AT&T INNOVATION BRIEFS

Innovation Briefs are summaries of recent discoveries and developments within Bell Labs. AT&T readers who would like to contribute future innovations are encouraged to contact the Technical Journal editor.

Lightwave Transmission at 80 Billion Bits Per Second

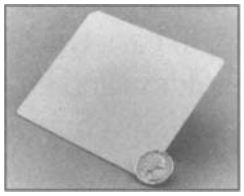
Recently introduced commercial lightwave systems transmit data at a rate of 2.5 billion bits per second. As part of a study on upgradable network designs, a Bell Labs research experiment has achieved an aggregate transmission rate of 80 billion bits per second. Eight channels at different wavelengths, each operating at 10 billion bits per second, were transmitted through 280 kilometers (km) of fiber. Optical amplifiers were placed at intervals of 56 km, with the channels separated in wavelength by 1 nanometer. Operation at such high speeds requires replacing the conventional optical fiber with dispersion-shifted fiber, which prevents excessive spreading of the optical pulses. However, optical non-linearities in dispersion-shifted fibers would ordinarily prohibit operation of such a multi-channel system. But special arrangement of the transmission fiber, using both conventional and dispersion-shifted fibers, resulted in error-free operation. Computer models predict that such systems may be extended for distances up to 1,000 km.

Software Implemented Fault Tolerance

Fault tolerance is a highly desired, but often very costly, objective. Extremely high reliability is, nonetheless, achievable, and has been built into the hardware of critical systems. Key elements of AT&T's worldwide telecommunications network are designed with a goal of less than one minute of down time per year. In hundreds of other network elements, however, the cost of this hardware protection has not been justified. To address this need, Bell Labs researchers have recently created new fault detection algorithms and recovery techniques, based on software, that offer high levels of fault tolerance at far lower cost. Running on standard open-system computers, the software — *watchd, libft,* and *nDFS* — monitors various systems, detecting and recovering from faults that are not handled by the network's underlying hardware or operating system. The techniques, for which two patents are pending, have already been used to enhance fault tolerance in some of AT&T's newer telecommunications products and services.

Teaching New Tricks to Old Ceramics

When Bell Labs scientists created a new ceramic ($Ba_2Ti_9O_{20}$), about 25 years ago, they could not possibly have envisioned all of its future uses. Initially, the ceramic's unique physical and electrical properties — it can function as an active element of electronic devices, as well as serve as an insulator — were used in oscillators and filters, discrete components of microwave radio systems. Today, portable wireless communication instruments are becoming ever smaller and more cost-competitive; manufacturers are pushing hard to develop space-saving circuitry. Re-enter an adaptation of the 25-year-old ceramic: a new generation of Bell Labs scientists is using it to develop radio frequency modules in the gigahertz range. The modules' insulating substrates would double as an active element of each module's circuits, with the ceramic's high dielectric constant and low microwave loss enhancing the circuits' power and frequency efficiency. The tricky, although not insurmountable, part of the development work is to assure that the ceramic's characteristics — it's surface finish, thickness, and dielectric properties — will remain consistent in mass production.



Sheets of ceramic, thinner than a quarter, may be used in future wireless telephone systems.

Fastest Telecommunications Lasers Invented

Bell Labs scientists have made the world's fastest telecommunications lasers, which may have applications in future data communications systems. One type of laser — emitting light at a single wavelength, or color, of light — turns on and off 22.5 billion times a second; another — emitting light over several wavelengths — operates at 25 billion cycles a second. The experimental lasers, which can be used to transmit information in the form of light pulses through optical fiber, are made of thin layers of semiconductor materials. Using the "quantum well" structure that was first patented by Bell Labs researchers in 1976, the laser's superior performance is achieved by the unusual behavior of electrons confined to extremely thin semiconductor layers, about 10 atomic layers thick (some 25,000 times thinner than the human hair). Lasers built on this principle might be used someday in high-capacity local distribution of telecommunications and in ultra-high-capacity local area networks of computers. Such networks would distribute data and video images inside a building, for example, or among buildings in an office complex, campus or city.