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THE PREMIER MAGAZINE OF BROADBAND COMMUNICATIONS

INSIDE: 1995-96 Fiber Topologies Chart

SEPTEMBER 1995 · CED · Cost issues · Laser chirp · Future proofing

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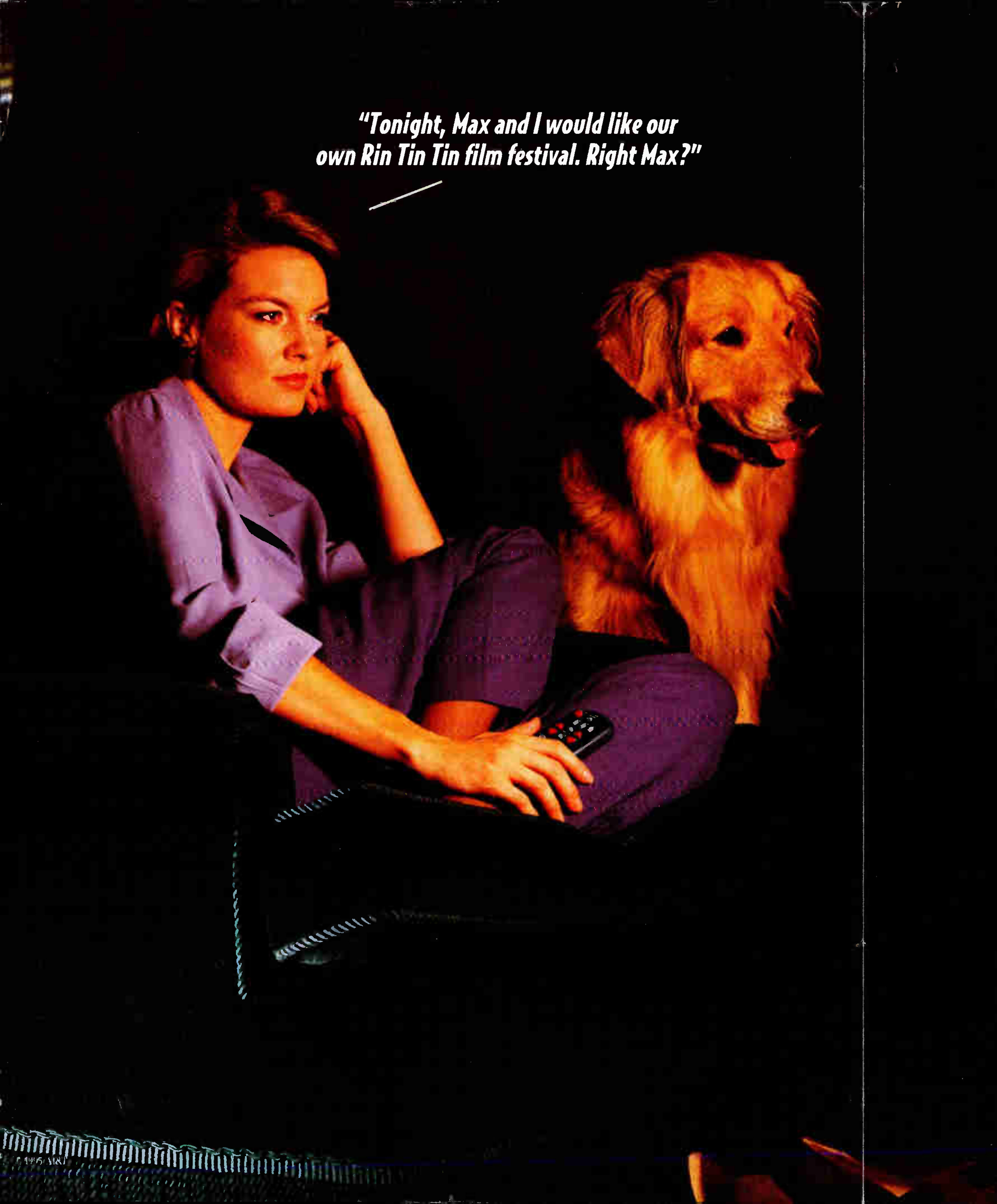
HFC vs. SDV: Let the duel begin



Is it time yet to invest in interactive? Here's a thought.

The latest research tells us that 55% of Americans are willing to spend at least as much every month on interactive services as they are on basic cable TV.[1]

That's an additional $5 billion a year. With who knows how much more for other broadband services.

Of course there are issues to be resolved. What program delivery standard? Which set-top box? And once you're ready, you'll need a partner who can move fast, to help you capture competitive advantage. Which is where AT&T Network Systems comes in.

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WHAT YOU NEED TO COMPETE

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[1] FIND/SVP telephone survey
FLX is a registered trademark of BroadBand Technologies, Inc.

Circle Reader Service No. 1

It's out with the old...But in with what?

The votes are in–and it appears this country will soon experience the most sweeping telecommunications reform it has seen in a half-century. Although the threat of presidential veto hangs over it, both the House and Senate have overwhelmingly approved legislation that would open up both the local and long distance markets to a wide variety of players.

The result? Deregulation of communications industries and all-out competition between local and interexchange carriers, competitive access providers, cable companies, cellular operators, PCS providers, and a host of other alternative carriers.

The Clinton Administration's reaction was sharply negative–both the President and Vice President Al Gore lashed out publicly against it–based on the belief that the reform will result in a consolidation of ownership and control as well as an increase in rates.

Yes, in my opinion, rates will rise in the short-term as network providers struggle to build their infrastructures and stay in business. If the legislation was passed based on the belief that an open, largely unregulated marketplace can deliver new, dynamic services and information, it must be recognized that the equipment needed to do that isn't cheap. Revamping existing networks into state-of-the-art platforms for interactivity, high-speed data and video transport and other services will be a massive, time-consuming and expensive undertaking–and users will probably have to pay more in the short term to gain access to those networks.

