Beginning in the 1880s and continuing throughout most of the 20th century, our telephone companies worked to build a nationwide network that would enable us to talk to each other. By the 1980s, it was pretty well complete. Anybody who wanted a telephone line could have it, and nearly every home had one. Most homes had several telephones, sharing a common line and number, and a few homes had more than one line. All businesses had at least one telephone line, and many had several lines and their own switching equipment.

A telco’s business was to provide a telephone line to every home and a network to connect it to any other telephone line—and to keep that network in continuous operation and available at, literally, the touch of a button. This was called “plain old telephone service,” or POTS. There was no choice about where to get your POTS. You got it from your local telco. Telcos took to calling their customers “subscribers,” and to calling the connections to customers “subscriber lines” or “subscriber loops.”

COPPER TO THE HOME

Almost all subscriber loops were copper wires, and the core technology was electricity. A telco needed to build at least one copper loop to every home and every business in its service area. It was assured of all its subscribers’ business. There was no local competition. Its market share was a guaranteed 100 percent. A telco grew by adding more copper loops to reach new homes and businesses. Because more homes and businesses sprang up almost every year, growth was guaranteed.

In the early days, telcos struggled to build new copper loops fast enough to meet the demand for new lines, so many subscribers had to share a “party line” with their neighbors. By the mid-1980s, most telcos had built enough copper loops so that each subscriber household could have its own line.

Let’s call this scenario “copper to the home,” or CTTH.

Large copper cables leaving the central office, or CO, were placed underground in concrete ducts, with a manhole every few hundred feet for splicing. Smaller cables in residential neighborhoods were usually strung on poles. Aerial cables could be knocked down and out by ice, wind and lightning. So, in the 1960s, telcos began to bury their cables in new neighborhoods, where two or three feet of dirt would protect them from the hazards of the environment.

Telcos didn’t want to dig up cables to rearrange lines, so they came up with new procedures for CTTH. The idea was to place a cabinet, called a “feeder-distribution interface” (FDI), in each neighborhood. The idea was to place a cabinet, called a “feeder-distribution interface” (FDI), in each neighborhood. This would allow feeder pairs coming from the CO to be connected, as needed, to distribution pairs permanently assigned to each home in the “distribution area” (DA) served from the FDI. Within the DA, cables were planned for the maximum ex-

From CTTH to FTTx: Solving for “X”

To understand why fiber all the way to homes is the best choice today, we have to understand how telcos created the existing copper to the home network.

By Kermit L. Ross ■ Millennium Marketing

<table>
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Ross Highlands – CTTH

Copper telephone distribution layout for “Ross Highlands” – an actual residential neighborhood of 748 single-family homes built about 15 years ago.
The Telecommunications Act of 1996 opened the telcos to local competition. At roughly the same time the Internet took off. There were already millions of PCs in US homes, and, for most households, the only way to connect a PC to the Internet was through a POTS line. Subscribers soon grew tired of having their primary lines tied up and began ordering additional POTS lines for Internet access. Millions of additional POTS lines!

They all rely on copper to reach the last few hundred or few thousand feet to subscribers’ homes – still CTTH!

**THE RULES CHANGED IN 1996**

The Telecommunications Act of 1996 (TA96) opened the telcos to local competition. Telcos didn’t immediately realize TA96’s implications because of another event that happened at roughly the same time: the first commercial Web browsers were introduced and the Internet took off like a shot. There were already millions of PCs in US homes, and, for most households, the only way to connect a PC to the Internet was through a POTS line. Subscribers soon grew tired of having their primary lines tied up and began ordering additional POTS lines for Internet access. Millions of additional POTS lines!

Telcos were taken by surprise by the increased demand. They scrambled to catch up. They added capacity to COs. They added thousands of new NGDLCs. And they added thousands of miles of fiber to connect the new NGDLCs to COs.

Thanks to the two-pairs-per-home design rule adopted in the 1970s, telcos usually didn’t need to add more copper cables in existing neighborhoods. For the last few hundred or few thousand feet to the subscribers, CTTH was still the rule.

**THE MARKET CHANGED IN 2000**

POTS growth stopped. In fact, telcos began to lose POTS lines. Since 2000, US telcos have lost more than 40 million POTS lines. They are currently losing POTS lines at an annual rate of 7 percent. Many subscribers who rushed to telcos to order additional POTS lines in the 1990s rushed away to order cable modems for faster Internet access. Some consumers discovered that cell phones met their

If we were building the distribution network in Ross Highlands today, we would do it with FTTH, probably GPON. We could build FTTH for about what it would cost to build CTTH, or maybe a little less.
needs for voice service and cancelled their POTS subscriptions altogether.

