Application of the In-Rack system and ventilation path for efficiency increase in datacenter cooling

Hyo-Sik Tae [1], Young-Gi Yun [1], Koo-Rack Park [1], Jin-Mook Kim [2]

[1.] Division of Computer Science and Engineering, Kongju National University
[2.] Division of Information Technology Education, Sunmoon University

ceo@hkinet.co.kr, ygyun@bohun.or.kr, ecgrpark@kongju.ac.kr, calf0425@sunmoon.ac.kr

Abstract: The number of datacenter are increasing for more than 30% annually due to the explosive increase of digital contents and data, as the spread of mobile devices such as smart phones and tablets. Nations and enterprises all over the world are trying to increase the efficiency in datacenter cooling as the necessity to increase the efficiency in datacenter cooling and enhance the economic effect rises.
This study was conducted to reduce the power consumption that increases the data center's cooling costs. It was confirmed that controlling the Rack is the best way to reduce the cooling costs and dividing the Hot zone and the Cool zone increases the efficiency in cooling. In order to prove this fact, comparing and analyzing the amount of electric usage of room unit air-conditioning and inner installed cooling rack was conducted.
[Hyo-Sik Tae, Young-Gi Yun, Koo-Rack Park, Jin-Mook Kim. **Application of the In-Rack system and ventilation path for efficiency increase in datacenter cooling.** *Life Sci J* 2014;11(10s):165-169]. (ISSN:1097-8135). http://www.lifesciencesite.com. 26

Keywords: Low-power; Green IT; IDC cooling; rack air-conditioning; thermo-hygrostat

1. Introduction

Many nations and enterprises are attempting multilateral approach on energy saving, as recently energy saving has been an issue in the industrial field. Especially, energy costs for the datacenter are rapidly increasing due to the expanded facility size and the improvement of the IT equipment performances as the expansion of internet business environment. Currently, datacenter industry is consuming about 1.5% of the world’s energy [1, 2].

According to the ITU-U ICT&CC’s report, “Direct and indirect impact (on energy) of ITU-T standards”, most of the IDC has serious heating problems. In a typical IDC, the main consume of energy are occurred 50% in computer room air-conditioning, 26% in server/storage, 11% in electric power convert, 10% in network, 3% in lights[3]. Currently the heat of the server CPU is removed by the cool air basically provided from the air-conditioning system and the air-cooling from individual fans. Therefore, it is no exaggeration to say that most of the air-conditioning consumed in the datacenter is used to cool the CPU.

According to the question investigation conducted by Data Center Users Group, it is considered that respondents are willing to make an extensive improvement of the energy efficiency on cooling system (49%), server (46%), power equipment (39%) and storage (21%). Also many researches are on progress on a multilateral basis to improve energy efficiency because conditioning equipment occupies about 30% of the total energy consumption [3].

Computers installed in the computer room or electric components used in communication equipment would malfunction in high temperatures, and it causes a lot of heat during operation so it needs a cooling system, and that system is the CRAC. The CRAC, which maintains the stability of the ICT equipment by cooling the heat inside the datacenter, occupies about 30% of energy consumption and it tis the main reason of the datacenter’s power usage increase. For the efficient use of the CRAC, it should be designed maximize the cooling efficiency, and control the flow of air to prevent the cooling efficiency from falling by the mix of hot and cold air. Therefore, in order to maximize the cooling efficiency, we would like to suggest In-Rack, which the CRAC is directly installed in the rack, and the Hot zone/Cool zone separation technique.

2. Related technique

2.1 Cooling architecture of the datacenter

There are room unit/row unit/rack unit architectures in the datacenter cooling architecture. The following picture shows the three basic cooling architectures. The black blocks are the racks in a row, and the blue arrows show the relation between the load equipment of IT rack and the CRAC equipment. The actual placement of the CRAC could differ depending on the architecture. In case of the room unit architecture, CRAC takes in charge of the whole room, and in the row unit, it takes in charge of each row or group. In case of the rack unit structure, it directly takes in charge of the individual rack.

