CLABBY ANALYTICS

Perspective

Water Cooling the Data Center

Introduction

Clabby Analytics believes strongly in the use of water cooling to cool datacenters. Why? Because air cooling (the use of a gas) is a lousy way to conduct heat when compared to water (a fluid). By some estimates, water is 3000 to 4000 times more efficient at conducting heat compared with air.

> ***This massive advantage in conductivity would seem to make pumping chilled water to hot spots and removing warm water exhaust a no-brainer. But most data center designers still focus on air cooling instead of water cooling in their data center designs. Go figure…***

But, after a visit to IBM's new Smarter Data Center in Raleigh, North Carolina, we have slightly modified our position on water cooling. What we saw there was the use of targeted air cooling where precisely targeted air cooling is used to deal with hot spots in the data center. IBM does this by using sensor technologies to monitor data center temperatures and energy management systems to deliver cooling to hot spots. And this approach is far more efficient than what we typically see in other data centers around the world (where whole rooms are cooled rather than targeted areas).

In this *Perspective*, *Clabby Analytics* explains some of the dynamics that we have observed in the market when it comes to data center water cooling the data center, and comments on the competitive environment for this technology.

Field Research

As a technology research analysts, we regularly visit data centers located all around the world and somewhere around 85% are cooled exclusively by blowing chilled, conditioned air over systems, storage, and network devices. Large data centers are often arranged with cold aisles that feed air to information systems, while hot aisles focus on removing that hot exhaust air. In fact, a whole science has developed around *data center airflow thermo-dynamics* that deals with how to sense and remove hot exhaust air.

As stated in the introduction, we are huge believers in water cooling — yet very few data center managers make use of water in the data center. Why so? When we press IT managers and data center designers for an explanation, we get a litany of varying excuses. Some say that air cooling works just fine for their particular circumstance. For instance, one IT manager had a single mainframe in a large room, and a small chiller/air conditioning system in place to provide that system with all the cooling needed to keep it running within specified heat ranges — and indeed, this approach worked fine. Others say they're afraid of injury and systems damage should a water pipe break (the old "water and electricity don't mix", or "do you provide life preservers" arguments). Others say that plumbing the data center would be too expensive (IT managers in unionized labor

buildings strongly emphasize this point). But, in the end, we chalk-up a lot of the resistance to water to:

1. Unwillingness to investigate new options ("if it ain't broke, don't fix it mentality);
2. Ignorance of the immense benefits of moving to water offers;
3. Lack of understand about how simple it is to deploy a water-based cooling system; and,
4. Vendor FUD (fear, uncertainty, and doubt — offered by vendors without water cooling).

Overall, the overt benefits of water cooling and the vendor FUD factor are worth much closer examination.

The Cost of Air Cooling — What a Waste!

When comparing water and air cooling, first you need to figure out how much electricity your data center is using on the chillers, air conditioners, humidifiers and other devices. And, for many IT shops, this is a major problem because they simply don't have the measurement tools in place to separate power costs for cooling from power used by information systems. According to some studies, if they could measure cooling costs they might find that their information systems are using only 30% of the total power consumed in the data center while cooling and power backup devices are consuming the remaining 70%! Why is this not a big deal? Many IT managers admit that they don't really worry much about power consumption because data center electricity costs are the responsibility of facilities managers.

Now consider how air-based cooling works. Air-based systems typically use fans and projected air flow sensing to remove heat from the data center. This approach is somewhat predictable as long as everything stays constant in the systems environment but if a change occurs such as a system failure or the addition of new equipment the air cooling system needs to be rebalanced. However, instead of rebalancing air systems regularly, IT managers tend to overprovision cooling to ensure that their information systems always meet specifications (and while effective this practice is simply wasteful).

Further, consider what happens to air flow if an information system goes to sleep (or automatically quiesces—an increasingly common feature systems vendors offer energy/cost conscious customers). Is there enough intelligence in the air flow sensors to adjust to this change or does the cooling system just keep running even though it doesn't have to? Sensors and energy management software can now be used to find hot and cool spots and adjust systems appropriately. Only, we see very few IT buyers making use of these products.

By comparison, water-based systems use pumps to move water through a usually closed-loop system (some data center designers actually repurpose the heat exhaust — using heated water to warm buildings, for instance). Cooling using water becomes very predictable because, unlike air, water is contained in pipes and maintains a much more predictable flow. So water cooling is simply a matter of bringing water to a heat source —

and then moving that heated water away to heat exchangers. If there is a change in system utilization of a server (for instance, if a server quiesces or a disk array spins down) the water flow can slow or stop entirely and wait until the system gets hot enough to require movement (sensors can detect this).Water can just be moved through the system on a timed cycle basis. Comparing these two methodologies both use mechanical devices to move heated transfer material away from its source — in one case a fan and in the other a pump. The primary difference is that air cooling is moving a gas, while water cooling is moving a fluid — and by its nature gas is much harder to control than a fluid. Both methods work, but with the conductivity qualities of water — and the ability to move it to and away from a heat source effectively and predictably, water has a huge power and cost efficiency advantage.

