LOCAL LOOPS WITH FIBER OPTICS

By DIETRICK E. THOMSEN

Fiber optics is quite a success in the long-distance transmission of information. Indeed, light waves in glass fiber cables are now bidding to replace electrical impulses in copper wire cables in the longest telephonic transmissions of them all, submarine cables. At the same time as it is poised to dive under the oceans, this new technology is also on the point of trying to find a place in the shortest-range telecommunications circuits — what engineers call local subscriber networks, the connections to subscribers' premises and equipment. To be a success in this part of telecommunications technology, fiber optics must be capable of performing the functions now performed by electronics and at the same time be cost-effective.

An important aspect of local networks is switching. Connecting a given user's telephone to someone else's usually requires several switching moves to line up the route between the two telephones. Most of this switching is done in the local networks at both ends; very little of it is done in the long-distance or interoffice trunk lines.

Optical fibers have been successful so far in long-distance and interoffice trunks because of their ability to carry large amounts of information cheaply and efficiently. Their application in local networks would open the way to providing many services not now connected to the average telephone, but this would require optical switches that can do the same interconnecting work as present-day electronic ones. It would be impractical to use optical fibers for the short-distance connecting lines if connections had to be made electronically. That would require changing the signal from light to electricity every time a switch was encountered and then changing it back again on the other side of the connection.

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At the recent Conference on Optical Fiber Communication '85 (OFC '85) held in San Diego, Stuart D. Personick of Bell Communications Research, Inc., in Holmdel, N.J., discussed the current and future state of the development of optical switches and their probable effect on the design of local networks. One type of switch is electro-optic: A light waveguide of lithium niobate changes its transparency in response to changes in the electric field across it, alternately transmitting and blocking the light. Another possibility is a mechanical switch, in which a fiber is moved back and forth to make or break a connection.

The final possibility is an all-optical switch. This would be made, Personick says, by putting two mirrors back to back at the ends of a cavity, the length of which resonates with the light wavelength used. Contrary to what one might think, he says, this does not make a double mirror but actually a transparent window. If a material that changes its transparency in response to a second beam of light shining upon it is put into the space between the mirrors, the arrangement will switch between a window and a mirror according to whether the second light beam is on or off.

The mechanical and electro-optical options exist now — in fact the electro-optical one was used for the first time to modulate a beam of laser light in an experiment reported at OFC '85 (SN: 3/2/85, p. 134). The all-optical switch, according to Personick, is some years down the road.

What developers are trying to do, Personick says, is find optical analogs to the transistor. If that comes to pass, such switches might be useful in circuitry of other kinds, logic circuitry perhaps, as well as telecommunications. In fact Personick compares the introduction of optical switches to the introduction of transistors. At first, he says, people used transistors as substitutes for vacuum tubes. Only gradually did they learn to use the unique properties of the transistor to redesign circuitry.

Personick expects that in the long run optical systems will bring about a radical redesign of local network circuitry. At present local networks are laid out according to two basic configurations: loops and stars. In the loop configuration all the stations are linked in sequence, like a string of bulbs wired in series, with each other and with the nodal point that connects one network to another. In a star configuration each station has its own connection to the nodal point. In practice, combinations may be used and various redundancies may be wired in.

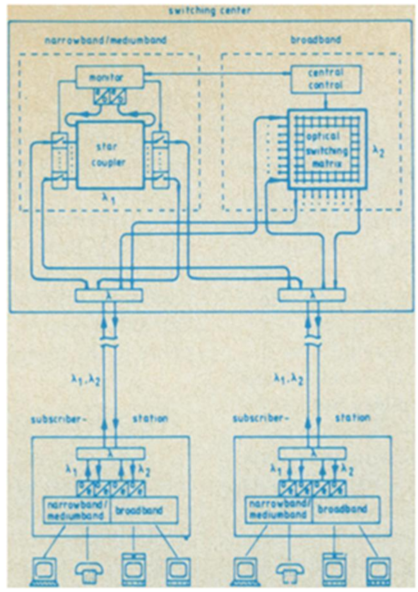
With electronic circuitry, loop connections have the disadvantage that all the stations together must share the carrying capacity of the one wire that links them. Bandwidth — total information-carrying capacity—is low for copper wires, and the cost of increases is high, say Personick and Steffan Fredricsson of Lightcom in Hayward, Calif. Fiber optics yields very high carrying capacity. "You have bandwidth to burn," Fredricsson says.

This leads Personick to suggest that in

the future the basic net may consist of a loop with information constantly going around and around. Each station would add or subtract information as necessary. It would be done in the mode known as time division multiplexing. For example, a message for station A might be encoded in every fourth bit that passes by in a stream that could consist of several billion bits per second. The connection for station A would then take out every fourth bit and send it to the receiver.

If a message has to be sent from one such net to another, the electronics equipment used today will take the message off the one network, hold it in a memory until an opening appears in the second net, and then feed it in. With optical technology the memory would be unnecessary; there would be enough bandwidth that the system wouldn't have to wait.

For the short term Fredricsson foresees systems in which point-to-point links would be used, a form of star pattern. Each link would have a transceiver at one end that interfaces with the user's equipment and the node of the network at the other. Each kind of equipment that the subscriber may have gains access to the system by a different protocol. These transceivers are expensive, and switching technology must be able to handle them all. Fredricsson showed a junction box his company has designed to deal with such circuitry.



Saniter et al/OFC '85

Experimental local loop in Berlin will provide wide- and narrow-band services on two wavelengths in one fiber, but with separate central switching.

Another way to use the wide bandwidth of optical transmission is to bring in a variety of services that subscribers up to now have not been able to get over a single link. In addition to voice telephony and computer terminal connections, these could include videophone, cable television or interactive TV. A pilot system providing services like these is being built in West Berlin. It was described at OFC '85 by J. Saniter of the Heinrich Herz Institute (HHI) for Communications Technology in West Berlin, representing himself and F. Schmidt and W. Werner of the HHI. They expect it to be working by the end of 1986.

This system divides the services into two groups: those needing narrow and medium bandwidth (primarily telephony and some information services) and those needing broad bandwidth (primarily TV). The two classes of service are sent on different wavelengths. However, the transceiver at the subscriber's end puts both wavelengths into the same fiber. At the central station the wavelengths are then divided. Each signal passes through its own switching connection, a star coupler for the narrow bandwidth and, for the wide band, a rectangular matrix of switches, to be made in integrated form by the HHI Department of Integrated Optics. (Integrated optics has a possible future application to logic circuits.) The two outgoing signals will again be combined into a single fiber to go to the receiving station.

"Knowledge gained from this experimental system," the HHI presentation concludes, "should provide a valuable starting point for the future use of optical switching and the application of integrated optical devices. . . ." □