ISSN : 2347 - 8446 (Online)
ISSN : 2347 - 9817 (Print)

Comparative and Qualitative Analysis on Water Cooling Technologies for Green Cloud Data Center

[I]Mahabaleshwar. S. Kabbur, [II]Shashank Krishna
[I,II]KLE Society's, S.Nijalingappa College Bangalore-21, Karnataka, India.

Abstract

Data Center heat management is one of the most critical but the less understood IT environment process. Computing equipments' are becoming smaller day by day in size, which has developed more heat in data centers, as all the data is dumped into the data center after these devices are used. High temperature in data center can lead to the reduction of the accuracy of data moment; damage the servers, routers and other data handling equipments. Hence there is available water cooling technology for cooling Cloud Data Center to maintain Data Center at the required temperature. Data moment in a data center can have high accuracy if the Data Center is maintained at the normal temperature. This mechanism can be installed on the roof top of the available infrastructure.

Keywords

Cloud, Heat, Damage, Cool, Accuracy.

I. Introduction

Data Center is a physical model used by data storage providing companies to network like private, enterprise and also provide sufficient components for IT requirements. Components for IT involve mainly storing, processing and also providing services for mission critical data in client – server model.

Power, cooling, networking and security along with high policy is the main requirement for a data center to run efficiently in order to serve its clients efficiently. Cloud or data center management involves ensuring the connections and network to be reliable. The connection and network should also work for the mission critical data, to store the most important data in secure and safe position. Data center is one of the most cost effective data housing provision service for most of the enterprise clients. A data center consists of high performance graphic processing units, many colossal hard drives and memory analytics which generate a high thermal energy (heat). Thermal energy which is one of the nastiest byproduct that is generated as a result of computing process. Managing thermal energy is very challenge at data center. Excessive or excess thermal energy leads to server crash of the networking. Most of the data center thermal energy issue increases as they are maintained in tightly packed racks that increase thermal energy.

II. Water Cooled Systems

This concept uses the building's centralized air components to resolve the thermal energy of the data center. The cooling unit located outside the computer room typically consists of roof chillers and towers associated with the central plant basically reservoirs, and it could very well support cooling equipment within the available infrastructure. Unit can also be installed at ground level and ducted through walls. This concept enables to maximize the use of the space available in the computer room as the cooling. Equipment is located on the roof or outside land area, as the cabinets are to be placed in the beside each other in lengthy selves. This architecture has to be designed and embedded in the building's infrastructure.

Water cooled systems are similar to glycol cooled systems where in refrigeration cycle components are located inside the computer room air units.

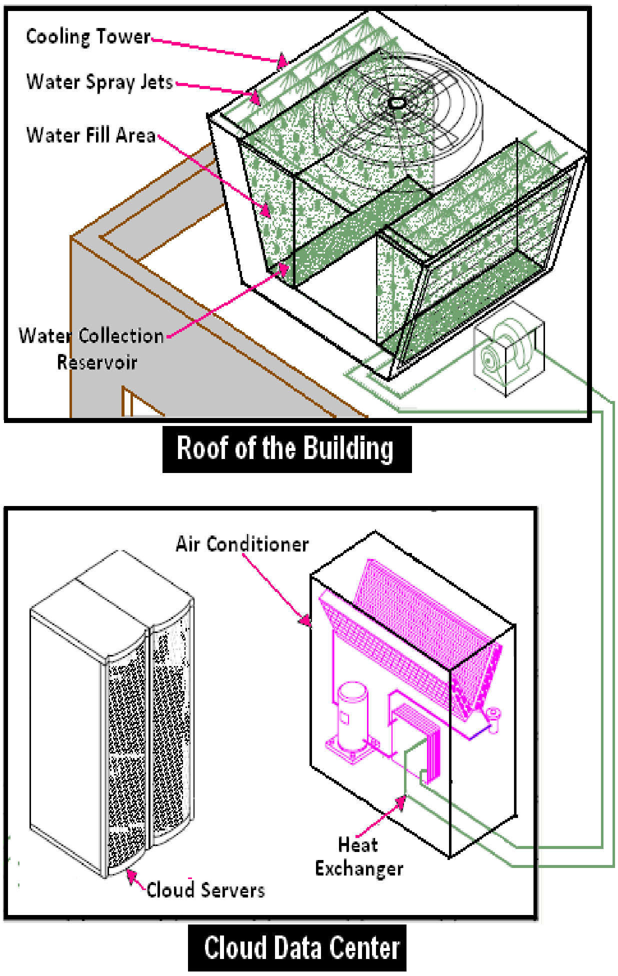

Fig. 1: Architecture of Water Cooled Systems

However, there are two important differences between a glycol cooled system and a water cooled system:

- A water (also called condenser water) loop is used instead of glycol to collect and transport heat away from the IT environment
- Heat is shoved out to atmosphere via a cooling tower instead of a fluid cooler.