How big is this advantage? This depends on the size of the data center and the cooling and systems/storage/network device mix. But most data suggests that it is reasonable to expect that data center cooling costs could be reduced by between 20% and 40% using water cooling (check out IBM's evolving Aquasar technology at http://hothardware.com/News/IBM-Delivers-Innovative-Water-Cooling-System-For-Datacenters/ to see how water cooling can be used to dramatically reduce data center cooling costs

Now Do the Math…
Just imagine that your data center is spending $20 million dollars a year for power and cooling. That's not hard— in fact, it's a representative figure for many enterprises. Of this amount, assign 30 percent of that cost or $6 million to operating your information systems. Remember that this number will stay constant regardless of whether air- or water-cooling is used. That leaves $14 million dollars a year in air cooling costs, but if you reduce energy consumption to the best case water cooling scenario of 40% that number drops to $8.4 million, resulting in total savings in data center power and cooling costs of $5.6 million.

Now consider doing nothing (the if it ain't broke, don't fix it approach). The price of oil (used to produce a lot of the world's electricity) was at $70/barrel last year — its at $100 per barrel today — and it is reasonable to expect that the price of oil could go up to $140 or more over the next decade as the world climbs out of its economic doldrums and the demand for electricity and oil increases.

> ***If you don't fix the problem — and if your data center stays constant in terms of size — doubling the cost of electricity means you're looking at $28 million dollars to air cool your data center versus $16.8 million using water. And that wasted $11.2 million for air cooling gets chopped directly from the enterprise bottom line. Go ahead and keep air cooling — but be prepared to pay heavily for wasting power and your company's precious financial resources. Oh, and by the way, consider the damage you're company is doing to the environment by wasting power, too.***

The Vendor Situation
Okay, let's say you want to look into the possibly of water cooling your data center. Who do you go to? Well, if you want to look at water cooled systems, you've absolutely got to look at IBM (the company has been developing and delivering innovative water cooled systems/servers for over 50 years). But what kinds of water cooled systems do Hewlett-Packard, Sun/Oracle and Dell offer? Actually, these companies do not design systems that

bring water cooling directly to the processor heat synch. Instead, they partner with third party ISVs who build rear door heat exchangers and the like to help usher away excessive heat. Is it any wonder that FUD about water cooling finds its way into some vendors' marketing spiels?

In contrast, IBM builds its own rear door heat exchangers, as well as water-to-the-heat-sink products — so for the broadest, most effective water cooling solutions for data centers you've really got to look at IBM. If you do consider IBM's water cooled systems, look closely at the Power 575 Hydro-Cluster, or check out how an IBM mainframe can be water-cooled.

We especially like IBM's mainframe water cooling design because they enables:

- A reduction in line cord power required by the server (15% less power draw for a z196);
- A reduction in air flow required by the server (20 – 25% less); and,
- It has integrated controls that use a water conditioning unit.

Further, IBM's mainframes incorporate triple redundant humidity sensors and internal controls assure condensation free operation even in out of spec high humidity conditions; 2N redundancy; water cooling of the processor multi-chip module; and an air to water heat exchanger within the mainframe boundaries, (not on a rear door).

In short, if you're looking for water cooling innovation at the systems level, you've got to look at IBM.

Summary Observations

As I travel the world, I do find increasing interest in water cooling in certain geographies—primarily countries that are not energy self-sufficient. And IT managers in these locales are now starting to consider water cooling as a way to combat the escalating costs of energy.

Here are a few anecdotal experiences based-upon my travels:

- We once asked an IT manager in Brazil if he was concerned about the cost of power, and he told me "Hey, we've got bio fuel from sugar cane and corn; we've got hydro power from all of our rivers; we have nuclear power — and now, they tell us, we have major oil deposits off of our coast". Clearly, green (environmentally sensitive) computing was not first and foremost on this person's list of priorities.
- An IT manager in Malaysia claimed "we have oil, turbine (wind), and thermal power", again showing little concern about energy efficiency in the data center.
- Western Europeans, however — with their strong emphasis on renewable energy, carbon credits, and conservation programs — demonstrate heightened awareness when it comes to water-based cooling because they recognize its efficiencies (and they also know that saving energy is good for their countries from a GDP perspective). But altruism aside, the Western Europeans are far from energy self-sufficient, so energy is very, very expensive. And they know that every Euro they can save by using energy wisely passes directly to their company's bottom line.

- In North America, even though Canada is rich in oil and hydro power, the country's IT managers are also green (environmentally sensitive) and recognize the benefits of using water. Likewise, IT managers at large firms in the United States seem to understand the benefits of water cooling, though most continue to deploy air-based cooling solutions. We attribute a lot of this situation to the fact that most midrange systems vendors don't offer, let alone promote water cooled systems — so they have little choice but to use air or work with third party water cooling specialists. And this bugs us, because it looks like other vendors have no strategic commitment to water cooling — and given the immense cost savings that can be achieved using water, it is unconscionable that they don't.

Based upon discussions that we've had with dozens of IT managers, the first step in promoting the use of water cooling in the data center appears to be to make companies aware of their air cooling costs. IBM and several data center design firms have the tools needed to model and compare the cost differences using air versus water. The next step will be to provide more proof of the immense efficiencies and operational costs savings that can be achieved using water, and IBM frankly needs to do a better job of this.

The biggest problem with water-cooling in the data center, however, is related to IT managers' and companies' unwillingness to investigate new options. Hopefully the educational measures, case studies, and analytical tools that are increasingly available will help light a fire under data center designers who persist in designing air-cooled data centers, and the executives who persist in wasting money on less than optimal cooling solutions.

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