But will prices remain high? In places where there is no competition, rates will perhaps climb higher faster and remain that way for a while. But in most urban areas, where competition will truly flourish, prices will roll back as network operators engage in battles for marketshare and offer attractive packages of services.

On the technical front, operators should beware of a few provisions in the reform bills, which could change some as they proceed through the conference committee compromise process.

Perhaps the biggest is related to an amendment that allows set-tops to be sold at retail outlets. Certainly, lawmakers are tired of hearing from frustrated constituents about incompatibility between cable set-tops and TVs. They think the cable companies continue to exacerbate the problem by eschewing standards, and they're convinced consumers have been gouged over the years through rental fees.

Of course, developing a national scrambling standard or switching to smart cards to allow analog set-tops to be sold at retail opens the door wide to professional hackers and pirates who would love to maintain their existing revenue streams that sap about $5 billion out of the cable industry today. The NCTA has been working vigilantly to combat piracy, but whether it can stave off this mandate is an open question.

The long and short of the new telecom reform is this: there's good news, and there's some bad news.

Roger J. Brown

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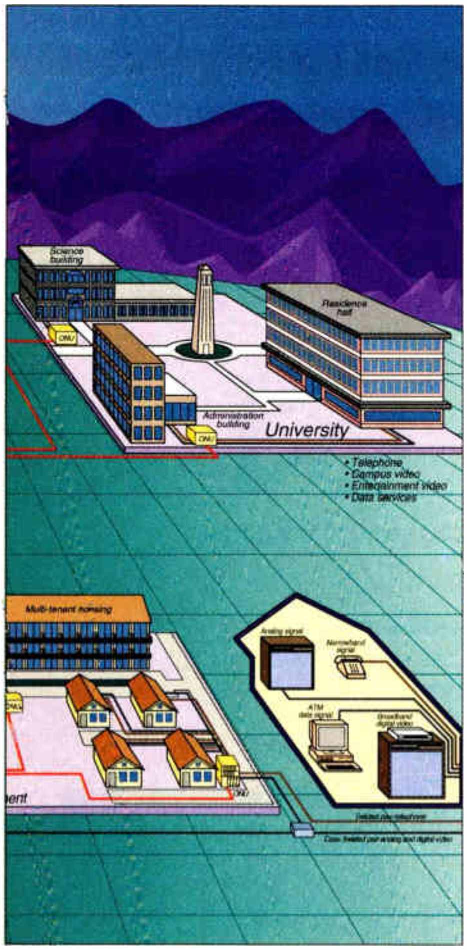

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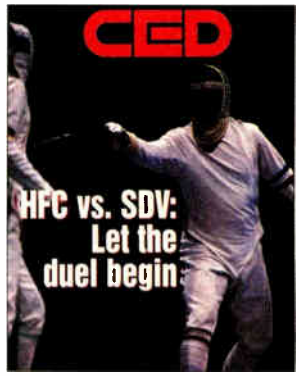

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Here's How Cable Operators

Hang Ten Mbps. There's a tidal wave breaking in cyberspace. An ever increasing swell of millions of net surfers worldwide. This global community of surfers will look to ride on the cutting edge. To push the envelope and surf to the farthest frontiers of the internet in the blink of an eye. Now is the time for cable operators to channel the power of this on-line surge before it crests.

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Zenith sells company to LGE; cash infusion should help network group

While some lament the passing of the last U.S.-owned television manufacturing company, others have become excited about new opportunities for Zenith Electronic Corp. following acquisition of a controlling interest in the Chicago-based company by LG Electronics, the Korean company formerly known as Goldstar.

Under terms of the agreement, LGE will invest $165 million directly into Zenith, with $150 million going into an expansion and modernization of Zenith's color picture tube plant in Melrose Park, Ill. The new capital will allow Zenith to build tubes larger than 27 inches in diameter, something it presently cannot do.

In addition, some portion of the remaining $15 million will go into Zenith's Network Systems business unit, which designs and builds video and data products for cable TV system operators, among others.

"The alliance will strengthen Zenith's ability to compete," said Al Moschner, Zenith's president and CEO, in a statement. "This infusion of cash, access to additional technology and ability to expand into new markets all provide great opportunities for Zenith, its shareholders, its customers and its employees."

In Zenith, LGE acquires a company with core strengths in digital signal processing and transmission related to high definition TV, digital TV, cable and wireless video delivery and data networking. Combined with LGE's strengths in product development, process engineering and manufacturing, many see wide synergies in the alliance.

Separately, Zenith's high-speed "HomeWorks" cable modems will be the hardware platform for a new Internet marketing partnership between Sonic Graphic Systems and PenTeleData, the Pennsylvania-based consortium of independent telcos and cable TV companies.

In the deal, Sonic's transaction-based software system will be used to market goods and services on PenTeleData's Internet access service, which will soon be launched over Service Electric Cable TV and Blue Ridge Cable in northeastern Pennsylvania, said Donald Roskos, director of multimedia services at PenTeleData.

The new system requires clients to pay a minimal set-up fee and a small percentage on each transaction instead of an ongoing monthly fee. Sonic will set up Web sites for a fee ranging between $1,000 and $10,000, depending on complexity. The company did not disclose the percentage it is hoping to take on transactions.

Brooks to build 3 more CAP nets

Brooks Fiber Communications announced plans last month to spend upwards of $26 million to build and operate fiber-based alternate access telecommunications networks in Albuquerque, N.M., Tucson, Ariz. and Bakersfield, Calif., putting the company in direct competition with US West and Pacific Bell. The addition of these three networks will bring to 13 the number of U.S. metropolitan networks operated or under development by Brooks, a privately-held company specializing in local telecommunications services in medium-sized U.S. cities.