As seen, a cooling tower rejects heat from the IT room to the environment outside by spraying warm water onto a sponge like material at the top of the tower. This functions in the same manner like that of a human body which becomes cool due to the evaporation of sweat; the small amount of water that evaporates from the cooling tower serves to lower the temperature of the remaining water. The cool water at the bottom of the tower is collected and sent back into the condenser water loop via a pump package. Condenser water loops and cooling towers are installed solely for the use of water cooled computer room air conditioning systems. They are usually part of a larger system and may also be used to reject heat from the building's comfort air conditioning system (for keeping the room cool) and water chillers (water chillers are explained in the next section).

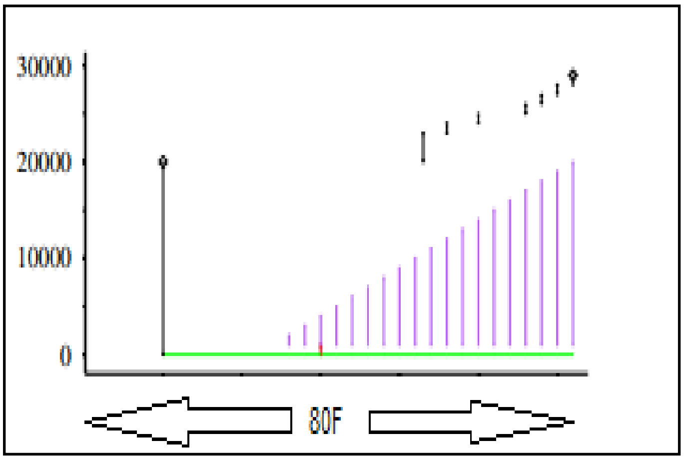

Fig. 2: Data transfer Cycle of Water cooled Systems

When temperature of data center is maintained at its optimum level of 80F we can clearly see that data transfer is constant and the entire data is transferred without any loss or data breakage of the data.

1. Advantages

- All refrigeration cycle components are contained inside the computer room air conditioning unit as a factory-sealed and tested system for highest reliability.
- Large fans are very efficient.
- This strategy requires less of floor area.
- This configuration is cost-effective; the cost per square feet is less for roof top than built in space.
- This strategy must be embedded into the building's infrastructure.
- Condenser water piping loops can be easily run for long distances and almost services many computer room air conditioning units and other devices from one cooling tower.
- In leased IT environments, usage of the building's condenser water is generally less expensive than chilled water (chilled water is explained in the next section).

2. Disadvantages

- Initial cost is high for cooling tower, pump, and piping systems.
- Roof penetrations may result in water leak into the data center.
- Units are exposed to outdoor elements, leading to reduction of longevity.
- Maintenance costs are high as frequent cleaning and water treatment is required.
- Brings in an additional source of liquid into the IT environment.
- A non-dedicated cooling tower (one used to cool the entire building) may be less reliable then a cooling tower dedicated to the Computer Room Air Conditioner.

III. Chilled Water Systems

A chilled water system uses chilled water rather than refrigerant one to transport heat energy between the air handlers, chillers, and the outdoor heat exchanger (typically a cooling tower in North America or a dry cooler in Europe). This system uses glycol solution to take heat away from air handlers serving the data center