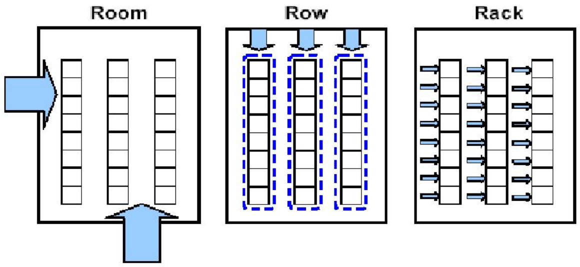

Figure 1. Room/Row/Rack unit cooling architecture

2.1.1 Room unit cooling architecture

In the room unit architecture, the CRAC operates for the whole room, and it effects to all the thermal load equipment in the room at the same time. In room unit architecture, more than one air conditioner provides cool air through the duct, damper or vent with no controlling process. Sometimes it partly controls the supply air or the return air with a dual floor system or the overhead return plenum. The room unit planning could be highly influenced by the original condition of the each room such as the height of the ceiling, form of the room, obstacles on the top and the bottom of floor, placement of the rack, position of the CRAC, power distribution among the IT equipment. Especially, as the power density become higher, the predictability and the uniformity of function become very low. Moreover, if there is a change such as moving, installing, or changing the IT equipment, the existing planning becomes useless, so additional analyzing and tests are essential. Another weakness of the room unit architecture is that it often cannot practically use the maximum rated capacity of the CRAC. This could cause the detour of the cool air, which is a situation that most of the air from the CRAC do not pass the IT equipment and return to the CRAC. Decrease of the cooling capacity will follow by this detour and then there could be an ironic situation that an additional installation of the cooling capacity is needed although the existing CRAC cooling capacity is not being fully used.

2.1.2 Row unit cooling architecture

In the row unit architecture, the CRAC is related with the rows, and each CRAC takes charge of one row. The CRAC can be installed between the racks or on the bottom of the ceiling or dual floor. It is easier to predict the flow of the air compared to the room unit architecture, and it can fully use the CRAC's rated capacity and raise the electric density. Row unit architecture as many additional strengths other than cooling performance. The flow of air become shorter so the required energy amount for the CRAC fan reduces and efficiency increases. In addition, it can realize the cooling capacity and the dualization fit to the actual required amount of the heat. For example, in the row unit architecture, it is possible to manage the rows according to their electric density. High density equipment like Blade server can be intensively managed on a specific row while low density equipment such as communication enclosure is managed on the other row.

2.1.3 Rack unit cooling architecture

In the rack unit architecture, the CRAC is directly installed in the rack to take in charge of the each rack. The flow of air in the rack unit architecture is shorter and accurately predictable, so it is not influenced by the difference of installation environment or the restricted condition of indoor. Moreover, not only it can make use of the full rated capacity, but also it has the highest electric density. Rack unit architecture has its original characteristics other than the fact that it can respond to an extremely high electric density, as well as the row unit architecture. First of all, the flow of air is shorter so the required amount of electricity for the CRAC fan reduces and the efficiency increases even more. In the rack unit planning, it is possible to realize the cooling capacity and the dualization fit to the actual required amount of each rack. For example, it can compose the heat fit to each case when the electric density differs, like the blade server and the communication enclosure. Also it is possible to place N+1 or 2N dual equipment fit to a specific rack. On the other hand, in the row unit architecture, this kind of placement is only possible in a row unit and in the room unit architecture, it is only possible in a room unit [4, 5].

2.2 Representative techniques related

2.2.1. Rack mounted air circulation equipment

The average cooling capacity of APC's rack mounted duct air circulation equipment is appropriate. However if hot spot occurs due to the use of high density rack, the installation of cooling fan equipment can improve the cooling load on the rack. The flow of air will be improved as well and the cooling capacity will rise about 3kW to 8kW per rack. Equipment such as ADU (Air Distribution Unit) effectively borrows the cool air from close racks. Like All air-Scavenging devices, the placement of the device should be carefully decided so it can bring the surrounding air and prevent the rack from overheating. UPS should be used in the auxiliary power unit in order to prevent the device from stop operating due to heat in case of power failure.

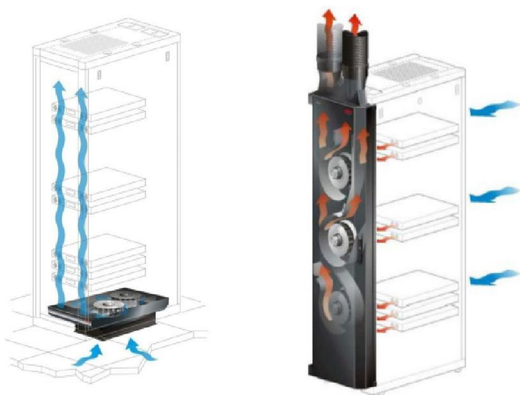

Figure 2. APC Rack mount duct air supply device

Fan tray device such as ADU are installed in the U shaped space at the bottom of the rack. It makes the air flow vertically between the front door and the server to form a cool "air-curtain". When density becomes higher, the back door of the cabinet can be removed and replaced with an air moving device such as ARU. Generally, when the hot exhaust air emitted from heat passage is gathered and sent to the upper part, it is conveyed to the circulation air plenum. The recirculation inside rack is prevented and the efficiency and capacity of CRAC is increased [6].