Brooks will invest about $5.8 million in Bakersfield, Calif. in the building and operation of the network, which will directly compete with the services of PacBell. The network will be 17 route miles in length, in the form of two interconnected loops. The first loop will connect the downtown business district, major long-distance carriers such as AT&T and MCI, and the PacBell central switching office, while a southwest loop will offer competitive service to California State University at Bakersfield, and businesses like Chevron, Mobil Oil and State Farm, as well as several business parks.

In Tucson, Brooks will spend about $10 million to construct that network, which will directly compete with the services of US West. The Tucson network will be 42 route miles in length, starting at the network hub and connecting to Tucson's long-distance carriers, US West's downtown central office, and hundreds of end-users. The path includes the core downtown business district, the University of Arizona campus, several broadcast media facilities, both the TMC and UMC complexes, the rapidly growing business centers adjacent to East Speedway and East Broadway and the prominent commercial parks in the airport area.

Construction of the fiber optic loop was slated to begin in August, and is scheduled to be completed in increments throughout the next 15 months. The first phase of the loop is expected to be operational as early as October 1995.

Finally, Brooks will spend another $10 million in Albuquerque to build a network 40 route miles in length, starting at the network hub and connecting to all of Albuquerque's long-distance carriers, US West's downtown central office, and end-users on a path that includes the downtown area, the University of New Mexico, the airport, Kirtland Air Force Base, Sandia National Laboratories, the Uptown area, and Journal Square Business Park, as well as nine or 10 area hospitals.

Around-the-clock monitoring of all three networks and their connections to other local and long-distance networks will be managed from BFC's Network Operations and Control Center in St. Louis.

Time Warner goes online in Elmira, N.Y.

Time Warner announced in late July plans to test market high-speed data provision to personal computers in its Elmira, N.Y. Paragon Cable system.

Time Warner has already launched a "commercial trial" serving 500 customers in its 750 MHz network, offering access at 4 Mbps for $14.95 per month. Eventually, the company intends to offer speeds up to 40 Mbps—when the technology becomes available. In fact, Zenith intends to introduce an asymmetrical system that features downstream speeds of 40 Mbps, according to a company spokesman.

The fixed fee includes rental of a cable modem built by Zenith Electronics Co., as well as unlimited access to a package of local, national and international news, shopping, sports info, e-mail and a wide range of local information about entertainment, schools and local government. Internet access will be offered for an additional $9.95 per month. Access to America Online and CompuServe is also an option, and Prodigy access is expected soon.

Whether Zenith continues to be the modem supplier of choice for the long term hasn't been decided yet, according to Time Warner officials. Zenith's HomeWorks product was "the only one that met our requirements," Tim Evard, project general manager was quoted as saying. "We expect that equipment from other suppliers will be available by the end of the year."

Hewlett Packard is the project's system integrator, and as such will help design and develop the server complex, as well as provide operations and support planning and training services.

Of the 500 modems to be distributed for the trial, 100 will be offered at no charge to schools, government offices and libraries, with the rest to be marketed to paying customers.

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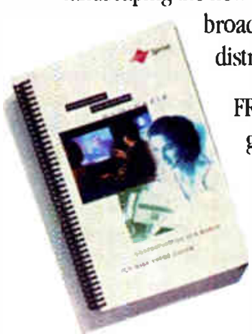

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Orlando to boast 2nd interactive network

In addition to its reputation as the number-one vacation destination on the planet, Orlando, Fla. is quickly becoming the mecca of futuristic, interactive networks.

Joining Time Warner's Full Service Network in the central Florida city will be a planned community outfitted with a full range of advanced broadband services built by the Disney Development Co., in conjunction with AT&T. The two companies will join to develop the township of Celebration, a planned community located near Disney World that will start with about 5,000 residents and grow to about 20,000 in 10 years' time.

When completed, the Celebration Network will be a digital, fiber-to-the-curb optical network that provides voice, data and video communication throughout the community. The infrastructure will be built around AT&T's SLC-2000 access system and the FLX switched digital video product offered by AT&T Network Systems and BroadBand Technologies.

Initially, AT&T will work with Disney to demonstrate a wide range of services, including home banking, home shopping and community information. Later, up to 300 homes will be offered a chance to be part of a testbed where users can access new services in exchange for their opinions on those services. Anticipated services include electronic bill payment over the TV or PC, and intelligent telephones with call management features designed to improve work-at-home productivity.

Participating homes may also receive voice-activated long distance service which allows people to speak directly to each other by simply speaking the name of a person whose phone number is stored in the AT&T network.

Antec, Nortel pen 3 alliances

Antec Corporation and Nortel, two leading companies each seeking to expand their markets, have signed a letter of intent to form three interrelated business relationships, it was announced in late July.

The first proposed alliance is a systems integration joint venture company that would provide both cable TV and telephone companies with integration services for hybrid fiber/coax networks as they evolve to offer voice, video and data services.

Secondly, the two companies will form a joint venture company that will focus on the product development of Nortel's Integrated Digital Access technology, as well as Antec's Digital Video technology. This effort will involve the design and introduction of new products, from the server to the set-top and everything in between.

And finally, a third agreement involves marketing and sales arrangements for Nortel's Cornerstone Voice and Data product line, as well as the products that will be developed by the joint venture company. It is expected that when the deal is finalized, Antec will be the primary sales channel to the cable television industry, and Nortel will be the channel for the same products to the telephone industry.

The agreement gives each company something neither was highly successful garnering on its own: access to a second industry, observers said. With this agreement in place, Antec now has access to a cable telephone product line—something it hasn't had since it scuttled its plans to develop such a product after its deal with AT&T fell apart about a year ago. In exchange, Nortel can use Antec's sales and marketing expertise to penetrate the cable TV market.

AT&T Paradyne develops new ADSL system

And you thought ADSL was dead.

