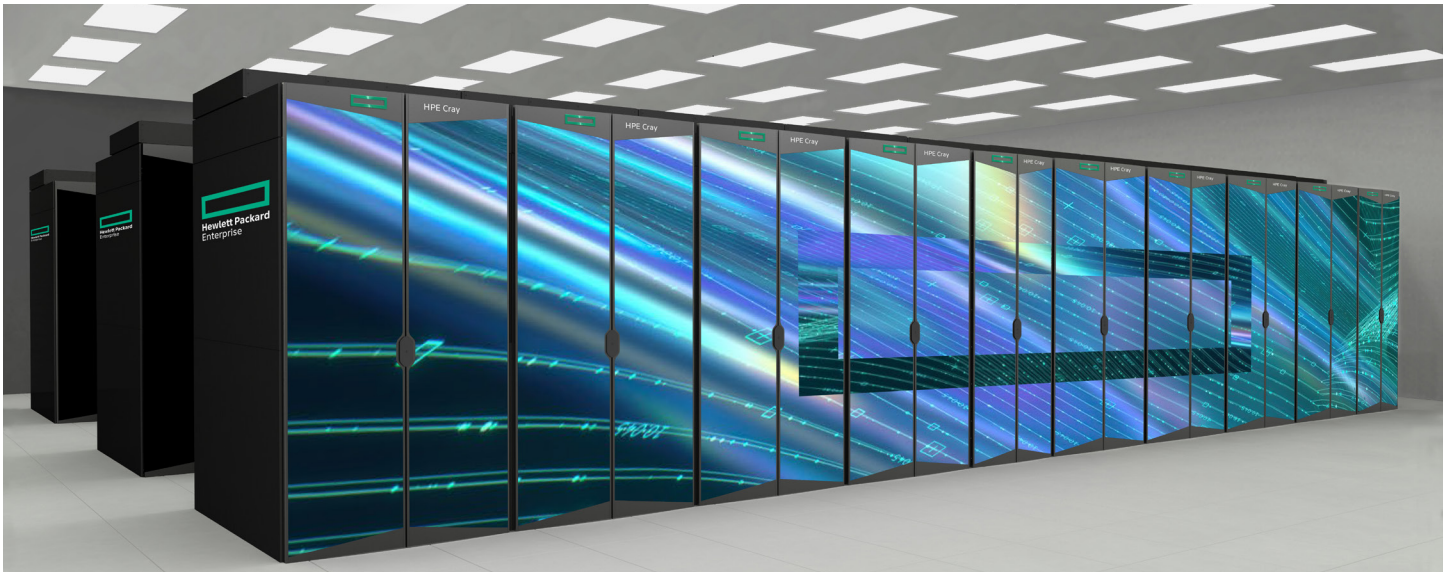
Supercomputing Power Requires Liquid Cooling Ingenuity

Hewlett Packard Enterprise and CPC collaboration advances liquid cooling for HPC industry



SUPERCOMPUTING REDESIGNED—THE HPE CRAY EX SUPERCOMPUTER

Supercomputing delivers the processing power sufficient for intensive science and engineering use. Modeling and simulation work in security, defense, weather/climate, computational fluid dynamics, mechanical design and more are all possible because of high-performance computing (HPC). Artificial intelligence, sophisticated analytics and a worldwide drive toward empowering digital solutions across a wide range of categories also demand more advanced supercomputing. These supercomputing designs must handle fast, diverse exascale workloads simultaneously.

"With supercomputing needs evolving so quickly, HPC systems need to support a variety of compute platforms along with the ability to upgrade to new architectures as they are introduced," said Mark Steinke, PhD, thermal architect, Hewlett Packard Enterprise. "Those are the scenarios that our HPE Cray EX supercomputer was built for. It's an entirely new design intended to meet current and future system requirements across HPC, AI and converged workloads."

> "The ability to seamlessly plug new or different blades into the system over time means connection to the liquid cooling manifolds needs to be equally seamless."

THE CPC CONNECTION

Liquid cooling was a given, but the selection of a quick disconnect (QD) provider or connector development partner was not. At the outset of the project, the HPE Cray team conducted a survey of what was available, including review of some incumbent suppliers' products. Primary drivers were flow rates and form factor fit. According to Steinke, "We couldn't find exactly what we wanted, so it was important for us to align with a partner who was willing to work closely with us to find a product that met our needs."

