (1(C_p.f_{rg}) . 1/R) . T_{CPU}$ ------------------------------ (2)

$$Q = C_p.f_{rg}.(T_{out} - T_{in}) \quad \text{------------------------------(3)}$$

$$Q(t_0+\Delta t) = C_p.m.T_0 + \sum\int Q_{SN},i(t)dt - \int Q_{GF}(t)dt \quad \text{------------------------------(4)}$$

$$W_{SR} = 10 . (W_{LF} + W_{CPU}) + W_{GF} \quad \text{------------------------------ (5)}$$

$$W_{part} = \int P_{part}(t)\, dt \quad \text{------------------------------ (6)}$$

$$P_{CPU} = P_{idle} + (P_{max} - P_{idle}) . U \quad \text{------------------------------ (7)}$$

For describing the server room's thermal evolution equations (3-5) are used [10]. These equations estimate the energy consumption of the system and its thermal nodes, which in turn allows choosing the least expensive operating mode of the cooling system. The total energy consumption of the entire system (server room or W_{SR}) combines the energies of all of its parts, which is a sum of energies consumed by local fans (LF) CPUs and Global Fans (GF) as depicted in equation (6)

The energy consumption of each part for the simulation period (*T*) with known value of power consumption (P_{Part}) is calculated using equation (7), another important issue that has been addressed in our model is power consumption. In principle, the power consumption of CPU depends on its utilization or workload (*U*, %), its power consumption in peak utilization (P_{max}) and in an idle state (P_{idle}). Having these values, it is possible to estimate the power usage of CPU using equation adapted from [15, 16].

According to well-known fan affinity laws, the power consumption of LF depends on its current rotation frequency (f_{RPM}) with a constant LF diameter and density of air. For known values of the max local fan rotation frequency ($f_{RPM,\ max}$) and its max power consumption (P_{max}), the power consumption of local fan can be estimated using equation (9). In this paper we have discussed about a model, where there are two types of fans utilized for cooling the server room 1) Local Fans (LF), each one which is attached to a CPU and can cool down a CPU locally if required 2) Global Fan (GF), which pumps the outside air into the server room and causes decrement of the temperature in the room. The control system of this configuration consists of two IEC 61499 enabled controllers, called next Controller. There are 10 CPUs exist in the system named CPU1-10 that together with LFs are equally divided into two groups and mounted on two racks, there are 10 LFs in the system and they are named LF1-10. There is one global fan in the system named GF and there are two controllers in the system called C1-2.

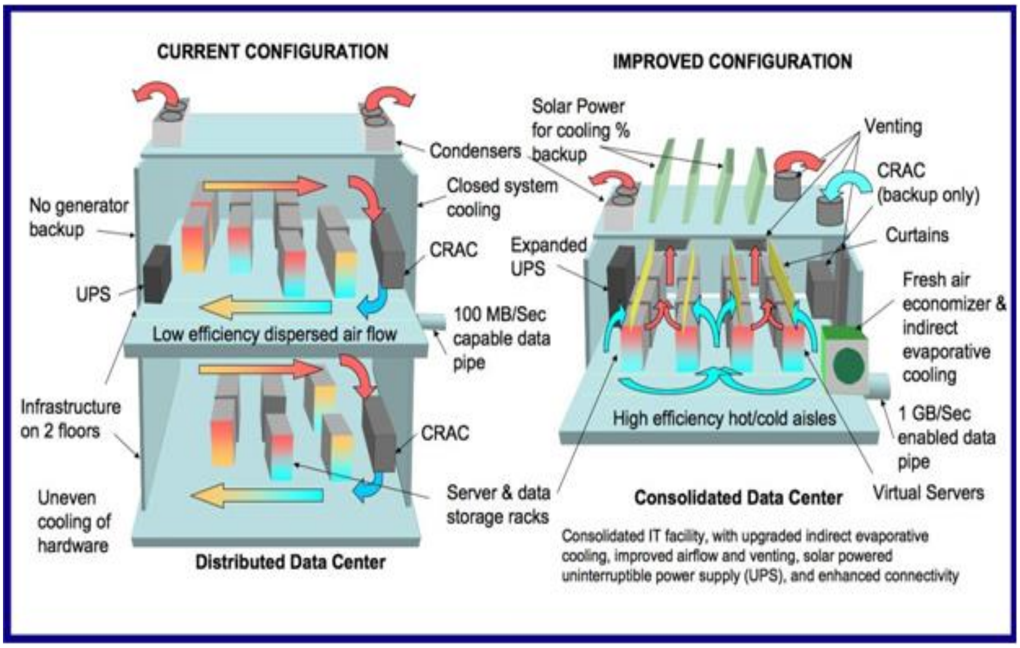

Fig 1 Current vs Improved Configuration of Data Center

II DESCRIBING THE INTEGRATED SIMULATIN ENVIRONMENT (ISE)