AT&T Paradyne announced that its new GlobeSpan technology will allow telephone companies to offer live and interactive video services, along with high-speed data, over existing twisted pair copper lines at up to 6 Mbps.

Interest in ADSL by telephone companies is growing again, after several false starts. The technology can be used to get telcos into the video market without completely rebuilding the current network. In the past, the technology was thought to be interesting, but expensive and little more than an interim technology. Today, economics are changing those thoughts among some telcos.

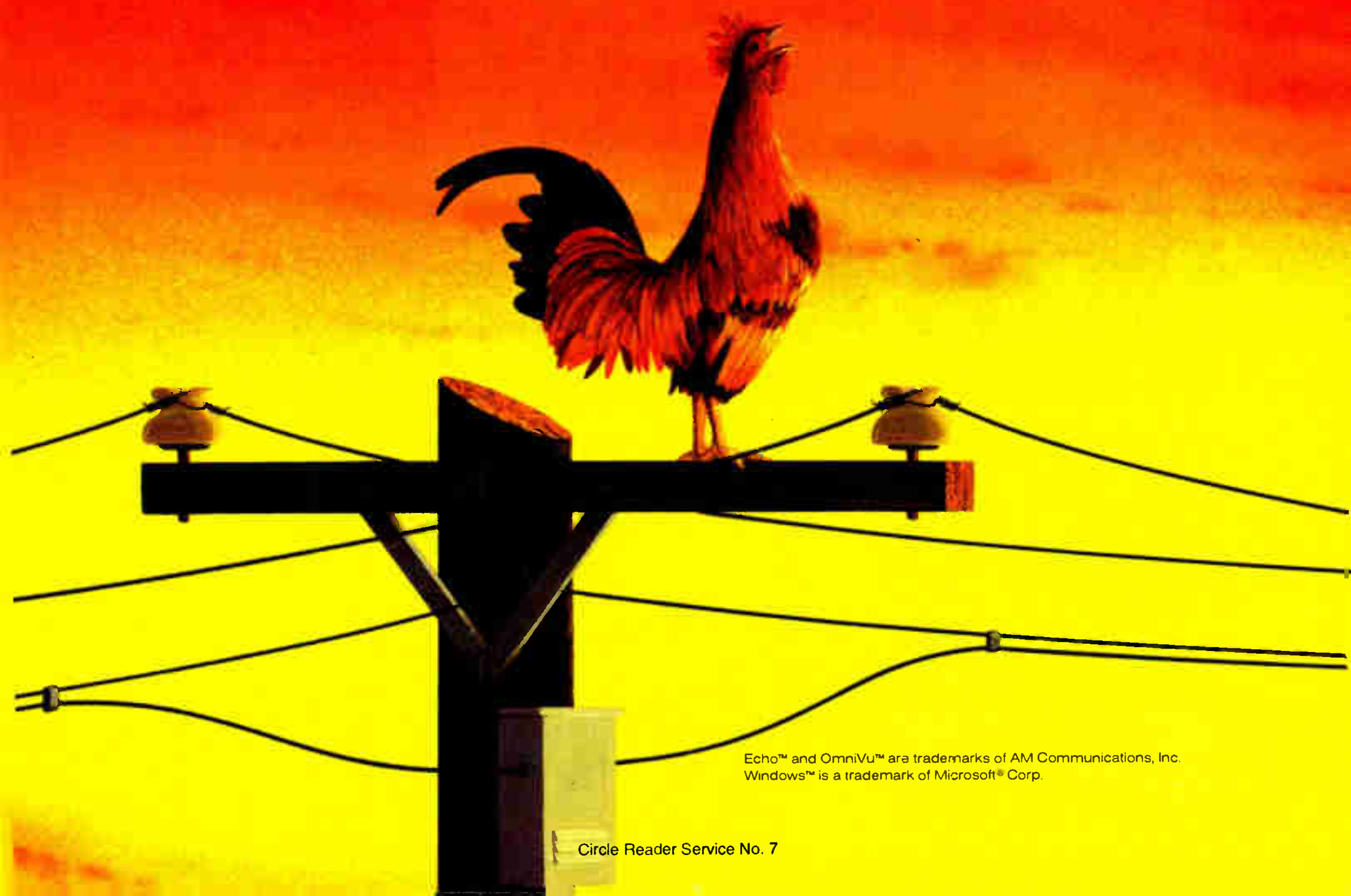
Co-developed with AT&T Bell Labs, the new technology is the first to fully integrate into its transmitters and receivers the capability of supporting both ADSL and high bit rate subscriber line (HDSL) applications.

HDSL is currently used by telcos to provide high-speed, T-1 services over standard copper lines. It traditionally required two lines to perform that function, but technology now makes it possible to use just one pair to gain that functionality.

The GlobeSpan transceiver is based on a new VLSI circuit called "Starlet," which is combined with the previously announced "Slade" analog chip to form an integrated and powerful digital subscriber line transceiver. The transceiver uses carrierless and amplitude phase (CAP) modulation coding to support the higher speeds over longer distances.

