Upstream: Optical Interconnects

Technology Review, December 2001

By Erika Jonietz

Optical interconnects: replacing wires between chips with streams of photons could speed things up mightily.

Networks of optical fibers speed massive amounts of data around the world, enabling the Internet and changing the very nature of communications. Now engineers and physicists are seeking ways to adapt optical systems to move data from point to point inside computers. If these so-called optical interconnects are successfully developed, they could allow computers to share more information among their components more quickly; without them, the continuous increases in computing speed and power that we now take for granted could abruptly level off.

Data in computers currently move across chips and from chip to chip electronically, through tiny metal wires. But as computers get faster and faster, manipulating ever more data, these wires are just not up to the task: it's a bit like connecting to the Internet over the phone instead of a broadband link. Moving data to a computer's central processor from its memory, for example, is already a notorious bottleneck; the wires simply can't ship data from memory fast enough to keep the processor busy. And the problem is only going to get worse.

Making the metal interconnects from copper instead of aluminum—technology pioneered by IBM—and tweaking designs will help. But within five years, experts say, they may not be able to push electronic signaling any further.

Systems that replace wires with optics will ultimately move data faster, use less power and transport data more accurately at high speeds. Computer designers are already taking the first steps to make such systems. Agilent Labs and University of Southern California electrical engineer Anthony F. J. Levi have jointly adapted fiber-optic technology to link high-performance computers like servers into networks. The technology, which Agilent commercialized last year, is used to connect the machines over distances of about two to 500 meters. The optics maximize the usage of available computing power by making data transfer within the network more than 50 times faster than is possible using copper cables.

To push optical connections down to the chip level, engineers must develop ways to generate and receive light signals on semiconducting devices. The crucial breakthrough for Agilent's network links was adapting tiny semiconductor light-wave devices called vertical-cavity surface-emitting lasers. Waguih Ishak, director of Agilent's Communications and Optics Research Laboratory, believes these lasers can be adapted for use inside computers as well.

But engineers face a further challenge. Unlike electricity, light is hard to steer through very small spaces: conventional optical fibers wildly scatter light if subjected to tiny twists and turns. Therefore, to transmit the signals generated by the lasers, the researchers need new ways to direct light through the tight confines of a circuit board.

Strategies vary. Stanford University electrical engineer David Miller plans to simply guide the photons through tiny air gaps using mirrors *(see illustration)*. MIT materials scientist Lionel Kimerling has created waveguides only 200 nanometers thick—less than one-hundredth the width of a human hair—from silicon fibers insulated with silicon dioxide. Agilent and IBM, among others, are looking to make waveguides from materials called photonic crystals *(see "Microphotonics,"* TR *January/February 2001)*; the materials act as miniaturized optical fibers. With photonic crystals, "You can manipulate both the optical and electronics on the same scale," says Gian-Luca Bona, head of the Photonic Networks Group at IBM's Zurich Research Laboratory.

Within five to 10 years, researchers say, optical interconnects will begin appearing in high-end computers; eventually, optics will make their way into home computers. Such computers will be fast enough to handle the flood of information coming through the fiber-optic cables that will one day stretch into homes. And with chips ready to accept optical data, the link between computers and data pipes will be fairly simple.

"There's not a breakthrough needed to do this," says Miller. "But we have a lot of research to do." Still, Levi is already planning for the day when this all-optical vision becomes reality: "When fiber-to-the-home happens, you will want fiber-to-the-processor-based systems in your home—to look at real-time holograms of the grandkids."

Erika Jonietz is an associate editor at *Technology Review*.