Liquid Cooling of Data Center Servers

Energy costs for data centers are considerable, and include the expense of cooling the increasingly hot- running hardware. Most data centers have relied on ambient air cooling solutions (alternating cool and hot rows) to meet their cooling needs. However, ambient air cooling solutions are often unable to handle high heat loads, are not targeted and can be cost and energy inefficient. As high power applications and server densities increase, new ways are needed to dissipate heat. The use of liquid cooling solutions is an increasingly popular part of many datacenter cooling strategies.

A typical data center has an air-centric infrastructure designed to provide thermal management. A collection of chillers, compressors and air handlers replace hot air with cold, and rows of servers can be laid out to alternate warmer zones with cooler ones.

But while these methods can provide cooler computing environments, they may not be the most efficient approaches when it comes to managing costs. In some cases, localized cooling solutions at the rack and board level can deliver needed cooling at a lower expense.

Ambient Air Cooling

Data center ambient air cooling solutions use alternating aisles of cool air between their racks. Cool air is supplied to the cold row through ducts under the raised data center floor supplied by CRAC units. The air is exhausted from the back of the rack in the hot row. Another way to cool inside a data center is to use fans mounted to the roof or rear door of a server rack and use rack-mounted and wall air conditioners. Ambient air cooling solutions are limited in their ability to handle high heat loads, as they typically are only able to effectively cool 5 to 10 kW per rack.[1]

One provider, Asetek offers a range of liquid cooling solutions for HPC clusters in data centers. Their cooling technology removes heat directly from processors and moves it to an optimal place for transfer to the environment. The Asetek approaches include internal loop liquid cooling for cooling fast processors; rack CDU liquid cooling takes component heat from rack servers and blades out of the data center without the need for air conditioners or water chillers; and the company's sealed server liquid cooling process removes all server heat from the data center meaning that no air in the data center needed for server cooling. [2]

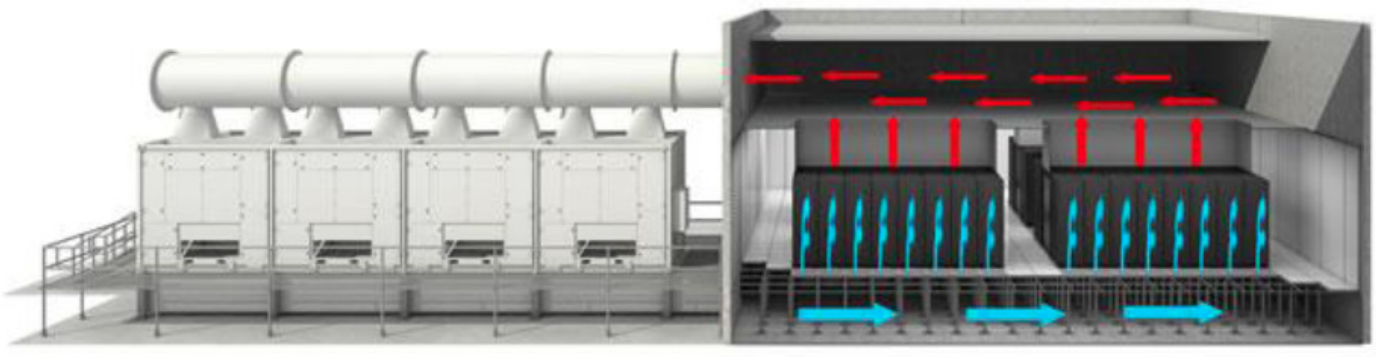

Figure 1. Air from hot data center servers rises into a plenum and feeds into a conditioning unit where it is cooled and returned to the base of the data center and used to cool the server racks to safe operating temperature . (APC)

Internal loop liquid cooling captures heat from CPUs and GPUs in high density servers and transfers it into an air stream. This enables the use of higher wattage CPUs and processor overclocking in a server that otherwise could not be relied on for safe performance. In these systems, multiple CPUs are liquid cooled when cold plates remove the processor heat into the flowing cooling liquid. Low power pumps, installed at each cold plate provide the flow, drawing cool liquid from a liquid-to-air heat exchanger, pump it at very low pressures through the cold plates and return it to the heat exchanger. The standard chassis fans move air through the heat exchanger. Heat in the liquid is transferred to the air flowing through the chassis.

