US Utilities Seeing the Light in Fiber Optics
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Utilities tired of having their SCADA systems crash when the phone company makes a boo-boo or when the sun gets in a snit are turning to a new method for transmitting data – light. They're finding that fiber optic communication systems deliver the information they need without interference from power lines, solar activity, or lightning, and without depending on another company's infrastructure.

"Fiber optics for distribution automation will become a trend in the nineties," said Dennis Caranchini, general manager at Arcomm Systems, Lenexa, Kan., a company which manufactures optical fiber. "In the eighties the fiber companies were all focused on putting in the long distance transcontinental phone systems, so they weren't calling on the utilities. But now this application [distribution automation[is growing and engineering people are becoming more comfortable with using it—the costs are coming down and it's beginning to prove in economically."

Of course, Caranchini is not a disinterested observer, and others are more cautious. Rich Sperduto, chairman of the fiber optics committee of the Utilities Telecommunications Council—and supervisor of the Electric Substations Department at Rochester (N.Y.) Gas and Electric—is more restrained in his outlook. His committee surveyed 80 US utilities, and found that fiber optics was more likely to be used to monitor transmission than distribution. "I don't think it's that cost-effective to use for distribution applications," he said. "The cost is too high to go into individual distribution-type circuits. But for high volume applications, on the backbone and main concentration level, I would see fiber optics as the medium of choice."

Nevertheless, a number of utilities are turning to fiber for data communication on the distribution level. And to do so, they often turn to "Mr. Fiberoptics" himself—Bob Landman, president of H&L Instruments in Burlingame, Calif., which makes SCADA transceivers geared toward fiber optic communication.

Landman, not surprisingly, is a fiber cheerleader and a radio naysayer. Relying on radio-based SCADA systems not only means you have to contend with the shrinking radio spectrum, he argues, but also "you have to have a lot of these radios: because they go only a short distance, you have to sprinkle them like sand all over the neighborhood. Instead, we say lay in fiber optic cable along with your power cable. Fiber is non-conducting, has a high bandwidth, and can provide you with spare fibers to expand services or lease to a cable company. The reliability is very high, and you don't have to do propagation studies if you're a hilly city like San Francisco or Cleveland, or worry about where to put ugly antennas."

All right, enough of the smooth sales pitch. But several utilities have been convinced by it. Landman says H&L is currently working out deals in Asia and Australia, but he's only willing to talk about systems installed in the US, the largest of which serves Pacific

Gas & Electric networks in downtown San Francisco. The municipal utilities in Orangeburg, S.C., and Oberlin and Cuyahoga Falls, Ohio, are also using fiber optics in their SCADA systems.

At press time, Landman was planning to unveil a new product at the IEEE/PES T&D show in Dallas in late September. He calls it "Fiber Loop" and says it's the fastest SCADA communication system ever.

But the earlier version of fiber optic communication seems to be fast enough for smaller utilities, or ones that don't want spontaneous reporting or automated load management.

PG&E uses underground network distribution systems in downtown San Francisco and Oakland. When it came time a few years ago to install SCADA systems for these downtown networks, the utility went with fiber.

"Fiber optics seemed to be the best choice," said Vladimir Manlapaz, senior distribution engineer with the San Francisco Division of PG&E. "It's an economic decision—it can be used along with energized lines. Otherwise you have to put in a separate duct line [for copper lines], or with radio, you have to worry about induction or atmospheric disturbances."

Downtown San Francisco is served by ten networks that deliver a total of 400 MW. Each network is made up of four to six feeders, and there are more than 900 transformers in underground vaults. For the $25 million SCADA system that serves these networks, H&L designed the fiber optic equivalent of a telephone cable repeater system. At each RTU location, a repeater—called a fiber optic transceiver—is placed to modulate, de-modulate, and re-clock data so distortion won't accumulate.

The communication system is centered around 10 bi-directional fiber loops. Each RTU is sampled every three to five minutes, depending on the size of the loop it's in. Each vault contains one or two transformers, and each RTU monitors one, two, or three vaults. The master station, which is located in the San Francisco Service Center two and a half miles south of the downtown area, connects to the fiber loops electrically, over leased phone lines. The system operates at from 300 to 19,200 baud.

The transceivers have three EIA-232 serial ports to accommodate up to three RTUs and, because the loop system is double and bi-directional, each transceiver has two sets of optical ports, left and right. Each port has a light-emitting diode transmitter and a photodiode receiver. The two transceivers at each end of the loop are connected to the SCADA master.

When an RTU receives a polling request via a serial port and recognizes its address, it responds as requested. The transceiver modulates the serial signal from the RTU and transmits it through both the left and right ports. The transceivers repeat the signal all around the loop, and the ones at the ends demodulate the response signal and send it out through serial ports to the master station. The master station polls alternately (clockwise and counter-clockwise) and diagnoses if there's a break in the loop.

The information monitored includes: protector status, protector heat sensor; transformer vault temperature; vault water level; three-phase secondary current; and transformer sudden pressure relay. Any abnormal conditions trigger an alarm. Corrective action is done manually, however, so it's more of a data acquisition system than a control system.

"It helps you avoid risks and avoid costs," Manlapaz said. Instead of having a team check every vault every month, each one is checked every few minutes. As for problems that have been forestalled, PG&E has detected quite a few sump pump failures and, most significantly, avoided a protector fire and transformer explosion that would have cost the utility as much as its entire SCADA system.

99% Communication

The city of Cuyahoga Falls, Ohio, also used fiber optic SCADA communication from the outset. "We looked at leased phone lines and FM radio transmission as well," said Bill Shives, an engineering draftsman with the city electric department, "but we went to fiber because of its reliability and because we own it—we're not making monthly payments on leased lines, and we control it." Reliability is especially important in Cuyahoga Falls, a hilly city where thunderstorms are not infrequent. Because of these obstacles, "a lot of the time, our vehicles can't even communicate across town [with radio]," Shives said.