Jottings

Researchers at USC and UCLA have developed a prototype optical modulator that can convert the equivalent of 15 million simultaneous telephone calls, or 15,000 video channels, from electronic to optical form, more than tripling the capacity of current devices. The feat was performed by substituting a newly synthesized polymer for lithium niobate crystalline materials typically used in modulators, the research team said. The **Tacan Corp.** is working with the team to commercially develop the product . . . **Pioneer New Media Technologies** became just the second set-top manufacturer to announce the availability of a box with dual tuners and dual decoders. The DoubleVision Command Station terminal fulfills FCC regulations to allow simultaneous viewing and recording of different programs over cable TV networks hooked to TVs and VCRs. General Instrument presently is the only other manufacturer with available product, but others are expected to follow suit as the Oct. 31 deadline nears . . . **The Society of Cable Telecommunications Engineers** is premiering two new training seminars based on telephony and fiber optics in a variety of locations on an ongoing basis. For information on dates and locations, call the SCTE at 610/363-6888 . . . **Expressvu** announced it will have to delay launch of its Ku-band direct-to-home video service to Canadian homes. The service was slated to go on-air Sept. 1, but was delayed because of an acute transponder shortage, which the company blames on cable operator hoarding practices . . . **The International Conference on Communications** has issued a call for papers based on the theme, "Converging Technologies for Tomorrow's Applications." The ICC '96 show will be held in conjunction with SuperComm in Dallas, June 23-27, 1996. Manuscripts are due by Sept. 15, 1995. For a list of suggested technical subject areas, call Brian Fraser at 214/684-7978 . . . **Unisys** has joined forces with Granger Telecom and Loral Communication Systems to use its spread spectrum technology in wireless telephone applications abroad. Granger will market and sell the products, which will be designed, engineered and built by Unisys and Loral . . . CED



Cambron's HFC network lies in wait

Keith Cambron has a unique distinction among telecom engineering gurus: during the course of grueling digital switch verification tests for Bell Laboratories in the early '80s, he completely ate the town of Mona, Utah out of steaks.

Actually, Cambron, now director of systems engineering for consumer broadband services at Pacific Bell, had some help both with the steaks and the testing from a small team of engineers, but despite the lack of glamorous dining opportunities, he still remembers those days fondly. Cambron spent a total of seven years with Bell Labs, where he headed up the teams which installed the first local digital switching system in the Bell System, as well as its first integrated pair gain system. And in 1984, divestiture brought him to Bellcore, where he helped to develop the first networks for Signaling System 7.

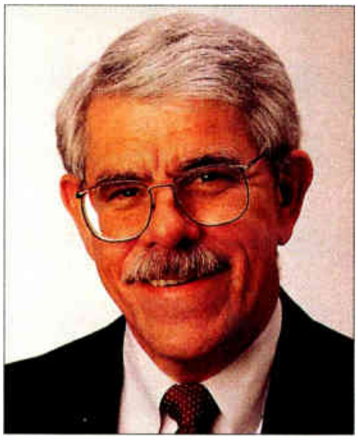


PHOTO BY BILLY HUSTACE, HUSTACE PHOTOGRAPHY

G. Keith Cambron

Cable's HFC groundwork

These days, Cambron is gaining notoriety for his work on PacBell's Advanced Communications Network (ACN), a hybrid fiber/coax plant which currently passes 130,000 homes in northern California, and which will eventually deliver telephony, analog and digital video, data communications, digital or CD-quality audio and interactive services such as games to approximately 5 million homes. In fact, his work with advanced technologies like the ACN won him *Telephony Magazine's* 1995 Fiber in the Loop Award for Network Design and Implementation.

"Our core network–our switching systems and our interoffice–are in excellent shape to provide these services," says Cambron. "It just took something to wake us up into finding a way to upgrade that third piece of our network, which is the distribution to the home. And we are very fortunate in the telephony industry, because the cable industry has done a really superb job in developing [hybrid fiber/coax]."

Next up for Cambron, now that PacBell's Section 214 application for video dial tone has been approved by the FCC, is ordering and installing video equipment in the telco's central offices, in preparation for utilizing all that HFC plant he has built. Much of the guesswork has already been taken out of implementing the new equipment because about two years ago, the RBOC built a testing lab in Concord, Calif.

The lab not only has all the equipment which will go into the network, but it is also linked to an outside HFC cable plant in Concord which passes a couple hundred homes and enables PacBell to test things like ingress, and how telephony works on the network in combination with analog and digital video. The fact that the test plant is outside in the real world has been especially valuable because it is located near an airport, in RF-unfriendly territory. "In fact, we are going to turn up a few customers for telephony on that plant," says Cambron, "and operate it out of the broadband lab."

Perhaps no one knows better the value of real-world replication in the lab than Cambron, who had to solve a puzzling engineering problem during his early days with PacBell. In the summer of 1991, there were "major SS7 outages, both in Pacific Bell and Bell Atlantic," he notes, adding that the technology had just been brought up in 1990 and '91. What made tracking the problem in PacBell's system difficult is that trouble propagated from one network system to another, and from one switch to another. Cambron and his team ended up working for 36 hours straight to re-create the problem in the lab, and only in that way, were they able to determine that it was actually a software problem.

Though he is a technologist, one of the perks of Cambron's position is that he gets to dream up broadband applications, new ways to integrate services and technologies. As an example, PacBell's network may one day offer subscribers an on-screen notification, while they are watching their favorite television programs, that urgent voice mail or E-mail messages are waiting for them.

Cambron wonders, though, just how much interactivity the customer will want. "My belief is that a large segment of the population, for a long time, is going to want to go home, relax and watch 'Roseanne' or 'Wrestlemania'," he notes. "And one of the jobs that we have is to make sure, if that is 70 percent of our customer base, that we can serve those folks economically."

The accompanying challenge is to make sure that while providing affordable entertainment, the telco is at the same time, able to offer more sophisticated, more bandwidth-intensive applications such as work-at-home to those who demand them.

