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Chillerless Data Centers

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Data centers are energy gobblers! The energy consumption of the world's data centers doubled from 2000 to 2005, growing from 0.5% to 1.0% of the total electrical energy generated worldwide. Today, in 2009, these data centers consume 1.5% of worldwide electrical energy; and this number is rapidly rising.

The cooperative technologies of cloud computing and virtualization are working together to make data processing more efficient in terms of energy usage. But these technologies also bring ever-reducing costs to computing services, thus generating even more demand on data centers. The result – more stress on our energy supplies.

"Green" is the new paradigm for data centers. Major operators of data centers are striving to make their data processing services ever more energy efficient. The energy efficiency of a data center is measured by its PUE, the Power Usage Effectiveness. PUE is the ratio of the power delivered to a data center's IT equipment as compared to the total power consumed by the data center.

A typical data center today has a PUE of 2.0. This means that only half of the energy needed to support the data center is consumed by the IT equipment – servers, network devices, storage units, and consoles. The rest is needed to support lighting, ventilation, telephones, and, most significantly, equipment cooling.

Equipment cooling is by far the largest consumer of electrical power next to the IT equipment itself. The most common cooling technique is to use water chillers to cool hot air flowing from the equipment bays. This cold air is then recirculated back through the bays to keep the equipment cool.

"Free Cooling"

Some major operators of data centers are taking significant steps to eliminate the energy-inefficient chillers in their new data centers. They are accomplishing this by using "free cooling." Free cooling is the use of outside air to cool data centers. When the outside air is cool, it is circulated through the equipment to control its ambient temperature. Should the day warm up, a fall-back strategy is invoked to either increase the cooling capacity of the data center or to reduce its heat load.

Both Google and Yahoo! are taking advantage of free cooling by locating new data centers in areas of the world where outside temperatures are naturally low so that they can cool their equipment by natural air flow rather than by water chillers. Google has already achieved a PUE of

less that 1.1 – that is, less than 10% of data center power is being used for purposes other than computing. Yahoo! expects to follow suit.

Google

Google chose Saint-Ghislain, Belgium, for its prototype chillerless data center, which began operations in late 2008. St.-Ghislain is 30 miles southwest of Brussels, which puts it about 70 miles southeast of the English Channel.

The average temperature in summer in this area is 66 to 71 degrees Fahrenheit. Google maintains its data center equipment at temperatures above 80º F. Google estimates that the ambient temperature will support free cooling year round except for about seven days per year. During these times, Google will turn off equipment as needed and will shift some or all of the data center's processing loads to other data centers to maintain equipment temperatures within allowable ranges.

The equipment yard at Google's chillerless data center in Belgium

Free cooling makes local weather forecasting a large factor in data center management. Google has developed automated tools to manage data center heat loads. These tools use advance weather forecasts to decide when to distribute workloads. These tools can also rapidly redistribute computing workloads during an unanticipated thermal event.

Google reports a PUE for its chillerless data center in Belgium that is slightly less than 1.1.

Paradoxically, Google has had problems with workload redistributions in the past. On Tuesday, February 24, 2009, Google's Gmail was down for two and a half hours. Google later explained that, in preparation for a routine maintenance event at one of its European data centers, users were routed to another nearby data center. This inadvertently overloaded that data center, which caused a cascading effect from one data center to another, ultimately taking down the entire Gmail network.[1]

Yahoo!'s Chicken Coops

Yahoo's planned chillerless data center is to be located in Lockport, New York, northeast of Buffalo and ten miles south of Lake Ontario. This data center will be one of the greenest data centers in the world. Not only will it use hydroelectric power generated by Niagara Falls to the east, but it will use the winds off of Lake Ontario for free cooling of its IT equipment.

The data center will comprise a set of independent modules called "coops" because of their resemblance to chicken coops. According to plans filed with the city of Lockport, each coop will be a prefabricated metal structure 120 feet by 60 feet. Louvers built into the sides of each coop will allow cold air to enter the computing area. The coops are angled to take advantage of the prevailing winds of Lake Ontario so that the winds will blow directly into the louver system.

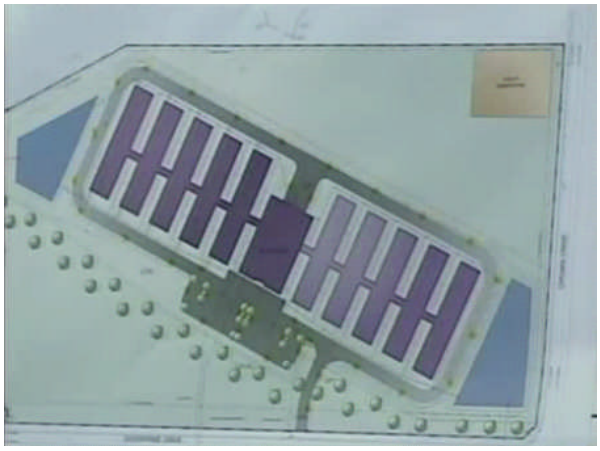
[1] Google Troubles: A Case Study in Cloud Computing, *Availability Digest*; October 2009. http://www.availabilitydigest.com/public_articles/0410/google_troubles.pdf

Each coop has a peaked roof with a “penthouse” on top that manages the release of waste heat from the hot isle in the coop into the outside air.

A coop will house five megawatts of equipment. Initially, five coops have been approved by the town, though the Yahoo! site plan shows room for many more.

On days that are warmer than 27 degrees Celsius (about 80º F), the coop cooling system is augmented with evaporative cooling. It is expected that this may be required about 212 hours (about 9 days) per year. The result is an estimated annualized PUE of 1.1, meaning that 90% of the energy consumed by the data center goes to power its IT equipment.

Yahoo! already operates green data centers in Washington State that use wind and hydroelectric power with free cooling for most of the year.



Yahoo!’s proposed Lockport chillerless data center

Summary

The day of the large campuses housing major data centers may be coming to an end. Both Google and Yahoo! are moving to compact and efficient data center modules that can be scaled by simply adding additional modules. This is similar in some respects to the move towards “data centers in a box” in which entire data centers are being built within a portable shipping container by, among others, HP, Google, Sun, Dell, Microsoft, and Rackspace.[2]

The U.S. Environmental Protection Agency (EPA) has set a goal for a data center PUE of 1.12 by 2011. The new chillerless data centers of Google and Yahoo! meet this requirement. To meet this goal across all data centers, we may see major enterprises like Google and Yahoo! adopting a “follow the moon” strategy in which workloads are shifted seamlessly between data centers to take advantage of better cooling during overnight hours (not to mention cheaper off-peak energy costs).

[2] Data Center in a Box, *Availability Digest*; July 2009.
http://www.availabilitydigest.com/public_articles/0407/pods.pdf