With fiber optics, the city's SCADA master station easily communicates with the eleven substations, each of which has one RTU, Shives said: "We run constantly at 99% communication [the maximum the software can handle], with never any misses." The utility monitors voltage, current and power factor on the feeder breakers, and the demand and kWH consumption for the total system. In addition, the fiber optic lines are used to monitor six generators and to control the main oil circuit breakers at the substations and the S6 switches.

A total of 17,000 meters of six-fiber cable was installed, half the cable is overhead, and the longest run between transceivers is about 3 km. The system was designed in a radial multi-drop bus configuration, which required half the cable that would have been needed for a looped system.

All the substations are polled in about one-third of a second, so the baud rate of 1200 is fast enough. In fact, the time it takes for the computer to put the information on the screen is the slowest part of the system, Shives said. And after almost two years of operation, how has the system performed? According to Shives, "flawlessly."

Cuyahoga Falls demonstrates another benefit of laying fiber optic cable—having fiber available for other uses. The city is using one pair of its fiber lines for data communication between offices, and is eyeing its third pair for possible use in substation relaying.

A Decision Based on Experience

Cuyahoga Falls is so happy with their SCADA system that they recommended fiber optics to Oberlin Municipal Light & Power. Oberlin was to have started operating two new fiber optic communication systems by the end of September: one to serve an H&L SCADA system, and the other to serve a protective relaying scheme for the distribution system. (GEC Measurements, Hawthorne, N.Y., makes the fiber optic-compatible digital current differential relay that Oberlin is using.)

"Fiber optics is a faster, more reliable communication system than the copper telephone wire that would traditionally be used," said Vic Oeftering, technical supervisor at Oberlin.

He bases his opinion on experience. Oberlin started out with a radio-based SCADA system connecting their five substations, and when that proved problematic, switched to leased-lines. But they found that "the phone company charges us for every little thing—and we've even found ourselves explaining to phone company personnel how their own system works," said Oeftering.

With the $10,000 H&L SCADA system that's almost in place, Oberlin ML&P will communicate with and control four substations and a remote generator via fiber optics. The system will connect with each substation in a daisy chain configuration, and will monitor breaker status, breaker load, amperage, transformer temperature, transformer pressure and breaker air and gas pressure.

It's not all perfect, Oeftering notes. Although the fiber itself is not that expensive, the devices you attach to it are; he also worries that the utility lacks technical expertise and experience with fiber optics.

Another municipal utility riding the optical wave is the one in Orangeburg, S.C. The city's Department of Public Utilities had been monitoring eight substations (in addition to gas and water infrastructure) with optical fiber—but found this to be an expensive and unwieldy system with more cable channels than they needed or wanted.

Now Orangeburg DPU wants to include seven more substations in their SCADA system. They've turned to H&L, because the expansion will cost $20,000 instead of the $200,000 they shelled out for the earlier system.

John B. Bagwell, control systems superintendent at Orangeburg DPU, gives a familiar rationale: fiber optic communication is more reliable, and will let them do lots of other things like put in in-house telephone and video, and bring cable TV into the city. The utility monitors each substation approximately every 2.5 seconds, with some being monitored every second. There are up to four substations on each communication line, one RTU per substation, and approximately 100 monitoring points per RTU.

State of the Art

"A lot of utilities are looking at or making investments in areas of overall load management—it's something that's important to them," said Caranchini, of Arcomm. "As they upgrade those kind of facilities, the decision to use fiber optics is a natural."

Landman would agree. His new communication system, Fiber Loop, was developed for large-scale load management. H&L designed the system for Texas Utilities' facilities at the Dallas/Fort Worth Airport but, to Landman's disappointment, TU has postponed the contract for up to a year and a half.

The airport needs reliable power, but with only two electric feeders per transformer, a fault on one feeder could easily result in overloading the other one. Instead of constructing more feeders, TU decided in favor of remote energy management. But the necessary load management decisions would have to be made within a few seconds.

Enter H&L's Fiber Loop—a fiber optic SCADA system that supports spontaneous report by exception. Fiber Loop is designed to interact with RTUs that have older electrical (non-LAN) interfaces, by using a deterministic approach—a token-based ring system.

H&L developed its own LAN protocol to be compatible with existing and future RTUs. At its heart is a new fiber optic transceiver that interacts with up to three RTUs operating at 19,200 baud while simultaneously supporting dual redundant fiber optic ring operations. One ring can accommodate up to 256 transceivers, and thus can support up to 768 RTUs.

To connect the fiber rings with the master station, H&L developed a Fiber Loop gateway with a UCA-compatible technology called Transmission Control Protocol/Internet Protocol (TCP/IP). The gateway is connected to the SCADA master via Ethernet and to the ends of the fiber optic rings via H&L's Fiber Loop master.

What it all adds up to is that a utility with 140 RTUs would be able to get spontaneous reports from all RTUs within three to four seconds. This compares favorably to H&L's older version of fiber optic SCADA communications. (With 500 RTUs, PG&E takes more than three minutes to poll them all.)

"For energy management you want a faster system," Landman said. "Three minutes is too long to make decisions on feeder switching and load shedding. And the computer has to be tied up polling all these RTUs whether they have any problems or not. With exception reporting, you only hear from the ones that have problems. If you have 10,000 RTUs out there, there might be only a dozen with something to report…. You have nearly instantaneous communication with all of them—you could never do this with fiber optics before."

Now that you can, it remains to be seen how many utilities will see the light.