Telcos began scrambling for strategies to replace their lost POTS lines and the revenues and profits lost with them. It soon became apparent that telcos would need to rebuild the CTTH networks that they had spent the last century building. They would need to change their technology from electrical circuits to digital packets, and to create new, compelling multimedia services to be carried by these packets. And they would need networks capable of delivering billions of packets to millions of homes every hour of every day.

PACKETS TO THE PEOPLE

The telcos’ engineers have risen to these new challenges with two technology solutions: the “digital subscriber line” (DSL) and fiber. A DSL has an encoder and a transceiver at each end of a pair of copper wires. It encodes information as digital data, organizes the data into packets, and a transceiver at each end of a pair of copper wires. It encodes information as digital data, organizes the data into packets, and transmits the packets to the distant transceiver. A DSL uses frequencies that are well above those used by a POTS circuit, so it can operate on the same copper pair as a POTS line.

The latest DSLs can deliver about 30 Mbps worth of packets over a copper loop up to 3,000 feet long. If a subscriber loop is longer than 3,000 feet, the DSL delivers fewer packets because of attenuation and interference from other signals.

For long distances, a telco needs a medium with low attenuation and immunity to electrical interference. A telco needs fiber! Fiber is ideal for transmitting large quantities of packets from one point to another – for example, from a telco’s CO to a subscriber. A telco can organize its packets into multimedia services, such as the voice/Internet/TV “triple play,” and it can combine the packets in ingenious ways to create new services. Telcos desperately need the revenues and profits from these new services to replace those they lost along with their POTS lines.

So, all they need to do is to replace their copper with fiber….right?

FIBER TO THE HOME

Almost everyone agrees that FTTH is the way to go for new residential neighborhoods. Methods and materials are now available to enable all-fiber distribution in new neighborhoods. In fact, a new neighborhood can be built with fiber at a lower cost than with copper. And the superior capabilities of fiber should enable the telco to capture and keep a higher market share in the face of whatever competition it encounters.

Major telcos and their suppliers have collaborated on new international standards for FTTH, and hardware built to these standards is coming onto the market in volume. The latest standard is the ITU G.984 specification for “gigabit passive optical network,” or GPON, which allows up to 64 homes to be connected through a passive optical splitter to just one strand in a fiber feeder cable. (The party line stages a comeback!) The splitters are housed in a new form of FDI, now called a “feeder distribution hub” (FDH), located about where the FDI would normally be.

But what about existing neighborhoods like Ross Highlands?

If we were building the distribution network in Ross Highlands today, we would do it with FTTH, probably GPON. We could build FTTH for about what it would cost to build CTTH, or maybe a little less. We would build our network to serve all 748 homes, and we would probably get most of them to “subscribe” to our services because our network would be installed along with the other utilities before the first homes were constructed.

It’s a different story if we want to replace the existing CTTH with new FTTH. To the left is our plan for over-building Ross Highlands.

We’ll need to install over 34,000 feet of new fiber cable, and most of it will require directional boring at about $10 per foot. We’ll need to install two FDH boxes with splitters. We’ll need to place and splice 125 fiber terminals. We’ll spend almost $600,000 before we can connect the first subscriber. Then, we’ll spend another $870 per subscriber for a new service drop, an ONT, and inside wiring. We’ll need to hook up as many subscribers as quickly as possible so we can spread the high fixed costs, and so we generate the revenues to recover our large front-end investment as quickly as possible.

FIBER TO THE NODE

Some telcos have decided that they can’t afford the large front-end investments...
to rebuild their CTTH neighborhood networks, and have adopted a strategy called “fiber-to-the-node” (FTTN). A new fiber feeder is built from the CO to a convenient “node” in the neighborhood, usually near the existing FDI. A new cabinet is installed there to house a “digital subscriber line access multiplexer” (DSLAM). This puts the DSL transceivers relatively close to the subscribers in the neighborhood. The existing copper distribution loops are used for the final connections to the subscribers.

In theory, FTTN will require less time and investment to deploy in Ross Highlands. In practice, there’s more to it than meets the eye.

