

Packet-Switching Scheduler Uses Opto Neural Network

By Sunny Bains, EE Times, London.

EDINBURGH, Scotland — Researchers in Britain have demonstrated a highly reliable scheduler for telecommunications switching that uses diffractive optical elements to provide inputs to an analog neural network. Though the current system is too slow and bulky for commercial application, researchers said the technology is potentially much faster and more scalable than digital technology. The project, a collaboration between British Telecom Laboratories, in Ipswich, and Heriot-Watt University, in Edinburgh, is moving into its second phase, the goal of which is to produce a more viable prototype.

"Even in its initial form," said John Snowdon, a lecturer at Heriot-Watt, "[this system] offers a potential speedup over the latest state-of-the-art purely digital scheduling systems and algorithms. The combination of fast digital electronics with the communication bandwidth offered by the optical interconnect enables us to build scalable solutions to routing problems." In addition, he said, "The use of neural network techniques allows us to tolerate considerable amounts of system noise — indeed, the system requires noise — and therefore provides a more scalable solution than conventional means." The information routing problem that the BT/Heriot-Watt team tackled is crucial for large networks. As data comes in through various channels, each has to be steered through a clear path to its destination simultaneously. Finding the best way to accommodate as many channels as possible is computationally difficult, so engineers have been looking for other options. Snowdon and his colleagues saw neural networks, which quickly adapt to changing circumstances, as a promising solution.

The question was how to provide the huge amount of communication required between each of the neurons. To ensure that only one would be allowed to pass an incoming signal, all elements in a given row and column had to be tied together. That requires a connectivity that scales with the number of channels that can be accommodated, and is therefore impractical to implement electrically.

The British team developed a simple, diffractive-optics-based solution of free-space interconnects to solve the problem. The neural-network packet scheduler they developed first receives requests for a particular destination based on the headers for the packets at the front of each queue. These are sent to a 2-D neural array, where each element represents the crosspoint that would be required to make that routing work. Then, a winner-take-all neural function is implemented: each neuron that is being sent a request then broadcasts a beam from a vertical-cavity surface-emitting laser (VCSEL) to all the others in its row and column. The more light that falls on a neuron, the less able it is to fire itself. Eventually, only nonblocking routes survive. With this system, researchers successfully obtained the optimal routing in almost every case.

The latest effort — driven by PhD student Keith Symington — involves implementing the scheduler using integrated structures, and optimizing the time constant of the neurons used to improve speed. According to Snowdon, "Our next-generation scheduler supports packet prioritization, making it attractive in real-world applications such as an ATM switch controller. It will also be fabricated in smart-pixel rather than discrete technology, leading to a remarkably small footprint and a considerable performance increase." But producing a truly commercial version of the scheduler won't be easy, Snowdon admits. "The main disadvantages of the system are in the immaturity of current optoelectronic components," he said. "For example, the current wall-plug efficiencies of VCSELs are low and therefore the power that is not converted into the optical domain is dissipated as heat. However, these technologies are constantly becoming more efficient and available."

But there is another problem to overcome, said Snowdon, though it's not insurmountable. "The major technical problems associated with any free-space optoelectronic interconnection are those of alignment. However, components such as the VAP [Variable Angle Prism] and quadrant detectors are already successfully deployed in commercial systems such as video cameras, vision systems and

CD players. The incorporation of these components into computer interconnect forms, in our opinion, is the major next-generation design challenge."

If the group is successful in developing the scheduler into a small, cheap product, Snowden said the market should be there for them. "This system solves a problem currently performed by other means in every Internet packet-routing switch. The potential overall increase in throughput that this scheduler could provide may alleviate problems with what has become known as the World Wide Wait."