Techno haze

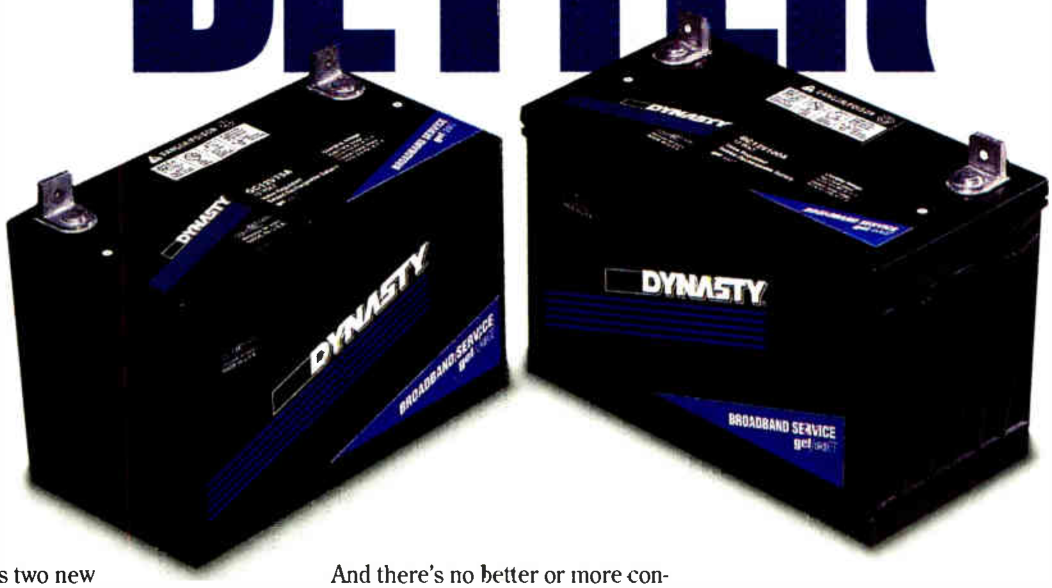
With everything from HFC to traffic engineering to ATM rattling around in his brain these days, Cambron notes that he tends to be a bit absentminded. He credits his wife, Nancy, and his secretary, Eve, as being "the only two people who keep me [together] and getting from home to work, and vice versa."

Technological issues aside, when asked to speculate how the future cable/telco competitive picture will shake out, Cambron predicts that legislators will strive for "two competitors in every market," and that the big winner will be the one which "maximizes service, and minimizes price."

"So the company that can build the cost-effective network that can carry a multitude of services," he concludes, "is the company that is going to be the Southwest Airlines of the networks."

By Dana Cervenka

THE BEST JUST GOT BETTER



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Winning at the numbers game

By Wendell Bailey, VP of Science and Technology, NCTA

The United States Congress finally passed its version of the 1995 Telecommunications reform act. This bill, number HR655, is a close match to the one that I reported on recently as being passed by the U.S. Senate. If the rest of the mechanical/political machinations transpire as is hoped, then the cable television industry will finally have a chance to see if it wants to actually get into the voice telephony business. Just for the sake of discussion, let's say that it does. What would be one of the first issues that it would be confronted with? My guess would be telephone numbers.

Yes, we care

I was in Denver recently at a meeting of the United States Telephone Association's (USTA) engineering conference. At that meeting, I was on a panel to discuss the issue of competition between cable television operators and traditional telephone suppliers. One of the questions that was asked of me was, "Does the cable television industry know or care about the problems with new telephone numbers?" The way that this question was asked led me to believe that the questioner expected me to say no, the cable industry doesn't know or care.

When I responded that the industry expects to be in the business of dial tone exchange management in the not-too-distant future, and that it wants to learn more about this most basic of resources as soon as it can, the audience wanted to know what I thought of the current problems with numbers. Here's what I think has happened to the U.S. numbering plan and what will have to be done, possibly as a result of cable operators entering the telephony business.

Years ago (I actually remember this) there was no way to "dial" long distance. All calls to areas outside the one the caller was in were placed through an operator who used trunk lines to other cities to route the call. The telephone number at the home was made up of a mnemonic such as REdwood 5-7696, or PLaza 7-1234. The "RE or PL" were dialed as 73 or 75. In later years, these numbers were changed to all numeric codes because there were some number combinations that were hard to compose with reasonable English words. This new structure was referred to as an "NNX" code, with the "N" standing for the numbers 2-9, and the "X" standing for 0-9. The long distance codes (area codes) were called the Numbering Plan Area (NPA) codes and were represented as "N 0-1 N," with the middle digit always being a 1 or 0. This was needed to alert the automatic switching machines that a call was meant for transfer to an out of area office.

This nice, neat scheme for keeping the numbers all orderly bears little resemblance to the old numbering plan. This is the result of two things. First, plain and simple growth of the population of telephone users. The telephone has been available since about 1890 (actually invented in 1875), and 100-plus years of simple growth has taken its toll on the finite number of numbers. Each NNX could support 10,000 individual telephone lines (0000 through 9999), and the number of exchanges (NNX) was limited to 640 (8 x 8 x 10) in any given NPA. The NPAs themselves were limited to 128. This all worked splendidly until the last few years.

The second thing that caused pressure on the plan was the growth of second lines in the average home. There had long been a demand for multiple lines in business, but the increased demand for extra lines to the home was new. This pressure point was greatly aggravated by the introduction and growth of cellular phones. Those needed numbers, too. And last but not least, in the recent past, was the dramatic increase of fax machines in homes and offices.

Computer modems and their needs are also beginning to be felt. The administrators of the North American Numbering Plan have, during recent years, introduced certain adjustments designed to ease some of the pressure while everyone figures out what to do for the long haul. For instance, area codes (N 0-1 N) now allow for the second and third digit to be any number (NXX). There has also been an increase in the already creeping "1 plus" dialing rules around the country. Also, old NNX codes (for local exchanges) now allow the NXX format of the area codes. All of these things have extended the total number of numbers. But the end is not in sight.

Get in the game

It seems that the cable television industry has come to the point where it is finally about to be allowed into an exciting new arena, and it finds that the incumbents have used up all of the numbers! True, some, perhaps a significant number, of cable's future telephony customers may want to keep their "old" numbers (this is called number portability), but at least some portion of those customers will represent a net increase to the total universe of number users. It is clearly time for the cable television industry to pay attention to this issue.

