Manufacturers Promote Fiberoptics in the Local Telecommunications Network

by Holly Bigelow, Managing Editor

"Subscriber loop," "subscriber-feeder network," and "local loop" are some of the many catchwords used to describe the next big market in the fiberoptic industry: the local telecommunications network. Kessler Marketing Intelligence, Newport RI, predicts that the subscriber loop will account for 42 percent of all telephony optical fiber installations this year. Suppliers are coming out with a spate of products to anticipate the demand.

In 1987 fiberoptic long-haul and inter-exchange trunks will be completed between existing digital central offices (COs), according to Scott Esty, senior market analyst at Corning Glass Works, Corning NY. By 1988, existing copper feeder cables will be replaced with fiber, and by 1995, fiber will routinely replace copper in the last mile to the home.

The long-term outlook for optical fiber use in local loops is assured, but what's still unknown is what equipment vendors will need to supply and when the completely fibered network will become a reality, according to a recent report from International Resource Development, Norwalk CT. The unpredictability stems primarily from the AT&T divestiture and the attendant lack of central authority over the bulk of the U.S. telephone network, the report says. In spite of the unsettled market, however, manufacturers are pushing ahead to supply fiberoptic products for local-loop service providers.

Defining the Loop

Defining the subscriber loop, and therefore the products designed for the market, is a problem (see Figure 1). Most telephony fiberoptic installations have occurred in long-haul trunk applications. Fiber is rapidly moving into the shorter-distance *inter-exchange routes* (CO to CO) operated by the local exchange carriers. The *feeder* portion of the network connects the CO directly to large business customers or to remote serving-area interfaces. From there, *distribution* lines travel along neighborhood streets, where they are connected by *drops* to the individual homes. "Technically the *subscriber loop* is everything on the subscriber side of the central office," said Esty. The term *local-loop* is often used to encompass both the short interexchange routes and the feeder network.

The evolution toward fiber is occurring separately in the local loop and the distribution network, according to Esty. Fiber is already being used extensively in the feeder portion of the loop, as the per-channel cost of fiber continues to decrease. Currently, Esty said that any new installation more than 8,000 feet from the CO requiring transmission capacity of 150 or more voice-frequency circuits will routinely be done with fiber. Below that point, in the distribution cables and individual drops to the homes, fiber is not yet practical, though it is being laid for some distribution networks on a trial basis only.

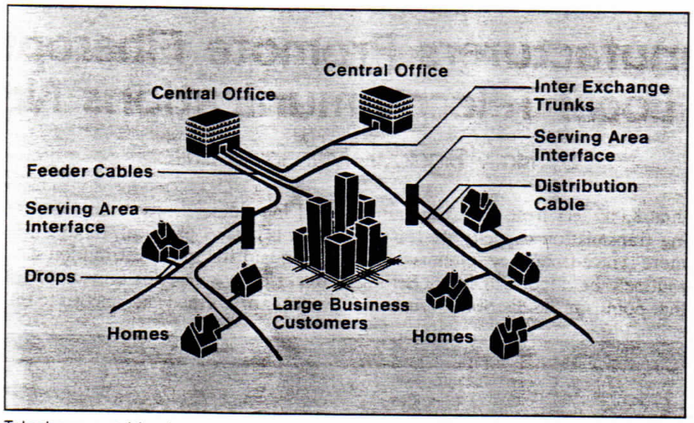
Fiber offers many advantages to the metropolitan planner who can't predict the next growth surge, and who wants to remain flexible in order to meet future traffic demands. Once fiber is installed in the loop, the physical carrier will not need replacement. With just a change of electronics, a 140-Mbit/s system can grow to 560 Mbit/s or beyond as traffic increases. The loop won't be totally "fiberized" until the economics justify it or the users demand the higher bandwidth for new services such as video on demand. Some network planners are starting to evaluate fiber vs. copper strictly based on plain old telephone service (POTS), according to Judith Page of AT&T Bell Laboratories. AT&T Bell Laboratories.

For the longer spans of the feeder network, fiber is cheaper than copper cable because it can be run for 40 kilometers or more without repeaters. This reduces construction costs and lowers maintenance costs by eliminating vulnerable outside plant repeaters.

Local-Loop Products

Many issues remain to be settled before a universal on-premises optical switch, with the premises equipment that can make use of fiber's bandwidth, becomes reality. A universal network architecture, either single-mode or multimode fiber, and lasers or light-emitting diodes (LEDs) must be selected as well. The customer-premises optical interface of the future may require wave-division multiplexing units, coherent detection receivers, single-wavelength lasers, optoelectronic integrated circuits, and other advanced developments.

