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Go for the Green

3M immersion cooling technology helps Japanese firm take Green 500 honors

The Suiren, a supercomputer developed by PEZY Computing and ExaScaler Inc., is cooled by a single-phase immersion cooling system, the ESLC-8 Submersion Cooling system, using 3M™ Fluorinert™ Electronic Liquid as the heat transfer medium.

Since the dawn of the supercomputing age, progress has been measured in terms of ever-increasing rates of speed and raw computing power. But these increases have come at a cost. More computing power typically leads to higher energy consumption, both to power the machines themselves and to drive the complex, costly systems needed to cool them.

In recent years, growing concern about the environmental impact of heavy energy users such as data centers and supercomputer facilities has led to a new way to rate supercomputer performance – this time, in terms of a machine's efficiency, expressed in terms of the number of operations performed per watt.

Formal recognition for achievement in this area was instituted in 2007, with the publication of the first "Green 500" list. Established by a group of supercomputing industry professionals, the bi-annual list ranks the world's 500 most energy-efficient supercomputers. Rankings are established by means of a specific methodology for measuring, recording and reporting the power used by a high performance computer system.

In the November 2014 Green 500 list, the Suiren (water lily), a supercomputer co-developed by PEZY Computing and ExaScaler Inc. for the High Energy Accelerator Research Organization "KEK" in Japan, achieved second-place honors, clocking in at 4.95 gigaflops per watt, using a total of 37.83 kW. In comparison, the world's most powerful commercially-available computer system, as ranked in the November, 2014 Top 500 List (top500.org), is China's Tianhe-2, which can process 33.86 petaflops per second. However, the Tianhe-2 requires 17,808 kW of power to do so, which equates to only 1.9 gigaflops per watt, making it far less energy-efficient than the Suiren machine. Ultimately, the purpose of the Green 500 list is to encourage the development of supercomputers that are powerful enough to meet the needs of their particular applications, while decreasing the total cost of ownership through improved energy efficiency. This was the stated goal of the KEK organization in commissioning the development of the Suiren.

The construction of the Suiren is based on the ExaScaler-1 component, consisting of 32 units in 4 submersion tanks. 8 PEZY-SC many-core processors and 2 Intel Xeon E5-2660v2 10C 2.2GHz microprocessors are in each unit with FDR InfiniBand™ cable. The machine is cooled by a single-phase immersion cooling system, the ESLC-8 Submersion Cooling system, designed and provided by ExaScaler, and employing 3M™ Fluorinert™ Electronic Liquid as the heat transfer medium.

Liquid immersion cooling played a key role in achieving the high energy efficiency rating for the ExaScaler-1 supercomputer. Air cooling, which typically uses chilled water to cool the air, consumes a considerable amount of electricity to power the air handling equipment, fans and chillers, none of which are required in immersion cooling. Although other liquid media, such as oil, can be used for immersion cooling, oil is flammable, is not very compatible with plastic cables, leaves a residue on components and maintains heat longer, making it difficult to replace or service components quickly. Because Fluorinert liquids have higher heat transfer performance with lower viscosity, good compatibility to materials without leaving a residue, and do not retain heat as long as oil, these problems can be avoided.

Fluorinert electronic liquids are part of a family of fully-fluorinated compounds known as perfluorocarbons, or PFCs. Clear, colorless, odorless and nonflammable, Fluorinert liquids have a number of properties that make them suitable for immersion cooling of electronics, including high dielectric strength, a wide range of boiling points and good materials compatibility. They have been used for over 50 years in demanding heat transfer applications, including the Shinkansen bullet train and the Japanese Experiment Module Kibo (Hope) on the International Space Station. They are also among the most widely known practical materials for use in direct contact cooling of power converters and environment testing room.

Although they are non-ozone depleting, Fluorinert liquids do have high global warming potentials (GWP) and long atmospheric lifetimes. Because of this, Fluorinert liquids, like all PFCs, should only be used in applications that require their unique performance characteristics, and care must be taken to carefully manage and minimize emissions.

In recent years, a new two-phase immersion cooling system, employing semi-open baths of 3M™ Novec™ Engineered Fluids, has demonstrated outstanding results in a number of commercial data center applications. Novec fluids are a family of proprietary 3M materials designed to address the need for safe, effective, sustainable solutions in industry-specific applications.

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In addition to their excellent heat transfer properties, Novec fluids are characterized by their favorable environmental and worker safety profiles, including low toxicity, zero ozone depletion potential and low global warming potential, making them a long-term, sustainable solution for a variety of electronics cooling applications.

Two-phase immersion cooling with Novec fluids has been shown to reduce data center cooling energy costs as much as 95%, while requiring ten times less floor space than conventional air cooling. Because of its heat transfer efficiency, it also allows for overclocking. Requiring no chillers, fans or hermetically-sealed enclosures, this new technique shows promise in emerging supercomputer applications. However, because Fluorinert liquids offer a decades-long track record of reliable service in immersion cooling, their use remains a viable alternative in specific high performance applications.

As expertise with immersion cooling employing Fluorinert liquids and Novec fluids continues to expand, it is anticipated that more and more supercomputers using this technique may be represented at the top of the Green 500 list. With growing awareness of the need for every sector to reduce its carbon footprint, we might even hope that one day, the Green and Top 500 lists will essentially be one and the same.

The Suiren requires only 68 square feet of space. Because the system is designed with immersion cooling using 3M Fluorinert Electronic Liquid, the servers do not require fans to blow air, eliminating additional fan noise.

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