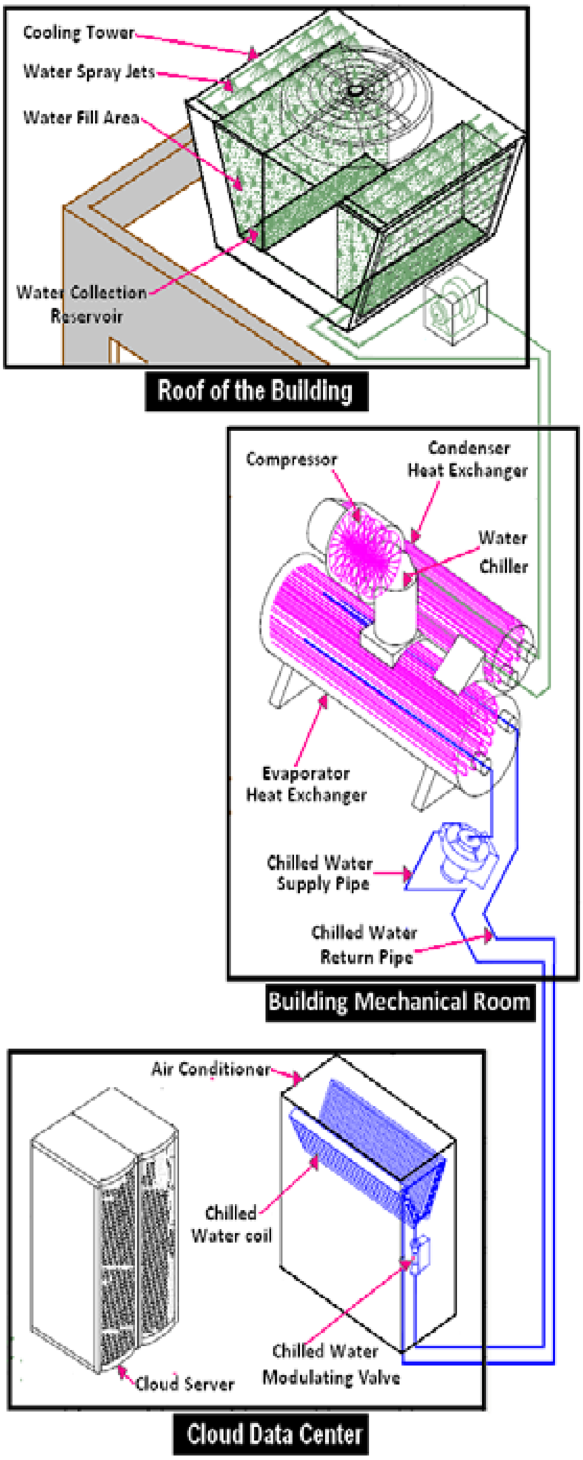

Fig. 3: Architecture of Chilled Water Systems

ISSN : 2347 - 8446 (Online)
ISSN : 2347 - 9817 (Print)

This fluid may then be cooled by a chiller using refrigeration, heat exchanger with a cooling tower water loop, or dry coolers operating in conjunction with power cooled chillers. In a chilled water system the components of the refrigeration cycle are relocated from the computer room air conditioning systems to a device called a water chiller. The function of a chiller is to produce chilled water. Chilled water is pumped in pipes from the chiller to computer room air units(also known as CRAHunits) located in the IT environment. Computer room air units are similar to computer room air conditioners in appearance but work in a different manner. They cool the air (remove heat) by drawing warm air from the computer room through chilled water coils filled with circulating chilled water. Heat removed from the IT environment flows out with the (now warmer) chilled water exiting the CRAH and returning to the chiller. At the chiller, heat removed from the returning chilled water is usually directed to a condenser water loop (the same condenser water that water cooled computer room air conditioners use) for transport to the outside atmosphere.
Chilled water systems are usually shared among many computer room air handlers and are often used to cool the whole building. The components of the chiller (evaporator, compressor, air or water-cooled condenser, and expansion device) often come pre-installed from the factory, reducing field labor and installation time and more reliable. Depending upon the geographic allocation, which affects average ambient temperature and humidity conditions which is based on annual statistical weather variation data, chilled water architecture may achieve significant additional energy savings by taking advantage of air or water.

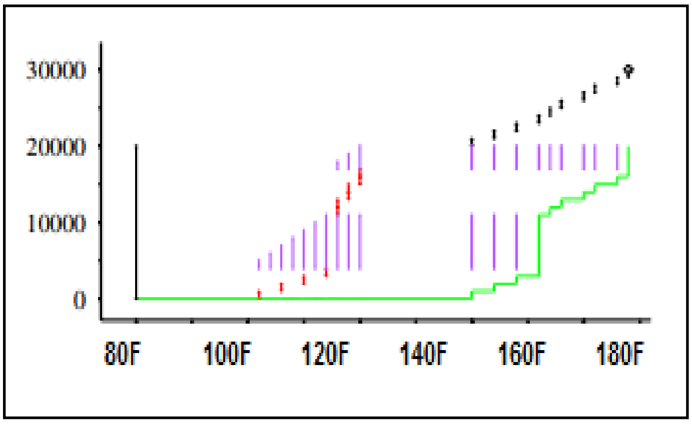

Fig. 4: Data transfer Cycle of Chilled Water cooled Systems

From the graph above it can be clearly seen that the data transfer is broken and also delayed is the vary in temperature. At 80F data transfer is high. As temperature reaches 100F to 120F there occur a breakage in data transfer and data loss increases as temperature increases.

