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control scheme, these network controllers could perform more intelligently. Still, it may be years before a utility takes the plunge and fully commits to Rehtanz's algorithms. It's not just that utilities are conservative about tinkering with untried technologies; cash for transmission upgrades is thin in today's deregulated markets, where it's unclear which market players—power producers, transmission operators, or government regulators—should pay for reliability. What is clear, however, is that the evolution toward real-time, wide-area sensing and control has begun.

PETER FAIRLEY

JOHN ROGERS

Microfluidic Optical Fibers

The blazing-fast Internet access of the future—imagine downloading movies in seconds—might just depend on a little plumbing in the network. Tiny droplets of fluid inside fiber-optic channels could improve the flow of data-carrying photons, speeding transmission and improving reliability. Realizing this radical idea is the goal of University of Illinois physicist **John Rogers**, whose prototype devices, called microfluidic optical fibers, may be the key to superfast delivery of everything from e-mail to Web-based computer programs, once "bandwidth" again becomes the mantra.

Rogers began exploring fluid-filled fibers more than two years ago as a researcher at Lucent Technologies' Bell Labs. While the optical fibers that carry today's phone and data transmissions consist of glass tubing that is flexible but solid, Rogers employs fibers bored through with microscopic channels, ranging from one to 300 micrometers in diameter, depending on their use. While Rogers didn't invent the fibers, he and his team showed that pumping tiny amounts of various fluids into them—and then controlling the expansion, contraction, and movement of these liquid "plugs"—causes the optical properties of the fibers to change. Structures such as tiny heating coils printed directly on the fiber precisely control the size, shape, and position of the plugs. Modifying the plugs' properties enables them to perform critical functions, such as correcting error-causing distortions and directing data flows more efficiently, thus boosting bandwidth far more cheaply than is possible today.

Today, these tune-up jobs are partly done by gadgets that convert light signals into electrons and then back into photons. This "removal of light" invariably causes distortions and losses. Rogers's idea is to do these jobs more directly by replacing today's gadgets with sections of fluid-filled optical fibers strategically placed in the existing network. Making sections of the fiber itself tunable could eliminate some of these "light-removing" components, Rogers says. "Anytime you can avoid the need to remove light, there is a big cost advantage, reliability advantage, and increase in capacity."

Other approaches to making fibers that actively tune light—as opposed to serving as passive pipes—are also under development. But with the telecom sector still in crash mode, leaving thousands of kilometers of underground fiber-optic cables unused, nobody expects a rapid embrace of new optical communications technologies. "These kinds of things are needed when you get to the next-generation optical networks," notes Dan Nolan, a physicist at Corning, a leading maker of optical fiber. "Right now you don't really need them, because the next generation has been put off."

Few, though, question that a push to a much faster Internet will eventually return. And when it does, Nolan says, devices like Rogers's could come into play. "I consider it very important research," Nolan adds. Though the timing for commercialization is uncertain, the fibers have already moved beyond lab demonstrations; prototype devices are being tested at both Lucent and its spinoff company OFS, a Norcross, GA-based optical-fiber manufacturer.

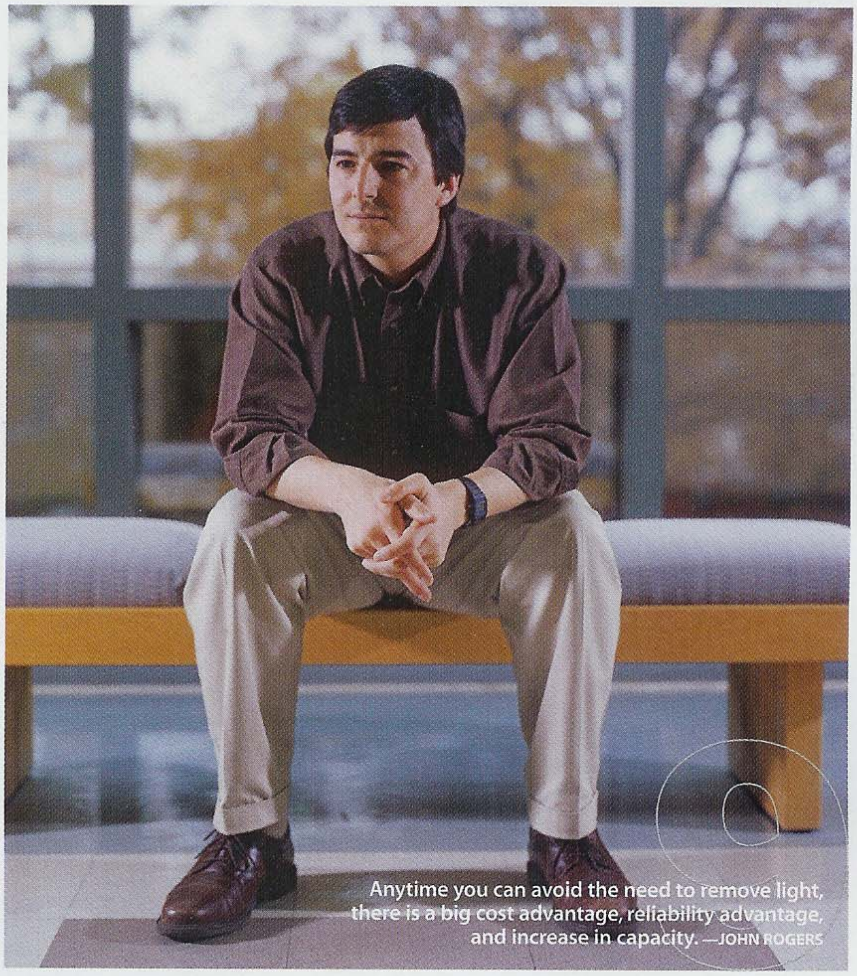
OTHER LEADERS
in Advanced Optical Fibers