IEC 61499 is an international standard that defines a component-oriented approach, based on *function blocks*, for modeling and implementing distributed industrial-process measurement and control systems. A function block abstracts a functional unit of software by encapsulating local data, state transitions, and algorithmic behavior within a well-defined event-data interface. Fully executable systems can be described through a network of function blocks at a high level of abstraction, independent of the implementation platform. The standard, thus, paves the way for sophisticated software methodologies to be applied in the development of industrial control systems, which has hitherto, been done using low-level techniques for programmable logic controllers (PLC).

Fig. 1 illustrates an architectural view of the Integrated Simulation Environment (ISE) that we implemented to simulate the thermal behavior of a server room cooling system.

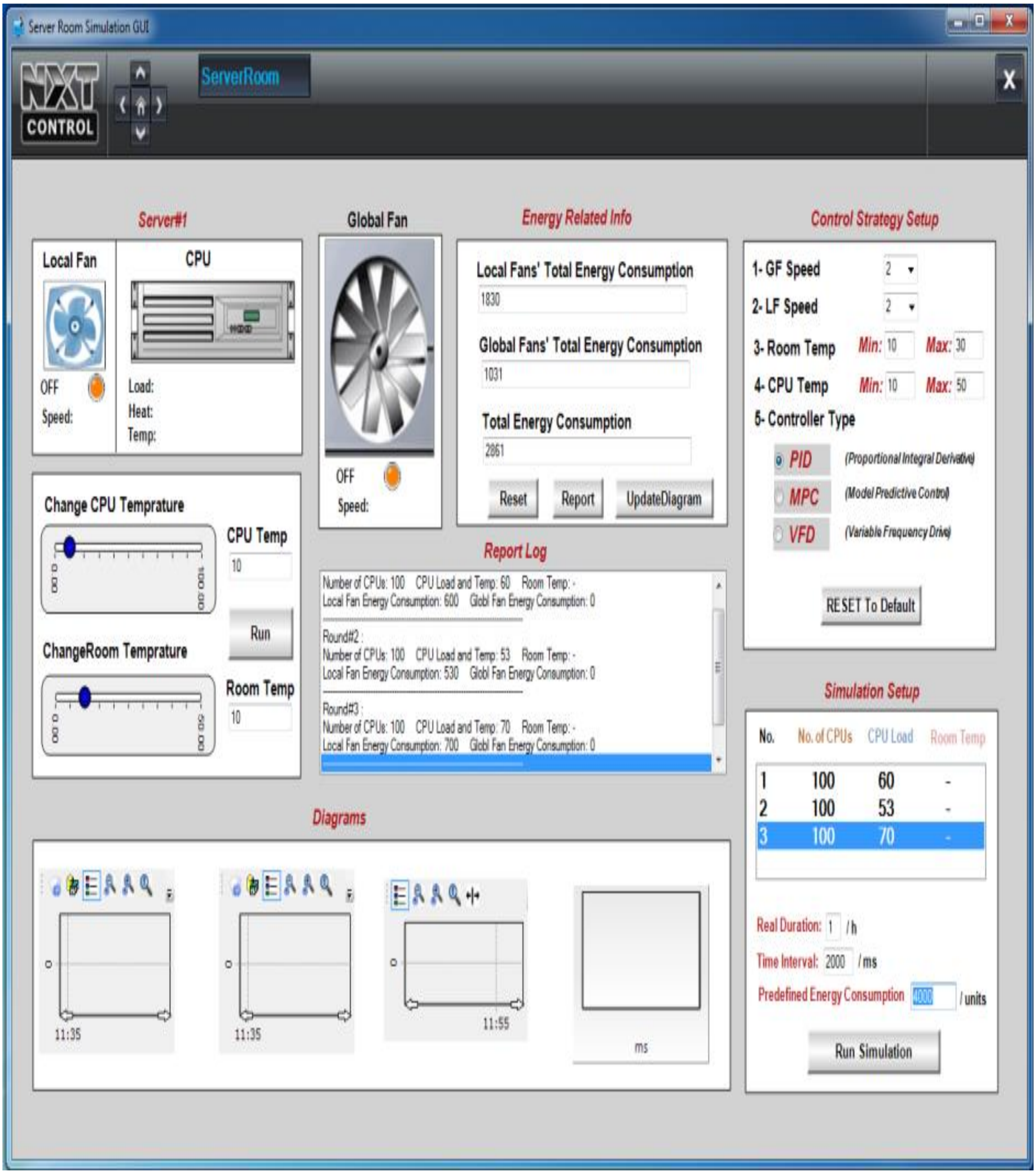

Fig 2 Human Machine Interface of the ISE

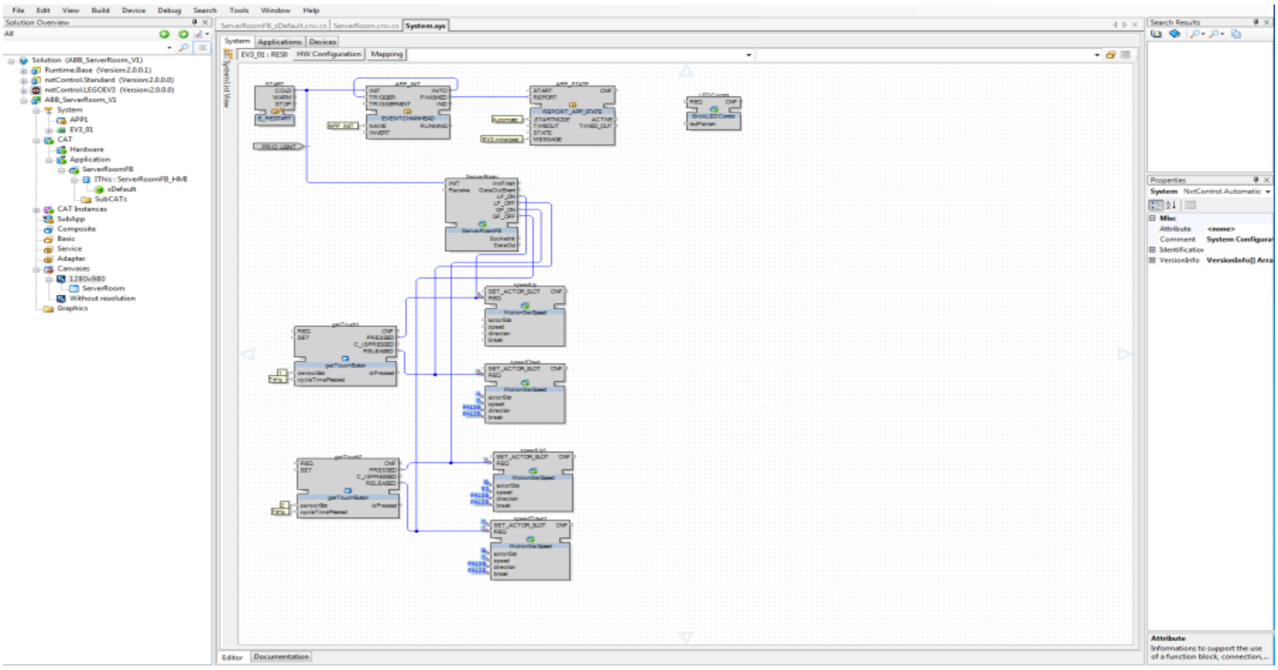

Fig 3 Schematic Function Block Diagram of the ISE

As illustrated in this figure, in our model there are two types of fans utilized for cooling the server room 1) Local Fans (LF), each one which is attached to a CPU and can cool down a CPU locally if required 2) Global Fan (GF), which pumps the outside air into the server room and causes decrement of the temperature in the room. The control system of this configuration consists of two IEC 61499 enabled controllers, called nxtController. There are 10 CPUs exist in the system named CPU1-10 that together with LFs are equally divided into two groups and mounted on two racks, there are 10 LFs in the system and they are named LF1-10. There is one global fan in the system named GF and there are two controllers in the system called C1-2.

Fig. 2 shows a partial physical configuration of the cooling system in ISE. The schematic views of the system, which has been shown in Fig.1, are illustrated in Fig. 2 with real components. Fig. 3 (described in detail in Section V) illustrates FB architecture in nxtStudio and Fig. 4 shows a partial view of the Human Machine Interface of the ISE.