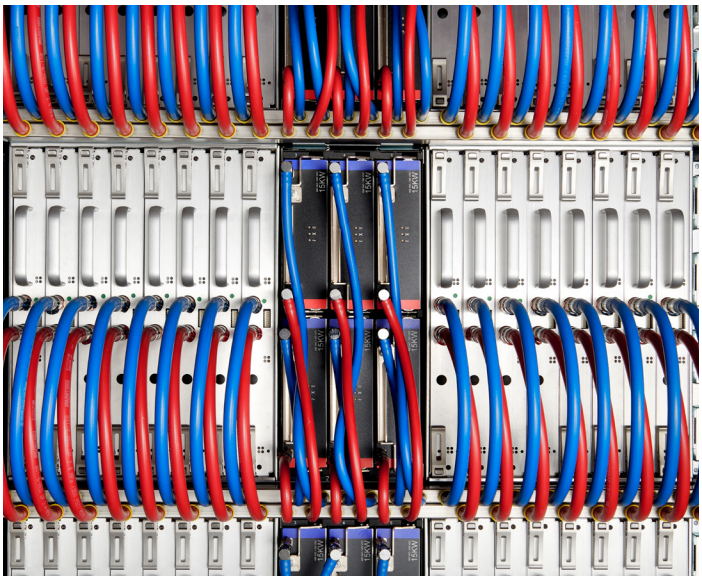
Close engineer-to-engineer discussions between the two companies set the stage for the solution to come. "The entirely new design of the HPE Cray EX system spurred fresh thinking from CPC," said Barry Nielsen, applications

development manager in CPC's thermal business. "We were challenged to create a solution that didn't exist. We applied our decades of fluid management connector expertise to the liquid cooling aspects of this exciting, new extensible computing platform."

THE CHALLENGE:
A NEW APPROACH TO HPC REQUIRES NEW LIQUID COOLING CAPABILITIES

HPE's new supercomputer was built with flexibility in mind. "We wanted to set up an environment where we could change the computing architecture—CPU-centric computing vs. GPU or accelerator-based computing. We have customers who are interested in both and some like mixing the two platforms," said Steinke. The HPE Cray EX framework allows users to move seamlessly between those different compute technologies.

Steinke also offered an illustration of how the system can scale. Early CPU compute blades were around 2,200 watts, while today's GPU blades are in the 4,000-watt range. Future blade generations may be 5,000 watts or more. "With high-performance computing comes heat and the need to effectively manage it through liquid cooling. Our modular system can scale to meet these advances, with everything being liquid cooled. By ensuring certain flow rate and pressure drop of those system elements, we can interchange parts to upgrade to different processors and networking technologies."



Dense liquid cooling within 1U space in the HPE Cray EX supercomputer.

As an exascale computer, the new platform is a very dense system. "We can fit eight sockets on a 1U form factor while most other systems use four," said Steinke. "To drive that density for exascale performance, liquid cooling is required." "Socket power is increasing in both CPU and GPU spaces. There's always more socket power available—you just have to efficiently cool it and package it."

To accommodate next-generation CPU, GPU and inter-connect technologies, the HPE Cray EX features bladed architecture for both compute and networking. "It is designed to be flexible and compatible with technologies that arise over the next decade," according to Steinke. "The ability to seamlessly plug new or different blades into the system over time means connection to the liquid cooling manifolds needs to be equally seamless." The supercomputer offers liquid-cooled cabinetry supporting direct liquid cooling of all components in a compact bladed configuration.

"Of course, cost- and energy-efficiency are important factors for end users," said Steinke. "Goals of the project included supporting very high-wattage CPUs and GPUs, while reducing interconnect cabling and maintaining a compact system architecture." HPE projects that operational expenses for a liquid-cooled system can be significantly less than standard air-cooled racks over the lifetime of the product. The compact system configuration also requires fewer expensive optical interconnect cables.

THE SOLUTION:
HPE/CPC COLLABORATION YIELDS A NEW, ULTRA-COMPACT, HIGH-FLOW QUICK DISCONNECT

Working side-by-side, the engineering teams of both companies made comprehensive, collaborative assessments of a range of options to meet liquid cooling needs. Engineers explored various hose barb configurations, joining methods, connection orientations on differing tubing sizes, upstream/downstream flow rates and more.

The compact architecture of the liquid-cooled cabinet required the quick disconnects to fit into very tight spaces without adversely affecting either flow rates or ease of use. "We wanted to maximize the module area, allocating very little real estate for fluidic connections," said Steinke.

Among the connector specifications were:

- Compact form factor, analogous to fitting into a 1U space while delivering the highest flow coefficient (Cv) rate for the size
- Low pressure drop across the connection points
- Non-spill at disconnect under pressure, facilitating blade removal without shutting down the entire system
- Highly reliable, leak-free performance over time

- Easy to connect/service including low force to connect because the QDs would be located throughout the system
- Chemically compatible with the specified cooling fluid

> "Customers can be assured that flow efficiency is top of mind for us as much as it is for them."

