

Industry Developments:

Liquid Cooling for Computer Servers

The use of liquid cooling systems for larger computer systems dates back to the IBM mainframes of the 1960s. The typical cooling solution then was to apply a thermal conduction module, which featured a water-cooled cold plate in direct thermal contact with the IC packages. A decade later, some Cray supercomputers pumped DuPont's Freon through a vertical piping to cool printed circuit modules. The Cray-2 of the 1980s was nicknamed Bubbles for its liquid cooling system. The supercomputer's tightly packed card modules were cooled with a continuous flow of 3M's Fluorinert liquid. [1]

While air cooling eventually came to dominate datacenter cooling technology, its high consumption has been a cause for concern. One study reported that about a quarter of the energy required by a typical data center is used for keeping it cool. [2] As a result, many engineers have returned to liquid cooling. With continued developments in this technology, liquid cooling is now at work in data centers around the world. It provides a way for keeping data centers in their safe operating temperature range without high energy expenses.

Total Liquid Immersion Approaches

The Green Revolution Cooling Company provides tanks filled with a mineral oil material to offer an environmentally friendlier system to cooling computer servers. A year-long submersion test by Intel found that no computer components –



Figure 1. A Server Board is Removed from a Container of Mineral Oil that Provides Cooling of the Hot Running Server Electronics [3]

processors, hard drives, etc. were damaged by the dielectric mineral oil. And no fans or other air cooling hardware was needed on the Intel equipment. Green Revolution claims their fluid submersion technology can reduce cooling energy use by 90-95% while also reducing server power by 10-20%. [3]

The ubiquitous social network, Facebook, has tried immersing some of its servers in dielectric fluid. Those experiments have not as yet led to a large scale immersion conversion, but the cooling method has seen progress and acceptance in other data center arenas.



Figure 2. Novec Fluid from 3M is Used in UK-based Iceotope's Data Center Cooling Technology [5]

Selected Immersion Cooling

The website, Datacenter knowledge, keeps tabs on developing immersion technologies. [4] These include the "open bath immersion cooling" concept, an example of passive two-phase cooling. Here, a boiling liquid removes heat from a surface and then condenses the liquid for reuse, without using a pump. Servers are immersed in 3M's Novec, a non-conductive chemical with a very low boiling point, which easily condenses from gas back to liquid. Each processor is capped with a copper plate coated with a material that enhances boiling to improve heat transfer performance. The boiling Novec vapor rises to a condenser, where it's cooled by water to condense back to liquid for reuse.

The Iceotope method keeps the heat in liquid without the need for power-consuming refrigeration systems. In Iceotope's server racks use conventional blade server motherboards, mounted inside individually sealed, hot-swappable enclosures that are flooded with Novec. The engineered fluid

is fireproof, electronically inactive, and has a high capacity to remove heat via natural convection. Novec passively transfers heat away from the electronics to a heat exchanger formed by the wall of the module, where water is continuously re-circulated and cooled. The company says the system can work with water supplies of up to 50°C and still keep servers cool. [5]

Chillydyne, Inc. developed its Cool-Flo liquid cooling system for data centers as a low cost, easy-to-implement, direct-to-the-chip, leak-free liquid cooling. The technology provides exceptionally efficient thermal energy removal from servers with significant energy savings. The system is easy to install and requires little service. It is designed for low total cost of ownership, with a typical payback in less than a year.



Figure 3. Rear View of a Server Rack with a Chillydyne Cool-Flo Liquid Cooling System [6]

Cool-Flo uses a proprietary no-drip, hot-swap connector. This allows the removal of select servers while the system continues to cool the remaining servers. The negative-pressure coolant flow technology is rack-based, direct-to-the-chip and leak-free. It is based on rocket-cooling technology and utilizes a pump developed with a grant from NASA's Small Business Innovation Research program. The system's reduced power needs are derived from the elimination of HVAC, reduced leakage of electrical current from CPUs, and reduced power needed to run servers' fans. [6]

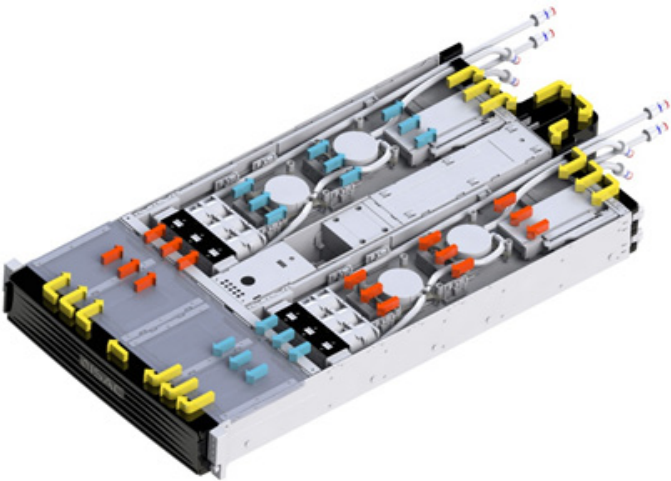


Figure 4. Self-contained ISAC Liquid Cooling Technology from Asetek will Cool Datacenters Serving the US Defense Department [7]

Asetek's Inside Server Air Conditioning (ISAC) System was selected by the US DoD (Defense Department) to cool its forward deployed data centers in association with DoD's TROPEC (Transformative Reductions in Operational Energy Consumption) program. The ISAC removes 100% of the server generated heat from within the server, completely eliminating the need for any variation of the tradition CRAC unit found in most data centers. The ISAC system adds two benefits; the first is that the liquid cooling system can remove 100% of the heat generated in the server from the data center. The second is that because there is no need for air movement external to the liquid cooled servers, the quality of the air provided to the data center is no longer an issue; there is no air exchange between the liquid cooled servers and the data center. [7]

Next-Steps in Liquid Cooling for Data Centers

To meet growing data center cooling challenges, many organizations are turning to liquid cooling. Liquid cooling is a powerful alternative to ambient air cooling, as water can carry thousands of times more heat than air. Rather than tweaking or re-engineering existing methods, disruptive cooling technologies are transforming the entire data center industry with wholesale changes at even the most basic level.

Radical new liquid cooling solutions can cut cooling costs by up to 97%, allow data centers to run neutral in terms of heat and provide 24/7 free cooling anywhere on the planet. The advantages in terms of data center design are also marked. This system is capable of taking water input temperatures of up to 45°C – this removes the need for chilled water going into the system and for chiller equipment inside the facility, including CRAC units, fans or heat exchangers. [8]

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Next Generation Cold Plate Characterization

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