III IMPLEMENTATION AND RESEARCH

I have named this software as **WebCon** which stands for Cyber Connector. As the name itself says, it is capable of connecting multiple systems across the cyber network. The WebCon is capable of working on its own without any external guidance. With its built-in security policies, its offers complete reliability for the WebCon owner and users. WebCon owner just needs to Create a key (Card Number) to the local database specifying the time for the corresponding key. The next thing he has to do is to give the key to users through cards (or through any other means). Then the user can go to any client system and use the card number for creating a new account with username and password. The time for the corresponding card number is credited to his/her account. The user can then login using the same username and password. The account will be valid till a non-zero balance. When the balance drops to zero, the account is closed and the user has logged out automatically. In addition to this, the user can log out of the server at any time he wills. The balance will not be reduced after this and his account would be locked for future use. The user can later then login and use the balance time.

In addition to the feature of creating a new user, WebCon also provides the facility of renewing an invalidated account. So, the users can have their unique Username and password without the fear of being deactivated.

Server

The server system is the main system for a WebCon network. All the clients are connected to the server. The Clients send their requests to the server and the server processes the request and resends the processed output to the appropriate client. The server also monitors the working of the clients and keeps track of the active clients.

Working on Server

Communication

The WebCon uses Microsoft **Winsock** control to communicate to its clients. The clients also use the same method to communicate to the Server. The Winsock control uses **Port-to-Port** communication which is a quite reliable method of communication across the network. An UDP protocol is used to establish the connection between the server and the client.

Communication Language

The server and client communicate to each other by passing the commands (Messages) within Token values. There are totally four delimiters which specify which action to be performed and they are

1) *Command*
   Whenever a command statement is encountered by the software, the command is executed with the highest priority.
2) *Request*
   Whenever a Request statement is encountered by the software, the request is treated with least priority when compared to the priority of the command
3) *Display*
   The display command is used to display any message. No process is made for the Display command. The message to be displayed is displayed to the client through Balloon Message Boxes
4) *Pulse*
   A pulse statement, unlike the above two statements, is independent and has no token values. The pulse is sent only by the server to all its active clients. The clients only work as long as the pulse is being received from the server. So, when the server is shut down, the pulse being sent to its clients also shuts down. As a result, all the active clients lock themselves until any further pulse is received from the server. A grace period of 20 Seconds has been given before the clients lock up within which the Server has to recover for the clients to remain open. This ensures that the server and clients are connected all the time and no loss of data packets takes place.

Tokens
The Token values specify what actions have to be performed by whom and where. All the Tokens begin with a '<' and end with a '>'. This marks the starting token whereas the ending token begins with a '</' and ends with a '>'.

Example: [COMMAND]<LOGIN><U>user1</U><P>pass1</P><M>XXXXXX</M>

In the above example, a command is given to the server that a login request has been made by machine XXXXXX for username 'user1' and password 'pass1'.
The server then processes the client's request and checks for the user in the local database and checks whether the password is correct and that whether any time is remaining in that particular account. The server then sends the processed results as below.

If The Username & Password are correct and if there is a time balance then a command as below is sent
[COMMAND]<ALLOW>

User Data Storage
The user data are stored in a local database. The database is located on the server and is protected from the client. The data are accessed using Database controls Ms-Access as Back-end.

Working with Client
Protection
It is easy to End any process through the Task Manager. Thus, it is also feasible for the users to shut down the WebCon client using the task manager. Thus, a separate policy has been created to By-Pass the system Task Manager access. Thus, the client is secure from the danger of being closed. Whenever an attempt is made to shut down the client, an alert message is sent to the server. In addition to the alert message sent to the server, the attempt made to close the client is also averted by Over Riding the close requests send by windows.

User Friendly
The WebCon client is made as user-friendly as possible. A client interface window remains open all the time. This menu has access to two features, which include the Logout and the Call Help commands. The user is privileged with the Real Time Updating of his Account details such as the Balance Time, the last login time etc. By pressing the logout button, the user is logged out of the server and the client is locked out until another login is made from the client. The above picture shows the Login screen for the WebCon client. There are three buttons namely "Login", "New Account" and "Renew Account" using which the user could do the appropriate action.

DLL
Plug-in has been provided for a client for multiple purposes like process management, system management etc. The reason for providing the DLL is due to the reason that they can be updated easily without affecting the main program.

