

Development of a Very Dense Liquid Cooled Compute Platform

Integrating processor and cooling technology to reduce cooling energy consumption.

Introduction

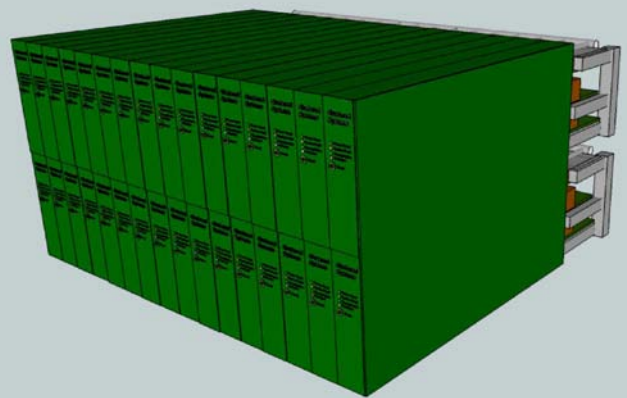
Over the last several years, there have been significant efforts to reduce the energy used for information technology cooling by making small improvements to the existing air-based cooling equipment and optimizing the control of air movement. However, moving air is energy intensive; air has a low specific heat, air to solid interfaces have a high thermal resistance, and hot and cold air mix in unpredictable ways. Air is simply incompatible with high-density systems that are required for high-performance computing (HPC). As computer energy consumption increases, air must be forced faster through smaller gaps for it to cool effectively. The energy now required for this process is unacceptably intense and an alternative cooling method is needed.

This project will result in a prototype of a high-density computing platform with 100% liquid cooling, using off-the-shelf commodity components and high-volume manufacturing techniques. The system will be powerful enough for HPC applications and cost effective enough for general data center applications. The system will incorporate a flexible cold plate to accommodate the sagging usually experienced with server enclosures. The liquid coolant used is a non-conductive dielectric. The system design requires no fans. The ability to package highly dense server systems with liquid cooling reduces the floor space needed for the server.

Benefits for Our Industry and Our Nation

This dense, liquid-cooled computing system incorporates a high-efficiency cooling system already used in data centers. The system will accomplish the following:

- Achieve a power usage effectiveness (PUE) of 1.19 or better compared to today's average PUE of approximately 1.7 or higher.
- Successfully support HPC applications with cost-effective manufacturing for mainstream computing applications.
- Have the capability of being cooled without the use of refrigeration systems for most of the year (in the majority of U.S. locations).
- Cooling energy is expected to be reduced by 81%.



Integrated processor and cooling technology.

Illustration courtesy of Edison Materials Technology Center.

Applications in Our Nation's Industry

Liquid cooling was used in the computing industry for decades, but was mostly supplanted by air when lower-power circuits were introduced. However, today's computer circuits are so dense and dissipate so much power that liquid cooling is coming back. It is a much more efficient way to cool components than conventional forced air flow techniques. This project will prove the ability to safely provide liquid cooling to a large amount of equipment, thereby decreasing energy costs. The industries that will benefit from or that are involved in a transition to this technology include the following:

- Data center and telecommunication facility owners, operators, rack equipment manufacturers, and construction and development companies
- Distributors of servers and computing equipment for data centers
- Manufacturers and resellers of facility cooling and refrigeration equipment

Project Description

The objective of this project is to design and develop a high-density compute platform prototype with 100% liquid cooling using commodity components and high-volume manufacturing techniques. The liquid cooling technology uses liquid refrigerant, and flexible cold plates to place a cooling surface close to heat generating server components. A Liebert XD pumped refrigerant platform connected to an existing cold water system will be used to reduce the temperature the circulating coolant. Cooling energy can be reduced further, by the use of an outside air heat exchanger in place of the cold water system. In this configuration, cooling energy can be expected to be reduced by 81%.

The design will culminate in a prototype evaluation system consisting of two racks containing the cooling systems and approximately 300 compute modules. A significant portion of this project is the evaluation of the prototype system at an actual end-user data center test site. Over a period of 6–9 months, a number of key parameters will be recorded via the server management system with minimal additional instrumentation. These include:

- Power consumption of the cooling system and compute system
- Temperature of the internal server and coolant
- Ambient conditions including temperature and humidity
- Functional performance of the system

Barriers

Data center operators resist new technology due to downtime and the perceived risks inherent to installing liquid bearing systems close to the equipment. This solution has been proven on a small scale and this project will reveal performance and energy savings on a larger scale, which will build confidence for prospective buyers.

Pathways

After development, the system will be installed at a test site and used to run production applications. All key parameters will be recorded over 6–9 months. In addition, system breakdowns (if any) and causes will be logged and all data will be available to DOE and the public. As part of the commercialization phase, the test site will be available for customer outreach.

Milestones

- Designing and building the first rack system
- Building and testing the second rack system
- Installation, monitoring, and measuring the rack system at the test site

Commercialization

A major computer component manufacturer has expressed interest in driving commercialization. This company may offer the system board design as both a product and as a reference design for its customers. Clustered Systems will produce the cooling shelf and Emerson will produce the rack and arrange for worldwide distribution. The rest of the cooling system will be built using commercially available components.

Project Partners

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