"We started out looking at our existing Everis™ LQ4 1/4" connector," said CPC's Nielsen. "The 1/4" inline connector configuration is efficient from a flow standpoint, but it wasn't going to fit well in some of the tighter spaces available for connectors on the networking side."

With a focus on every centimeter of the cabinet's size, the HPE team challenged CPC to create a 1/8" (inner diameter) connector for the networking side of the system that met the flow rate and pressure drop requirements. Such a product didn't exist at that time. A new solution was needed.

"One of the primary points of a liquid cooling system is efficiency. To enhance overall cooling, we had to optimize efficiency down to the component level," said Steinke.

"Connectors are among the primary flow path resistors in an HPC liquid cooling system, depending on their configuration and valve type," Nielsen note. "You would be surprised at how things like termination style or hand mate vs. blind mate configurations can impact Cv. We model flow through our QDs theoretically in addition to testing the connectors empirically. Customers can be assured that flow efficiency is top of mind for us as much as it is for them."

The final HPE Cray EX design features two sizes of CPC Everis quick disconnect bodies and inserts

THE RESULTS:
NEW CONNECTOR SOLUTIONS ENHANCE LIQUID COOLING FOR THE ENTIRE HPC INDUSTRY

In response to HPE's need for excellent flow efficiencies in an ultra-compact connector, CPC developed the Everis™ LQ2 Series—1/8" quick disconnects (QDs) designed specifically for liquid cooling applications.

Independent testing confirms that the LQ2 Series flow rate is 22 percent better than other 1/8" connectors currently on the market. "Higher flow capacities reduce pressure drops by an average of 34 percent, optimizing liquid cooling system performance," said Nielsen.

The team also incorporated a 90-degree elbow into the QD, allowing it to fit tightly to the switch bay without requiring a large amount of cable hose bend radius in the front and rear of the cabinet. "We didn't have to take away computer space or switch space to allocate for quick disconnects by using that 90-degree elbow," Steinke notes.

The innovative CPC Everis LQ2 connector quick disconnect body with elbow and swivel for the HPE Cray EX switch blades

Another seemingly simple but very important design element was the introduction of a swivel joint in the connector. The swivel allows the QD's thumb latch to remain positioned on the top of the connector facilitating easy, one-handed operation while simultaneously avoiding tubing kinks or bends.

"We wanted to be able to both easily see and access the connections. On the switch side, networking cables egress from the switch face. It can get really congested at the back of the cabinet. To service an individual switch, technicians must be able to easily pull the cables and the quick disconnects from that blade to pull it out."

Both the Everis™ LQ2 and LQ4 Series connectors are part of the HPE Cray EX liquid cooling system. The 1/8" QDs are used with the networking switch blades and power supplies while the larger 1/4" connectors are attached to all the compute blades.

CPC modified its existing Everis LQ4 connectors to include a locking hose barb, swivel terminations and a one-piece insert to best meet HPE's specifications. The Everis QDs use a patent-pending technology designed to increase the life of the valve. They also feature multilobed seals for redundant

protection against leakage and greater sealing efficiency than standard O-rings while requiring less force to connect.

ADVANCED COMPUTING, ADVANCED LIQUID COOLING—NOW AND INTO THE FUTURE

Today, the HPE Cray EX exascale technology platform is an existing or planned part of supercomputers at preeminent U.S. scientific institutions.

Steinke credits good collaboration between the HPE and CPC engineering teams for delivering the advanced liquid cooling solutions that support the highly sophisticated, modular HPE Cray EX design.

"We worked closely together to discuss what our needs were and what was possible at CPC," he said. "We obtained real-time data moving through the development process that sometimes resulted in design modifications aimed at optimizing performance. CPC was responsive to that. There was a high level of willingness to collaborate and discuss design details. We wanted something that was a high performer in terms of flow rate and pressure drop, size and serviceability. Collaboration between the engineering teams allowed us to achieve that."

Nielsen agrees that close collaboration yielded positive outcomes for HPE, CPC and high-performance computing in general. "Now there is a new ultra-compact connection technology for thermal management that quickly and securely connects fluid manifolds to high-powered blades, all of which are liquid cooled. The entire HPC industry is the beneficiary of that creative thinking."

Learn more about the about the HPE Cray EX supercomputer at hpe.com/us/en/compute/hpc/supercomputing/cray-exascale-supercomputer.html.

To learn more about CPC connector technologies specifically for use in liquid cooling of electronics, visit our website or contact us at 1-800-444-2474.

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