The group which has doled out the numbers to those in need has been (since 1984) Bellcore. Because of increased concern that it might be viewed as biased toward its owners, Bellcore recently began the process of giving the job to someone else, preferably someone chosen by the FCC. Whether this change was instituted for the stated reasons, or simply because Bellcore wanted to give up the nearly impossible task of creating new number blocks without unleashing a firestorm of criticisms, may never be known. But one thing is perfectly clear. If cable operators want to get in to the numbers game, now is the time. And it comes none too soon. CED

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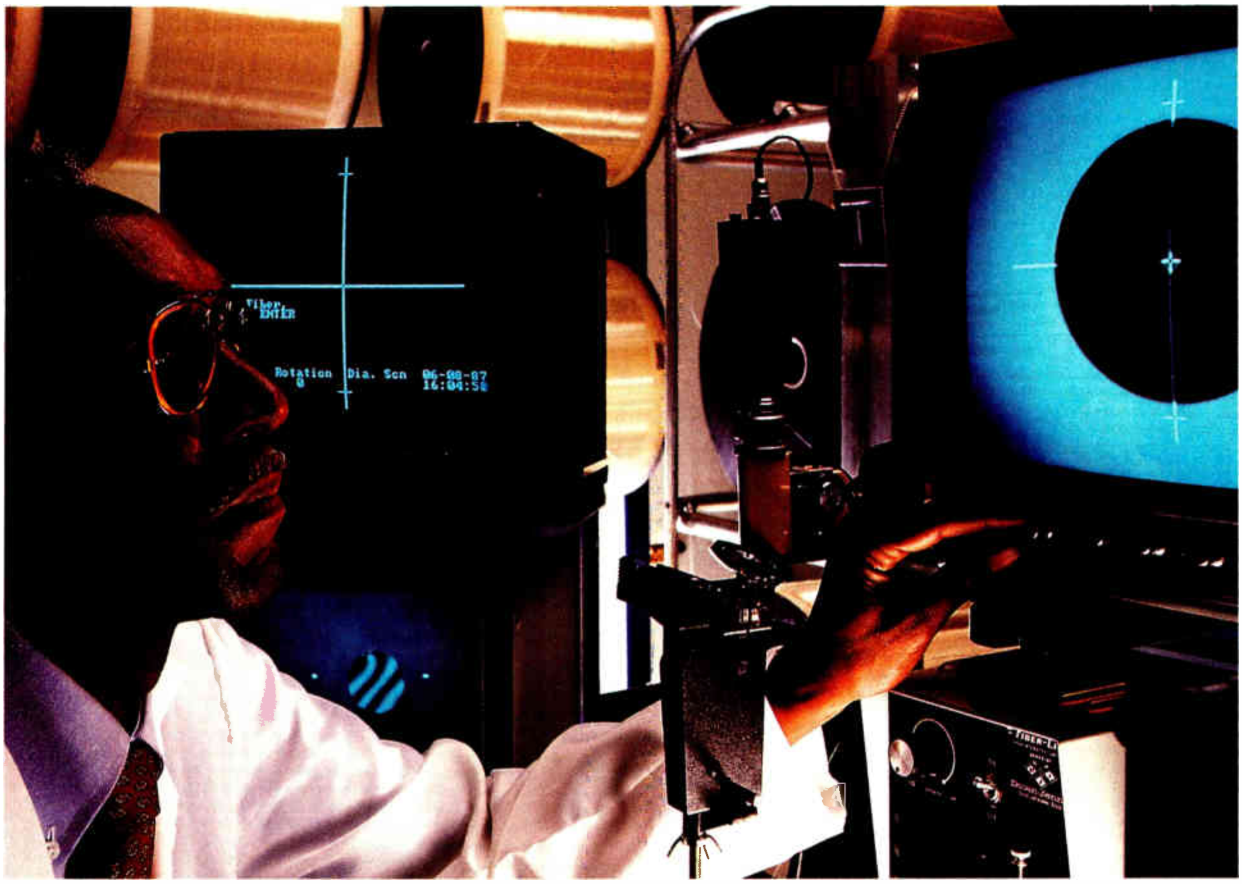

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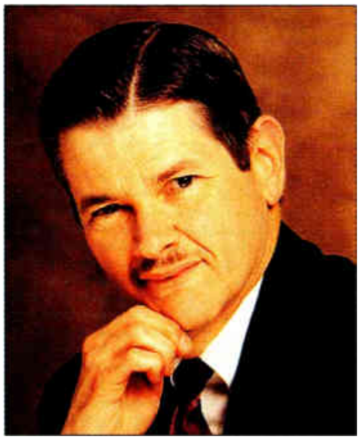

By Jim Farmer, Chief Technical Officer, Antec Technology Center

Publication deadlines being what they are, it is mid-July, and I'm sitting on the porch of a cabin at the Surf Rider on Siesta Key, looking at the waves coming in off the Gulf. I'm saying to myself, "I was raised in Florida and knew about beach bummery before I knew about engineering. Where did I go wrong?"

I don't know if it is the power of the pounding surf or the ride over high waves (for the Gulf) on Milt Beede's catamaran, but I'm thinking about power. In particular, I'm thinking about powering broadband plants with 90 volts and at lower frequency.

Efficient powering

Why change the way we power? The answer is efficiency, found in the second most universal law (behind Murphy's) in the industry: Ohm's law. It tells us that the power delivered to a load (such as an amplifier power supply) is equal to the voltage across that load times the current through it, P=EI. (Some people consider this part of Ohm's law; others call it the power law.) Another form of Ohm's law says that voltage is equal to current times resistance, E=IR.

If we need to deliver a certain amount of power to a load (an amplifier or whatever), we must impress a voltage across it, which produces current through that load. (In grad school my thesis advisor insisted that I rewrite my thesis to remove references to "current flowing." He reasoned that since current was defined as the flow of charge, then "current flow" was redundant. I haven't been able to use "current flow" since.)