Fiberoptic products for the feeder network, however, have been on the market for some time, and more products are being introduced continuously. "The feeder market is a significant opportunity because it is happening now and is filling the gap as the inter-exchange trunk growth in the long-haul market levels out," Esty said.



Telephone outside plant networks, showing a breakdown of the subscriber portion of the network into feeder, distribution and drops. Source: Corning Glass Works.

With the new market comes a requirement for different specifications. Components for the feeder must be "hardened" to be able to withstand the rigors of the outside environment of a service-area interface: temperature ranges from −40°C to 85°C and relative humidities of up to 100 percent. In contrast, equipment residing in the air-conditioned indoor environment of a CO is designed for temperatures from about 0°C to 50°C at 20 to 80-percent relative humidity. Further penetration of fiber into the local loop will also require simplification and cost cutting, according to Esty. End users will need large quantities of components designed to be handled by craftspeople with very little previous fiberoptic experience.

Transmission Systems

In feeder distribution, the transmission of bulk traffic from a CO to a remote location carries high-density traffic that is broken down into individual circuits only within a few thousand feet of its destination. One version of AT&T's SLC 96 digital subscriber loop carrier, a standard in telephony applications, now comes in a configuration that works with fiber-optic cable. "The SLC 96 is really a feasibility feature for phone companies," according to Sue Fleming of AT&T Network Systems, Morristown NJ. "If you suddenly have an influx of offices or homes in a new subdivision, the SLC 96 provides a fast way of extending the intelligence of the CO closer to the user."

Rockwell International's Collins Transmission Systems Division, Dallas TX, just announced a similar digital loop carrier system, the LMS-3192, designed for digital muldem-lightwave systems. The system's high density (768 voice circuits plus up to 52 DS1 lines) makes it appropriate for carrier service area (CSA) applications, where lightwave feeder cable is routed to the remote cabinet for distribution to clustered high-growth areas.

Fujitsu America has also introduced an optical fiber transmission system, called the OMT 45, that is designed for use in local-loop distribution applications. The new terminal reportedly provides voice, data and video over both singlemode and multimode fiber cable. The unit's transmit card can be provided with a singlemode laser, multimode laser or multimode LED, and can span distribution loop lengths of up to 45 kilometers without regenerators.

Licom Inc., Herndon VA, recently announced the development of a fully integrated synchronous transmission system for use in fiberoptic local distribution and inter-office segments. The IMX30 was designed in accordance with the newly released standard for a Syntran DS3 signal format. This standard is designed to facilitate implementation of sync transmission within existing async networks, and

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will adapt to future network standards such as ISDN (integrated services digital network), according to Licom.

Syntran, which is not limited to fiberoptics, is an approach to multiplexing DS1 to DS3 transmissions on the electrical network. Synchronous networks using the Syntran format "offer a fundamental change in orientation from a wire-pair based network to a timeslot based network," said Lynn Chapman, Licom's vice president of engineering. This format allows improved response times and more flexibility to rearrange the network when service changes are required.

Another standard being developed for synchronous optical networks, called Sonet attempts to provide a family of accepted optical signal standards centered around a basic rate of 49.92 megabits per second. Higher-level signals are obtained by multiplexing these base rate signals, making for a modular system that can potentially reduce costs and increase efficiency. "Sonet is intended to be a complete standard for fiberoptic systems that takes advantage of the upcoming optical network," said Bengt Lagerstedt of Ericsson Network Systems, Richardson TX. "It will provide a way to use different vendors' equipment at the optical level."

Originally the Syntran standard was designed to cover transmission rates up to the DS3 level (45 megabits per second, 672 voice circuits), and Sonet would cover anything above DS3, Lagerstedt said. Syntran products will probably be replaced by Sonet as soon as that standard becomes accepted in new installations, he added. Sonet is being designed for local-loop systems, but will eventually be used for long-haul links as well. Both Syntran and Sonet are being developed by T1 standards committees made up of representatives from Bellcore, suppliers, inter-exchange carriers, and the Bell operating copies. Sonet standards have not been fully documented yet, and therefore no products have been introduced, said Lagerstedt. Licom's IMX30 is the first Syntran product.

Lasers or LEDs?

The question of whether lasers or light-emitting diodes will become the standard for the shorter-distance links of the local loop and subscriber loop remains unanswered. Whichever is selected, the widespread deployment of fiberoptics in the subscriber network will depend on a dramatic cost reduction and a package design that is reliable and easy to use.

