China's LineShine returns the nation to the top of global supercomputing rankings

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The latest TOP 500 list of the world's most powerful supercomputers was unveiled on June 23 at the International Supercomputing Conference (ISC) in Hamburg, Germany. Delivering a sustained double-precision floating-point performance of 2.198 exaflops, or a sustained double-precision floating-point performance of 2.198 quintillion floating-point operations per second, LineShine, stationed in the National Supercomputing Center in Shenzhen, ranked first in the world.

As the first supercomputing system to achieve more than 2 exaflops of sustained performance, LineShine has established a new benchmark for exascale computing and surpassed all existing systems worldwide. Its debut at the top of the list marks China's return to No 1 in global supercomputing for the first time since Sunway TaihuLight led the TOP500 rankings in 2017.

Unlike many of today's leading supercomputers, whose performance gains rely largely on adding more GPU accelerator cards, LineShine follows a fundamentally different technological path. Its victory, according to its developers, is rooted not in simply scaling up hardware, but in a breakthrough in system architecture.

Lu Yutong, chief designer of the LineShine system and director of the National Supercomputing Center in Shenzhen, said the system is the first to adopt an online-accelerated all-CPU architecture, breaking through the limitations of the traditional CPU-GPU heterogeneous model.

Instead of relying on separate graphics processors to accelerate computation, LineShine integrates AI matrix acceleration units directly into its CPUs, allowing the processor itself to perform both traditional scientific computing and AI acceleration. "In essence, we have embedded the accelerator into the CPU itself," Lu explained. "This eliminates the costly data movement between CPUs and GPUs and returns computing acceleration to its fundamental purpose."

The US-developed El Capitan, which has won the title of the world's second-fastest supercomputer with 1.809 exaflops, represents the conventional CPU-GPU heterogeneous computing approach. LineShine, by contrast, pioneers an entirely new architecture.

For decades, one of the biggest bottlenecks in high-performance computing has been the need to continuously transfer massive volumes of data between CPUs and GPU accelerators. By removing that bottleneck, LineShine significantly improves computing efficiency while simplifying the overall system architecture.

Jack Dongarra, winner of the 2021 ACM Turing Award and a co-founder of the TOP 500 project, said LineShine shows the world a promising new architectural direction for scientific intelligence. The architectural breakthrough is supported by equally significant advances in chip design. At the heart of the system is China's domestically developed LX2 CPU, which introduces multi-precision computing and matrix acceleration capabilities into a single processor, deeply integrating traditional supercomputing power with intelligent computing.

Lu said LineShine is positioned as a domestically developed, full-stack

Figure 1. LineShine Exascale Supercomputer Ranking First on Global TOP500 List.

integrated computing infrastructure designed for scientific research, engineering, and intelligent computing.

Since its deployment, the system has supported applications across a broad range of fields, including atmospheric and oceanic science, materials research, drug discovery, brain science, and large language model inference. It supports mixed-precision computing, complex workflows, and highly parallel multitasking, achieving an average scaling efficiency of 84.4 percent in large-scale parallel environments.

To meet growing demand from science, engineering, and industry, LineShine has also evolved into a production-ready scientific intelligence platform capable of supporting multidisciplinary, end-to-end, and multi-precision computing applications.

In remote sensing, Fu Haohuan, deputy director of the National Supercomputing Center in Shenzhen, said his team has used LineShine to conduct large-scale training and system optimization of remote sensing models. The system has achieved industry-leading end-to-end training performance while enabling high-ratio compression and efficient reconstruction of eight years of global time-series remote sensing imagery, already supporting remote sensing interpretation and precipitation forecasting, significantly improving forecast accuracy, and contributing to land resource monitoring and disaster early warning.

In bioinformatics, Yang Yuedong, a professor at the School of Computer Science and Engineering of Sun Yat-sen University, said LineShine has enabled virtual screening of trillions of chemical compounds in a single day, and has improved screening efficiency by a factor of one thousand, providing powerful support for innovative drug discovery and precision medicine.

While higher computing performance is often accompanied by sharply rising energy consumption, LineShine has also established a new benchmark in green computing. Lu said the system pioneers the world's first 100 percent liquid-cooled computing cabinets, achieving an energy efficiency of 51 gigaflops per watt. Combining the world's highest sustained computing performance with industry-leading energy efficiency, she said, LineShine demonstrates that next-generation supercomputing can be both more powerful and significantly more sustainable.

DECLARATION OF INTERESTS

The author declares no competing interests.