Asetek's rack coolant distribution unit, CDU, uses liquid to directly cool the high heat flux component within servers, including CPUs and GPUs. By directly liquid cooling hot spots in a server, this method removes more than half of the thermal load on CRAC, computer room air conditioning.

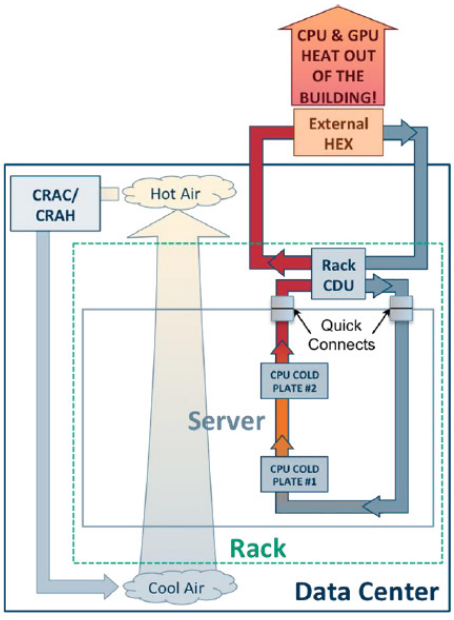

Figure 2. Data centers with a rack cooling CDU use two cooling paths to remove heat from the data center. A traditional air path with CRAC units removes heat generated by disk drives, power supplies and other low heat flux components. The rack CDU system uses a direct liquid cooling path to remove all processor heat from the data center. (Asetek)

Sealed server liquid cooling is a method for removing all server heat from a data center and eliminating the need for a CRAC system. These are self-contained cooling units that do not exchange any air with the surrounding. Two liquid loops are involved: a low pressure server loop and a facilities loop. They do not share liquids. Heat moves between the loops in a liquid-to-liquid heat exchanger. All heat within the sealed server is removed via liquid to the exterior environment. Re-circulated cooler internal air cools the other components within the server.

Google's Data Center Cooling Solution

Google has customized much of the operation of its data centers, which serve as the engines powering its massive Internet business. This includes their cooling solutions. The liquid cooling design patented by Google features custom motherboards with components attached to both sides. Heat-generating processors are placed on the side of the motherboard that comes in contact with the heat sink, which is an aluminum block containing tubes that carry cooling fluid. Components that produce less heat, such as memory chips, are placed on the opposite side of the motherboard, adjacent to fans that provide air cooling for these components. Motherboards are attached to either side of the heat sink, creating a "server sandwich" assembly that can be housed in a rack. [3]

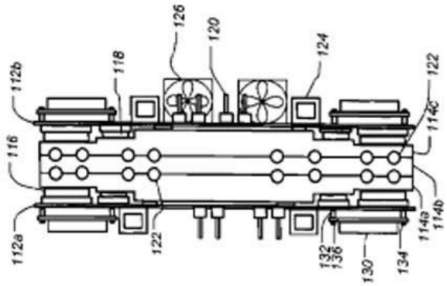

Figure 3. Google patent drawing shows a cross-section of a design for a liquid-cooled server assembly featuring a heat sink with motherboards on either side.

Server cabinets with integrated chilled-water cooling units provide highly-efficient thermal management of blade servers, 1U servers and other high density heat loads. Data Center Resources offers self-contained cabinets for use in non-conditioned spaces including warehouses, server closets and more. Alternatively, water-cooled heat exchanges can absorb IT heat load in data centers with traditional cooling to significantly reduce cooling requirements and energy costs.

References:

1. Datacenterresources.com
2. Asetek.com
3. Datacenterknowledge.com