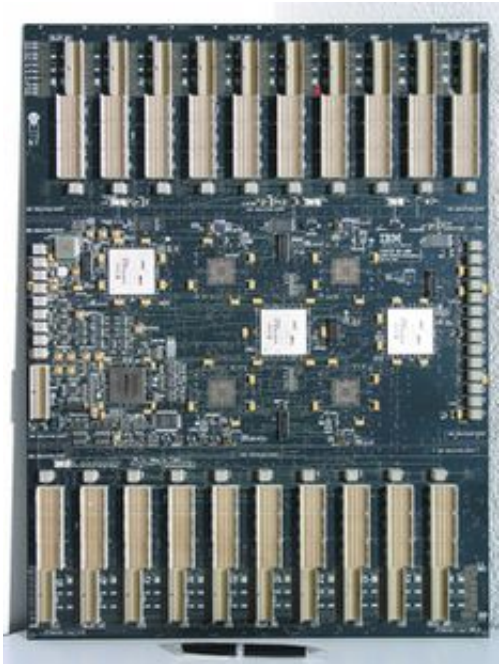
Light speed communications for supercomputers

December 17 2007



OSMOSIS controller. Credit: IBM

The performance of tomorrow's supercomputers will be dictated by their ability to exchange large volumes of data instantly between the hundreds of thousands of processors of which they are built.

Using optical networks to transfer data throughout the system using light, researchers at IBM and Corning Inc., under a project sponsored by the US Department of Energy/NNSA, have succeeded in demonstrating the

world's most advanced and powerful optical packet switch. This novel switch is capable of transmitting 2.5 Terabits of data—equivalent to 20 high-definition movies—in a single second.

Today's supercomputers, such as IBM's Blue Gene system, are based on tens of thousands of relatively simple and power-efficient processors that work in parallel to solve a problem collectively.

To grow future supercomputing performance and accommodate the resulting spiking data flows in the system, IBM researchers have been investigating the use of light for data transmission—on the chips themselves, between two processors and throughout complex communication networks. Optical data transmission is very promising by virtue of its high capacity, the ability to transfer data with minimum losses over larger distances and low power consumption.

Motivated by these prospects, a team of computer scientists at the IBM Zurich Research Laboratory and optical engineers at the US-based company Corning Inc. set out to design and develop a high-performance optical communication network by focusing on the most critical components—the switches. The function of a switch is to control data flows and prevent congestion within the complex network of data highways.

As a result of the joint four-year project entitled OSMOSIS (Optical Shared MemOry Supercomputer Interconnect System), IBM and Corning researchers have now demonstrated the most powerful optical packet switch. It combines 64 optical data links, each running at 40 Gigabit per second, which transmit up to 2.5 Terabits per second. For comparison, this corresponds to 20 HD DVD movies in a single second.

"We will need such powerful optical interconnect systems in the future if we want to scale supercomputing capabilities and efficiency well beyond

the petaflop range," explains Ronald Luijten, OSMOSIS project leader at IBM's Zurich Research Lab. "Such systems could, for example, accelerate discoveries in the fields of biomedicine and biology, and may even empower computers to design such complex, large-scale systems as new drugs."

One of the main challenges in the development of the optical packet switch is the lack of optical memory, as it is not yet known how to store and retrieve optical data bits easily and in a cost-effective manner. Luijten's team, which was responsible for the switch design, overcame this issue by adopting a hybrid electro-optical approach using electronics to buffer and schedule data and optics—leading-edge Corning semiconductor optical amplifiers—for the transmitting and switching processes. They developed a state-of-the-art electronic controller that can compute an optimal switch configuration during each packet slot of 51.2 nanoseconds, thereby operating practically bufferless while maximizing throughput and reliability.

"The function of the controller, which is the intelligence of the switch, is to perform scheduling and resolve contention," explains Luijten. The controller board—one of the most complex designs ever developed—was awarded the 2007 Mentor Graphics Award for outstanding circuit board design.

Source: IBM Zurich Research Laboratory