3. Suggested system

3.1 Structure of the suggested system

Improved performance of the IT devices and the expansion of facility have drastically decreased the cooling efficiency of the pre-existing room cooling system. Inner installed cooling rack, which is the suggested system, is installing the air-conditioning system inside the rack to increase the cooling density of the rack inside. The position of the cooling device is selected to fit the load and it increases the cooling efficiency. Figure 3 is the drawing for the inner installed cooling rack, which is composed of rack(2), outdoor emission device(30), inner cooling device case(10) evaporator(24), brain center(50), condenser(22), humidifying device(40), outdoor inlet(17) heat exit(18).

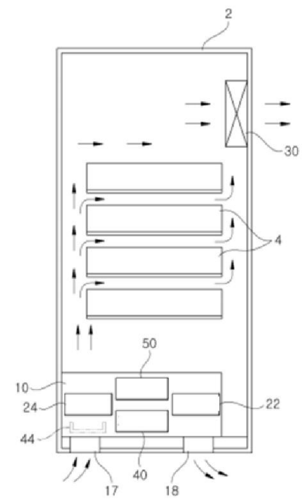

Figure 3. In-Rack drawing

3.2 Operation structure of the suggested system

3.2.1 Inner installed cooling rack

In general, the government, enterprises, financial institutions, school, laboratories run computer rooms installed with communication devices (network devices, server, communication exchanger etc.) and high capacity computers and servers. Most of the computers or communication devices are likely to be embedded and installed on a rack, so it is important to maintain a constant temperature of the computer room but it is even more important to maintain a constant temperature inside the rack. Inner installed cooling rack is planned to install the air conditioning device inside the rack so it could control the cooling amount inside each rack. The air conditioning device controls the temperature inside the rack and it prevents unnecessary air flows to increase the cooling efficiency.

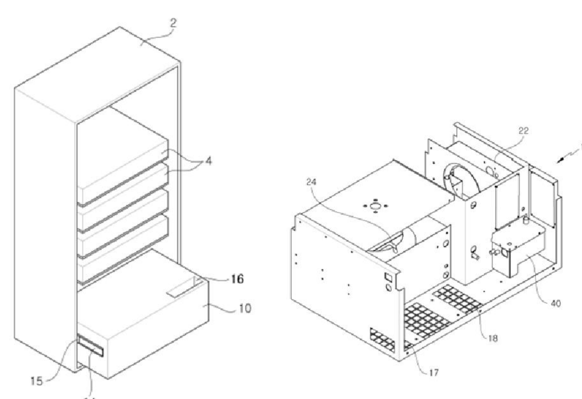

Figure 4. In-Rack whole drawing and the cooling device drawing

In case of the inner installed cooling rack, it can increase the cooling efficiency by separating and inducing the flow of hot air and cool air. Exit for cool air emits the cool air to the freezing device which composes the freezing cycle and the upper part inside the rack to provice cool air in the rack. Outdoor air inlet operates to make the outdoor air flow to the freezing device evaporator side. Heat exit emits the hot air that entere the condenset outsude so the hot air is emitted through the emission device on the back side of the rack.

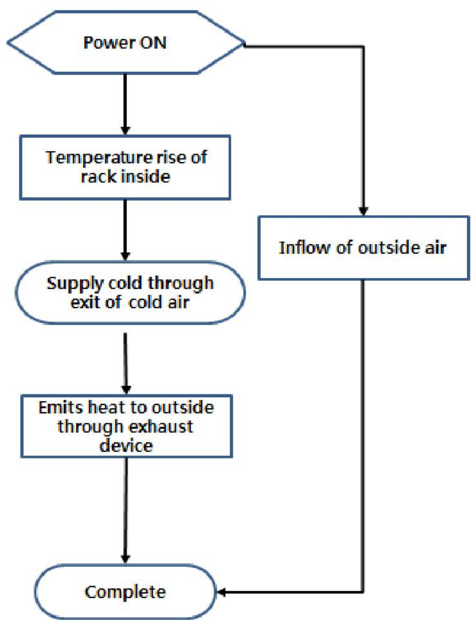

Figure 5. Operation structure order

3.2.2 Hot Zone / Cool zone

Pre-existing rack air-conditioning techniques cool down the entire room. Therefore the cool air from the air conditioner and the hot air from the computer device are mixed, and causes high amount of energy consumption. However if the Hot zone/Cool zone are separated and make an air tunnel, the cool air that entered the evaporator inside the air conditioner makes a cool zone at the front part of inner rack. Hot air and cool air does not become mixed and therefore the cooling efficiency dramatically increases. Also each fan inside the computer device and the outdoor air emission device operate to form a cool zone on the frontal upper part of the rack and the cool air exchange heat with the heat occurred from the computer device as it passes each computer device vertically. The heat is emitted through the outdoor air emission device and it helps the cooling process to be effective, so it is possible to maintain a constant temperature inside the rack.