Installing Procedures
The WebCon Server has to be unique and can be installed on preferably a higher configuration system. The server and client can be installed using their respective install shields. This doesn't do all. The main part of the WebCon starts here. Now i have to set up the registry so as the Server and Client come to know each other. This Feature provides from any external intruder from intruding into the server.

Setting up the Registry

1) *Client*

A Client needs to store the following data in the registry:
Machine ID
This enables the server to identify the appropriate client. The same copy of the Machine ID (MID) is stored in the server for recognition purpose.
Machine IP
This is set just as a precautionary measure. This stores the IP of the Machine
Finally, we need to press the register button.

2) *Server*

The registering of the client details in the server is a complex one, but it is simplified in a method below
All the three details have to be given first before giving 'Add'

Machine ID - List
The Machine ID of the client is given. The Exact ID stored in the client should be given

Machine IP - List

The Corresponding IP of the Machines with the above Machine ID is to be given. This could be quite confusing, but it is not a tough job.
Finally, we need to press the register button

Server Registration
Step 1: Enter your Machine ID and Machine IP of Your Client. You Can Add Multiple Clients. The Machine ID should be Unique

NOTE: Improper Registry Setting will lead to Improper/Non-working of WebCon system

Shutting Down the Task Manager
The task manager has to be disabled manually (Permanent basis) by overriding the windows default settings using the "Task Disabler" provided with the WebCon.
Server Interface
The server interface at the startup is shown in the picture below. It contains fields to display the active clients and the users logged in. Also, it has two check boxes for emergency purpose. Two Over Ride settings have been provided for use by the administrator during the emergency.

IV RESULTS AND DISCUSSION

To have a base comparison checkpoint the initial simulation has been conducted without the involvement of any fan. Thus, we assumed that the rate of airflow in the server room was equal to zero. Values of base parameters of the model are shown in TABLE I. As the numbers in this table suggest, CPU temperature exceeds the upper limit right after finishing the first quarter, as it reached 85.8 ^{0}C. CPU temperature continued to go up to 133 ^{0}C by the end of 1 hour period of simulation which is almost double CPU's tolerance.

Table I Values of Base Parameters When No Fan Is Utilized

TIME PERIOD	TEMPERATURE, ^{0}C		ENERGY CONSUMPTION, W			
	CPU	SR	CPU	LF	GF	TOTAL
900	85.8	22.9	15.6	0	0	157.3
1800	114.5	25.6	38.2	0	0	318.7
2700	103.9	23.9	56.8	0	0	285.9
3600	133.4	32.2	82.5	0	0	189.1

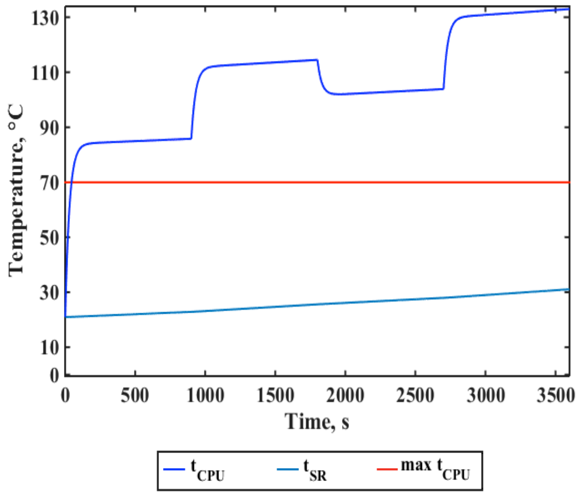

Fig 4 the values of the CPU and server room temperature at the none fans work

Table II Values of Base Parameters of Model in Case When None Fans Work During All Modelling Period

TIME	TEMPERATURE, ^{0}C					ENERGY CONSUMPTION, W		
	SR	CPU Temp for Different LF Speeds			CPU	LF	GF	TOTAL
		SLOW FAST	MED					
900	85.8	22.9	38.1	22.9	15.6	215.3	85.8	157.3
1800	114.5	29.7	22.5	33.8	38.2	638.7	114.5	318.7
2700	103.9	23.9	30.8	39.5	56.8	185.9	103.9	285.9
3600	133.4	32.2	37.5	22.5	82.5	125.9	133.4	189.1

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This paper is an output for the cyber cooling process in any cyber center and has been implemented for small scale purpose i.e LAN. Any future use of it would surely inspire for a large scale development in WAN basis.

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