Some researchers have touted LEDs as the answer. GTE Laboratories, Waltham MA, is working on a low-operating current edge-emitting light-emitting diode (LOC-LED) that can couple 5 to 7 microwatts of optical power into a singlemode pigtail at the "substantially reduced" operating current of 20 to 25 milliamps. By operating at such a low current, without temperature or power stabilization, the device is said to achieve the transmission rates and distances expected in subscriber loops, and it is potentially lower in cost and easier to use than diode lasers.

"The device has the inherent advantage that it is much less temperature sensitive, so you can consider operation at wider ambient conditions, −20°C to 75°C, and get acceptable power outputs," said Len Ulbricht, a member of the technical staff at GTE Labs. "It also makes for a simpler, and therefore cheaper package, since there's no cooler required and you don't need the rear-facet detector and optical feedback control circuit that a laser requires." The low operating current also means that the LOC-LED is compatible with monolithic integrated-circuit technology, so standard silicon ICs can be used to power the device, making it more cost effective.

"LOC-LEDs would be ideal for reducing the component count," Ulbricht said. "It's easier to put an LED, rather than a laser, into a simple package so that an engineer unfamiliar with lightwave technology could treat it like a black box and plug it into a board using a standard interface." According to Ulbricht, the Laboratory has received several inquiries about buying the LOC-LED, though it is not yet a commercial product.

Though LEDs have gotten quite a bit of attention, others are not so quick to exclude lasers from the loop. According to Corning's Esty, "About two years ago, we were seeing some work that Bellcore did using LEDs on singlemode fiber for feeder links in unmanned, remote terminal locations. Now they're backing off of that concept, saying that lasers can be produced in less-expensive, more-reliable packages."

Lytel, Inc., Somerville NJ, recently introduced a laser-PINFET module that could be made more inexpensively due to an automated assembly technique that provides only 10 percent coupling of the laser light. Normally 40 to 50 percent coupling is required, but a high-quality laser chip produces more than enough power for the local-loop transmission rates and distances.

Lytel's module takes advantage of the fact that lasers for short-haul transmission do not need to meet the stringent operating specifications required for long-haul uses. At the recent Optical Fiber Communications conference in Reno NV, Bellcore scientist M.M. Choy presented results of a study aimed at improving laser yield by tailoring the selection criteria to short-distance loop requirements. A random sample of buried heterostructure lasers that did not meet long-haul transmission specifications showed more than half of them met the requirements for short-haul transmission.

Another effort at improving laser diode packaging is Mitsubishi Electronics America's new receptacle module concept, model FU-11SLD-N. "We're trying to promote a solution that has basically two parts," said Jamie Dreyfuss, Mitsubishi's product marketing manager. "First is the type of package itself—fiberless, connectorized, with different types of connectors, and requiring no thermoelectric cooler. Second is the coupling technique which uses a Selfoc lens." Dreyfuss explained that this coupling technique provides stability over a wide temperature range as well as minimal noise. It also has low spontaneous emission coupling, but yet it provides high-efficiency coupling when the device is lasing. "The purchaser doesn't have to connectorize a pigtail, which minimizes handling, and the smaller device is panel-mounted, which is more accessible to the user, who can plug a fiber right into it," he said.

By omitting the thermoelectric cooler from the laser diode package, the power consumption is lowered and the unit is reportedly made more cost-effective and reliable, since the coolers themselves are less reliable than lasers, regardless of operating temperature. "At any temperature, the laser will last longer than the cooler, and once the cooler goes, the whole package goes," Dreyfuss said. Coolers are normally used to improve the operating characteristics and lifetimes of diode lasers.

The new package is designed for both interoffice and feeder environments, according to Dreyfuss. The unit's preliminary data sheet lists a −20°C to 60°C operating range, but Dreyfuss said that more recent data shows the laser module works at −40°C to 70°C. "We're pushing the temperature range of the packages further," he said.

A cheaper, short wavelength (780 nm) multimode version, models FU-05LD-N and FU-06LD-N, was designed for possible use in the distribution network. This device uses a mass-produced laser that is similar to those made for CD players, with minor improvements in noise and reliability. "By producing low-cost, mass-produced lasers, we are promoting the local-loop cause," said Dreyfuss. The multimode lasers cost about an order of magnitude less than most singlemode lasers currently on the market.