A. Advantages

- Computer room air handlers generally cost less, contain fewer parts, and have greater heat removal capacity than computer room air conditioners with the same footprint.
- A chilled water heat rejection system uses either water or a water/glycol solution to take heat away from air handlers serving the data center.
- Chilled water systems are inherently more efficient, cooling larger amounts of heat as typically found in large data centers.
- The components of the chiller (evaporator, compressor, air- or water-cooled condenser, and expansion device) often come pre-installed from the factory, reducing field labor and installation time and improving reliability.
- This architecture costs considerably less, to operate than other architectures, particularly as scale increases over 1055 Kilo Watt.
- Chilled water configurations can operate at lower noise levels than other systems.
- Chilled water piping loops are easily run over very long distances and can service many IT environments (or the whole building) from one chiller plant.
- Chilled water systems can be engineered to be extremely reliable.
- Chilled water systems have the lowest cost per Kilo Watt for large installations.
- Centralized systems can provide redundancy by installing multiple chillers and pumps.
- This strategy offers flexibility; adding new chilled water circuits to the existing system is a relatively simple operation, and more chillers and pumps can be added to the existing system to increase cooling capacity.

B. Disadvantages

- Chilled water systems generally have the highest capital costs for installations below 100Kilo Watt of electrical IT loads.
- CRAHs generally remove more moisture from data center air than their CRAC counterparts, which requires more money be spent on humidifying the room in many climates.
- Introduces an additional source of liquid into the IT environment.
- Many operators do not like to have IT equipment near water.
- Large chiller building blocks require redundant chillers and pump systems.
- Efficiency is dependent upon the outside round the year temperature.

IV. Comparison Between Water Cooled Systems And Chilled Water Systems

Water cooled System	Chilled Water System
Less initial cost than chilled water system.	High capital cost for installation below 100kW of electrical IT load.
Low maintenance cost, as because there is no blockage of pipes.	High maintenance cost of refrigerant piping due to blockage of pipes.
Easy to install than chilled water cooling system.	Difficult to install because it contains two different chiller and evaporation system.
No additional components are required.	Additional components are required like package pumps, valves, NRV, which raises the capital and installation cost when compared to water cooled system.
~25% Amortized Cost	~ 45% Amortized Cost

22% of renewable energy available	12% of renewable energy available
Less power required	More power required
12TB data transfer is faster than other systems	12TB data transfer takes more time than water cooled system
Flow of liquid is faster and cooling is faster than other systems	Flow of liquid is slower and blockage of pipes is more due to high chilled water
Cooling is efficient and CPU / router usage percentage decreases	Cooling is efficient and CPU router usage percentage increases
Atmospheric condition doesn't affect the cooling of the servers	The cooling system may come to halt in extreme cold conditions due to pipe blockage and addition expense to remove the blockage.
Nozzle need frequent cleaning and rest all parts can be maintained on a timely manner	Whole system needs frequent cleaning and especially the chiller needs extra service which increases the cost of service on the system as a whole
Parts can be replaced easily and servers need not have to be shut for a long time	Parts of the system are difficult to replace and hence server shuts for a longer time during service of the system
Data transfer rate is high in all seasons and does not affect the clients during service of the system.	Data transfer rate is also high but depends on clients affected during service of the system

V. Conclusion

There are many solutions available to cool a data center, with variations in degrees of effectiveness and energy efficiency. In this paper two data center cooling models for cloud have been discussed, each having inherent advantages and disadvantages. New technologies like virtualization, economization, and variable speed fans significantly reduce energy use and considered seriously. The products and techniques described in this paper can help with many of the challenging issues facing the IT industry and the world at large to save energy and money, reduce carbon footprints and limiting greenhouse gas emissions to save the environment also.

References

[01]. *White paper 59, by Tony Evans*
[02]. *Rittal White paper 507*
[03]. *Viability of dynamic cooling in a data center, by T D Boucher.*
[04]. *Analytical modeling for thermodynamic characterization of data center cooling systems, by M Iyengar and R Schmidt*
[05]. *Smart cooling of data center, by C D Patel, C E Bash and R Sharma*
[06]. *Towards a unified ontology of cloud, by L Youseff, M Butrico, D Da Sliva*
[07]. *Review of cooling technologies for computing products, by R C Chu, R E Simons, M J Ellsworth*
[08]. *Greening the internet with nano data centers, by V Valancius, N Laoutaris and C Diot*
[09]. *Rack cooling effectiveness in data centers and telecom central offices, by M K Herrlin*
[10]. *Energy efficient cloud computing, by A Berl, E Gelenbe, M Di Girolamo and G Giuliani*
[11]. *Cost of Cloud, by Albert Greenberg, James Hamilton, David A. Maltz, Parveen PatelMicrosoft Research, Redmond, WA, USA.*
[12]. *Google Green, The Big Picture, by Google*
[13]. *Nasuni's analysis report (nww.com)*
[14]. *Survey by Brandon Butler, Microsoft Azure Cloud OS.*
[15]. *Cycle computing, amazon cloud services.*