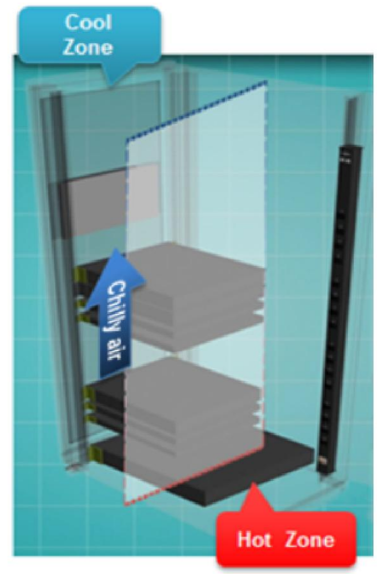

Figure 6. Application of How zone/Cool zone separation technique

4. Analysis of the suggested system

Difference between the electric usage of the room unit air conditioning system and the inner installed cooling rack system is ascertainable when the two systems are compared in a computer room in optimum environment condition. The experiment was conducted in a computer room in optimum environment condition(21℃~24℃) maintained for an accurate measurement, and a heating element was installed and operated on the inner installed cooling rack in order to compose a planning management environment. First, the amount of energy used in the center concentrated air conditioning system, which is the pre-existing cooling method, was measured, and the inner installed cooling rack was operated and measured after the power of center concentrated air conditioning system was down. Table 1 show the comparison of the energy consumption of the two systems.

Table 1. Result of measuring electric usage

No.	Room unit	Inner installed cooling rack	Energy saving rate
1	828	697	15.9%
2	817	699	14.4%
3	819	655	16.4%
4	823	691	16.0%
5	827	695	16.0%
Average	**823**	**693**	**15.7%**

In order to increase reliability of the result value, experiments were conducted for 5 times in the same condition. The average amount of energy used by the center air conditioner was 823, which is about 130 higher than the average amount of energy used by the inner installed cooling rack which was only 693. The average energy saving rate was 15.7%.

5. Discussions

Efficiently managing the air flow for cooling servers of the datacenter is the best way to obtain effects with low effort. However, most of the datacenter lack of recognition and are losing opportunities to improve the efficiency of air conditioner and energy performance. Even though they already have sufficient cooling capacity, they install additional facility systems to solve local temperature rise problems [7].

Inner install cooling rack techniques enable the control of cool air in a rack unit, allowing to reduce the energy consumption of devices such as air conditioner, cooler, cooling tower, condenser, pump and dehumidifier. Enhancing the efficiency of cooling devices benefits directly to the whole system efficiency, so can be considered as an essential technique in computer rooms, as energy consumption is greatly increasing.

In case of the inner installed cooling rack, it prevents the unnecessary use of cooling which has been a problem in the pre-existing room unit cooling. The separation of Hot zone/Cool zone maximizes the cooling efficiency. Also the inner equipment are proved to be stable and 15.7% average energy saving has been confirmed.

In addition, the inner installed cooling rack has better flexibility when build than the room unit cooling. When building a room unit cooling, the position of every cooling device needs to be considered and there is difficulty in additional composing or moving of the devices. However, inner installed cooling rack enables a fast building by rack unit planning, and there is no need to consider the position of the cooling devices because the positions are configured at a rack unit. Therefore, it contributes to not only energy savings but also saving costs for building and managing.

Corresponding Author:
Prof. Koo-Rack Park
Division of Computer Science and Engineering
Kongju National University
Cheonan-si, ChungNam, 331-717, Korea
E-mail: ecgrpark@kongju.ac.kr

References

1. J.G Koomey, Estimating Total Consumption by Server in the U.S and the World, 2007
2. Jin-Kyun Cho, Woo-Pyung Park, Seong-Ho Shin, Jin-Young Lee, A study of air-control/cooling energy analysis program development and weather-condition level replacement for Green-datacenter implementation, Korea Architecture Journal-Planning, July 2013, pp.289-298
3. Association of Korea IT-Business development, Trend and Standard Item of Green IDC standardization, 2012, pp.13-25
4. Kevin Dunlap, Neil Rasmussen, Advantage of Row and Rack level cooling architecture, Schneider Electric
5. Jiro Fukuda, Forward of Data-center and Future work, Journal of Japan air control and clean engineering, 2010, pp.371-375
6. Peter Hannaford, High-level server distribute solutions, APC by Schneider Electric
7. Jin-Kyun Cho, Woo-Pyung Park, Seong-Ho Shin, High-level datacenter energy decreasing analysis method for air-control efficiency, Journal of Korea architecture, 2013, pp.287-296