Mitsubishi is not the only device manufacturer aiming for the subscriber-loop market. According to Jim Lewis of Lasertron in Burlington MA, the extreme temperatures in subscriber-loop applications exclude germanium avalanche photodiodes (APDs), which don't perform well under those conditions. Instead, a PIN diode-based receiver is necessary. For the subscriber loop, transmission distances are shorter than for long-haul trunking, usually less than 10 km, though components developed for the loop must be adaptable to a range of distances from 35 km down to 5 km. With a typical PINFET receiver, an attenuator would be necessary to prevent amplifier saturation for shorter systems.

In response to this problem, Lasertron developed the QDFM series of receivers using a GaAs integrated circuit design that allows a wider dynamic range (about 50 dB at 50 megabits per second) than the standard hybrid PINFET. Systems employing these PINFETS will be able to serve in a broad range of applications without customization of source power during manufacture or customization of the optical link using attenuators during system installation.

Lasertron is working toward the modular approach. For example, the company's new 1300-nm local-loop laser, the QLM1300SM-851, comes with standard monitor photocurrent and modulation current so that they are interchangeable and compatible with fixed circuitry. "Normally, the installer would adjust all the operating points of the circuit to fit the individual laser—around four or five parameters," said Lewis. "We took those and designed the laser to require only one adjustment, so there's less tweaking of the system." The lasers also have a built-in tolerance to the higher optical reflections caused by inexpensive local-loop connectors and the presence of receivers at close range.

Singlemode/Multimode

"Singlemode fiber answers all the needs of the feeder network perfectly," said Corning's Esty, "but we want to present the concept that multimode has certain characteristics that may make it the fiber of choice for the distribution network." Esty compares the feeder network to a data communications application, since it is more link-intensive than length-intensive. Multimode fiber is easier to splice and connectorize; since its larger core requires less-accurate alignment. According to Esty, multimode fiber can have greater than 2 GHz•km bandwidth (gigabit capacity), which is acceptable for current services. Finally, multimode systems are still cheaper than today's singlemode systems.

Corning, along with network planners, is exploring the possiblity of developing a new type of multimode fiber, called "overmode," that will "better meet the needs of the distribution network." Esty said that the new fiber would have a core diameter of 20 to 35 micrometers, compared to the 8 or 10 μm of singlemode fiber, making it easier to work with.

Many are convinced, however, that singlemode is the way to go because of its unlimited bandwidth potential, compatibility with optoelectronic integrated circuits, and cost. "Lots of people want to use singlemode fiber now, because it's cheaper and currently in mass production," Mitsubishi's Dreyfuss said.

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One scenario is install singlemode fiber now, and use cheaper, short-wavelength sources until the need for higher bandwidth arises and longer-wavelength, more expensive devices could take over. At OFC, a group of Bellcore scientists presented results that show the possibility of using 780-nm devices on 1300-nm fiber. For singlemode fiber, the core is so small that light propagates down the fiber in only one mode. For example, a 9-μm core fiber is small enough to propagate a single mode of 1300-nm light, but this same fiber is too large to propagate only one mode of 780-nm light. This can be mitigated by using a short length of 5-μm core fiber to filter out the higher modes at the receiver end. However, with singlemode fiber, aligning connectors remains a problem.

Splicing & Cabling

As with other changes in the local-loop arena, large volumes of products designed for break-out, splicing, and testing feeder and distribution cables will be required. These products will differ from those used for long-haul fiber trunking. Cables must be designed so that relatively untrained craftspeople can cut into them without disturbing working fibers, locate the proper fiber, and taper, or terminate fibers as the cable moves out from the CO. Manufacturers are making cables with color-coded fibers, for easy identification, and splice and connectorizing arrangements that allow easy cable entry. In the future, mass splicing arrangements may be developed to make it easier to work with large-count fiber cables.

Fiberization of the loop will open up a large market for suppliers of line test equipment. "Every van in every telephone company will have to have fiberoptic test equipment," said Mike Schneider, market analyst for Wilcom Products Inc., Nashua NH. Twenty years ago, Wilcom introduced the T136, a hand-held loss test set for testing noise and loss on copper cable in the subscriber loop. "A field worker would climb a telephone pole to test from each house back to the central office to make sure the line was OK," Schneider said. Now the company has introduced the equivalent in an optical loss test set, the T324B. Another product recently introduced clamps on to the buffered fiber to identify it. "The fiber identifier has equivalent application to the copper world where you had to identify tracer tones from the CO. Otherwise, there's always going to be that doubt whether you've found the right fiber," he said.

When utilization of fiber in the subscriber loop happens, it will drive quantities and capabilities up, and prices will come down," Wilcom's Bart Rohles said. "It's a big market—a lot bigger than long-haul."

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