For starters, many neighborhoods, including Ross Highlands, are too large to be served from just one node. If we need to shorten the copper loops to less than 3,000 feet, FTTN from a single node will work in only about 40 percent of residential neighborhoods. Since the FDI is usually placed on the edge of the DA it serves, another DSLAM will often be required about halfway out on each distribution cable branch. In many cases, three or four additional nodes will be required to reach all the subscribers in the neighborhood. That’s the case for Ross Highlands.

Each additional site requires several thousand feet of fiber to connect it to the primary node. Placing these cables will require expensive directional boring, just as for FTTH. Each DSLAM requires a mounting pad, a cabinet and power, either an AC service or express power from the primary node.

Our plan for FTTN in Ross Highlands looks like the diagram below.

The fixed cost of FTTN for Ross Highlands is only about half that of FTTH, but about twice what many telcos have estimated. We can’t reach all the subscribers from a single DSLAM. We’ll need to split the DA into two pieces, and we’ll need two DSLAMs for each of them. The costs of operating the FTTN network will be higher than for FTTH, if only because of the additional AC power connections and consumption. The higher operating costs will continue over the life of the network, and they’ll slow our ability to cover our fixed costs. If we don’t capture a large fraction of the subscribers in Ross Highlands, we’ll be forced to spread the fixed costs and the recurring costs over fewer subscribers. This will extend our timeline to break even on our investment.

Telcos and their suppliers are working on methods to “bond” two copper pairs together in order to reach more distant subscribers so as to avoid the costs of additional DSLAMs. It appears possible to reach subscribers out to 4,500 feet in this way – if enough pairs are available, and if bonding will scale. However, each such connection will require, literally, twice the DSLAM and distribution cable resources. And a substantial fraction of the homes in a substantial fraction of DAs are more than 4,500 feet from the FDI.
There have also been recent, well-publicized problems with the backup batteries in some FTTN cabinets. Solving these problems and taking steps to avoid a recurrence of them could well raise both the short- and long-term costs of FTTN.

When the dust has settled after all the construction, the costs of FTTN will be substantially more than claimed by some of its proponents. And the final connections to subscribers will still be copper…CTTH!

SOLVING FOR “X”

FTTH and FTTN each have their proponents and advocates. The pros and cons of the two strategies have been argued with passion and, sometimes, religious fervor by some of the most knowledgeable and experienced technologists and leaders in the industry. Statistics, data and analyses are presented and debated in public forums and private conference rooms.

When we compare just the fixed costs of the two strategies, it looks as though FTTN would be the way to go in Ross Highlands. However, FTTH might be the better strategy for the long term, when we consider its potential for lower operating costs and higher revenues from the rich array of services delivered by an all-fiber network. And, if we have the slightest suspicion that we might need to upgrade or rebuild our FTTN network in a few years, FTTH looks like the course to follow now.

In the end, none of the arguments that telcos are having about the “X” in FTTx matter very much. Both solutions for “X” appear to work. The costs of both are enormous. And both will transform the telcos’ businesses from POTS to broadband multimedia services. What matters is that each telco selects a strategy for transforming its network to packet technology and to broadband operation, and that it is relentless in pushing its chosen strategy to completion in the shortest possible time.

In the 1980s, the guiding principle was “We’ll build it and they must come.” In the 1990’s, it was “If we don’t build it, they will go away.” In the new 21st century, it’s “If we don’t rebuild it in time, they will have gone!”

We need to get busy! BBP

About the Author

Kermit L. Ross is founder and principal of Millennium Marketing, a consulting firm in Frisco, Texas. He has more than 43 years of experience in the telecommunications industry, beginning at Indiana Bell Telephone Company in 1965 and including sales, marketing, and executive positions at Raychem, Raytheon, GN Netcom, Teltone, Optilink, DSC, Teledata, and Tagua Systems. He can be reached at klross@grandecom.net.

Solving For “X”

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FTTN is cheaper in overbuild situations. But what if you need more bandwidth in the next few years? Or even in the next 15?

The costs of operating the FTTN network will be higher than for FTTH, if only because of the additional AC power connections and consumption. The higher operating costs will continue over the life of the network, and they’ll slow our ability to cover our fixed costs. If we don’t capture a large fraction of the subscribers in Ross Highlands, we’ll be forced to spread the fixed costs and the recurring costs over fewer subscribers.