YOEL FINK
MIT
(Cambridge, MA)
Tunable polymer fibers

TIMOFEI KROUPENKINE
Lucent Technologies' Bell Labs
(Murray Hill, NJ)
Liquid-crystal-based optical tuning

STERLING MCBRIDE
DENNIS PRATHER
Sarnoff
(Princeton, NJ);
University of Delaware
(Newark, DE)
Tunable lenses employing microfluidics

DAN NOLAN
Corning Research
(Corning, NY)
Optical pulses to tune signals inside fibers



Anytime you can avoid the need to remove light, there is a big cost advantage, reliability advantage, and increase in capacity. —JOHN ROGERS

CHRIS LAKE

Still, the idea of adding a plumbing system to optical networks is jarring to some researchers. "Success will ultimately depend on how well you can put in the solution without disrupting the ends of the fiber," says Axel Scherer, a physicist at Caltech. "The question is, how do you do that in an easy and inexpensive way." MIT physicist John Joannopoulos holds similar reservations. But if the fluidics system works, Joannopoulos says, "it gives you extra control. Once you have that, then you can make devices out of these fibers, not just use them to transport something."

The marriage of optics and tiny flows of fluid also holds promise for other applications. One possibility Rogers is investigating: a tool that could use light to detect substances like disease-indicating proteins in blood, useful for medical diagnosis or drug discovery. Even if it doesn't speed your downloads, Rogers's plumbing might still improve doctors' checkups. **DAVID TALBOT**

OTHER LEADERS
in Personal Genome Analysis

RICHARD BEGLEY
454 Life Sciences (Branford, CT)
Simple, high-speed, cheap DNA sequencing using microfluidic technology

DANIEL BRANTON
Harvard University (Cambridge, MA)
Fast, accurate DNA sequencing using nanopores

EUGENE CHAN
U.S. Genomics (Woburn, MA)
Low-cost, fast optical DNA sequencing

GEORGE CHURCH
Harvard University (Cambridge, MA)
DNA sequencing using polymerase-colony technology

DAVID COX

Personal Genomics

Three billion. That's the approximate number of DNA "letters" in each person's genome. The Human Genome Project managed a complete, letter-by-letter sequence of a model human—a boon for research. But examining the specific genetic material of each patient in a doctor's office by wading through those three billion letters just isn't practical. So to achieve the dream of personalized medicine—a future in which a simple blood test will determine the best course of treatment based on a patient's genes—many scientists are taking a shortcut: focusing on only the differences between people's genomes.

David Cox, chief scientific officer of Perlegen Sciences in Mountain View, CA, is turning that strategy into a practical tool that will enable doctors and drug researchers to quickly determine whether a patient's genetic makeup results in greater vulnerability to a particular disease, or makes him or her a suitable candidate for a specific drug. Such tests could eventually revolutionize the treatment of cancer, Alzheimer's, asthma—almost any disease imaginable. And Cox, working with some of the world's leading pharmaceutical companies, has gotten an aggressive head start in making it happen.

Genetic tests can already tell who carries genes for certain rare diseases like Huntington's, and who will experience the toxic side effects of a few particular drugs, but each of these tests examines only one or two genes. Most common diseases and drug reactions, however, involve several widely scattered genes, so researchers want to find ways to analyze an individual's whole genome. Since most genetic differences between individuals are attributable to single-letter variations called single-nucleotide polymorphisms, or SNPs, Cox believes that identifying genomewide patterns of these variants that correspond to particular diagnoses or drug responses is the quickest, most cost-effective way to make patients' genetic information useful. "I would like to know whether genetics is going to be practical while I'm still alive," says Cox.

To help answer that question, in 2000 Cox left his position as codirector of the Stanford University Genome Center to cofound Perlegen, which has moved vigorously to bring SNP analysis to the clinic. The company has developed special DNA wafers—small pieces of glass to which billions of very short DNA chains are attached—that can be used to quickly and cheaply profile the millions of single-letter variants in a patient's genome. Perlegen researchers first created a detailed map of 1.7 million of the most common SNPs. Based on this map, they then designed a wafer that can detect which version of each one of these variants a specific patient has.

Now, in partnership with major pharmaceutical makers, the company is comparing genetic patterns found in hundreds of people with, for example, diabetes to those of people without it. With Pfizer, Perlegen is examining genetic contributions to heart disease; for Eli Lilly, Bristol-Myers Squibb, and GlaxoSmithKline, Perlegen researchers are hunting for SNP patterns that correlate to particularly adverse or favorable reactions to different drugs. The next step is to use this information to design a simple test that discerns telltale SNP patterns. With such a test, doctors could screen patients to identify the best drug regimen for each.

Some biologists argue that a truly accurate picture of an individual's genetics requires decoding his or her entire genome, down to every last DNA letter; but for now that is a daunting technical challenge that remains prohibitively expensive. Cox counters that SNP analysis is the quickest way to practically bring genetics and medicine together, and many geneticists share his vision of ultimately analyzing SNPs right in a doctor's office. "I think this will become a routine thing in the future," says George Weinstock, codirector of the Human Genome Sequencing Center at the Baylor College of Medicine in Houston, TX. And, adds Weinstock, "Perlegen is one of the leaders in the field."

Within a few years, genetic screening to predict a patient's drug response may become commonplace. To make that happen, it will take tools like the ones Cox and his coworkers at Perlegen are already beginning to employ. **CORIE LOK**

DEBRA MCCLINTON