Anyway, we have to supply voltage to the device, and that voltage produces current. This is where the rub comes in: coax has resistance. We must put current through it, and Ohm's law yields a voltage drop along the coax equal to the resistance of the cable times the current being supplied.

Paying to heat the coax

The voltage at the load is equal to the voltage at the power supply, less the voltage drop on the cable. This drop reduces the voltage available at the load. The power delivered is equal to the current times the voltage. We have lost voltage due to the resistance in the coax, so the coax resistance is costing us power that we can't deliver to the load. Bad, very bad, because we pay for the power we put in, but we don't get to use all of it. The difference goes to heating the coaxial cable, a rather useless thing.

One way to improve efficiency is to reduce the current drawn by the load. This reduces the current in the coax, which, in turn, reduces the voltage drop. One way to reduce the current is to increase voltage (maybe from 60 to 90 volts). The higher voltage allows us to reduce current while delivering the same power, as shown in the power equation above.

Why are people talking about reducing the powering frequency to possibly as low as 1 Hertz? This is also done to reduce the power loss in the distribution plant. Remember that alternating current first goes positive then negative, and back again. This transition (between positive and negative) cannot be instantaneous, so the voltage waveform spends some significant time at other than the peak positive or negative value.

When the voltage is too low (during transitions from positive to negative and back), power is not being delivered. This means that when the voltage is high, even more power must be delivered in order to make up for what cannot be delivered while the voltage is too low.

For example, suppose that, due to the waveform and power supply, we can deliver power over one-half of the waveform. In order to get the required power to the load, we have to deliver twice the power during the half of the time when we can do so. Obviously, this increases the current during the peaks of the waveform, again costing us power.

Lowering the frequency

One way to get around the problem is not to use a sinusoidal voltage for power, but to use a waveform that is almost square in shape so that it spends most of the time near its peak value and relatively little time in transition. For other reasons, we can't make the transition infinitesimally short, so we're stuck with some limitation in efficiency. However, if we lower the frequency (e.g., 60 Hz to 1 Hz), we make the transitions less often, increasing efficiency.

Constant voltage transformers tend to "smush" the sinusoidal waveform peaks, which improves efficiency compared with sinusoidal powering. The transitions tend to be slower than necessary though, leaving some efficiency on the table.

Why not go for broke and use direct current, which spends no time during which power cannot be delivered? The problem here is that DC encourages corrosion in mechanical junctions, as a result of an unavoidable reverse battery effect. Alternating current prevents this.

Redundancy demands more juice

Thus, we have two ways to improve efficiency of powering, first by increasing voltage in the plant, and then by reducing the frequency of the power.

Compatibility and safety issues must be addressed, but as the plant is called on to power more devices such as telephone and redundant systems, power demand will invariably increase. Hence, there is the need to find more efficient ways to deliver power to the broadband cable plant. CED

Have a comment?

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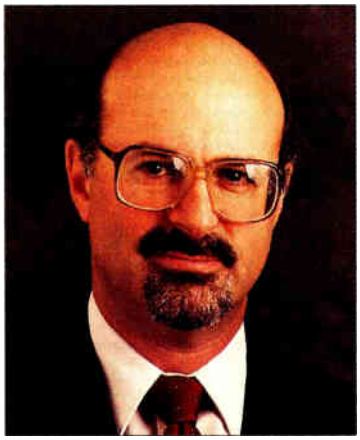
Retail sales of boxes and cable piracy



By Jeffrey Krauss, interpreter of techno-babble and President of Telecommunications and Technology Policy

The FCC is pushing for retail sales of set-top boxes. The Congress is pushing for retail sales. And so are the consumer electronics retailers, like Radio Shack and Circuit City. But nobody is willing to examine the cable piracy risks that go along with retail sales. Retail sales of set-top boxes will encourage piracy, and will also make enforcement more difficult.

What if?

Last month, I wrote about the attempt by Everquest to get an FCC equipment authorization for a cable descrambler that descrambles all signals in addressable systems. This is exactly the kind of equipment being employed by cable pirates. Everquest argues that the FCC has no rule against the sale of this kind of equipment. But it does have a rule against the sale of cable boxes that don't have equipment authorizations.

Everquest told the FCC that its descramblers would be sold only to small cable systems and "approved distributors." The implication is that only cable customers who subscribe to scrambled premium programming would be allowed to buy them. But what would happen if these boxes were available at retail to anybody?

Today, most cable set-top boxes consist of a convertor and a descrambler. (If my cable box does more than that, I don't know about it.) Some have a few other features, such as on-screen displays or parental control capability. And today you can go to Radio Shack and buy a plain cable convertor, without descrambling capability. It's perfectly legal. But they don't sell descramblers, because that's illegal.

Government pressures

Both the FCC and Congress are pushing to allow retail sales of cable boxes that have additional capabilities. What additional capabilities? Nobody is quite certain. Maybe program guide displays, maybe parental control, maybe data modems, maybe other features and services. Nobody knows today which new services and capabilities will be successful. The presumption is that cable subscribers will want to buy, rather than rent, set-top boxes that provide these new successful services.

The one cable service that we all know is successful is premium movies. Cable subscribers would love to buy, rather than rent descramblers, especially if it meant avoiding those monthly charges. That's what the Everquest unit would do if you bought it at a retail store.

In pushing for retail sales, Congress pays lip service to cable security. The currently-pending House legislative language to require retail sales of cable boxes permits restrictions on equipment sales to take into account "system and signal security and [to] prevent theft of service." (By the way, this section was introduced by Rep. Thomas Bliley, who represents the Richmond, Va. district where Circuit City has its headquarters.) But the FCC's Notice of Inquiry on competition in the video programming market, FCC Docket No. 95-61, promotes customer ownership of set-top boxes without any consideration of security or theft of service.

The problem

So, you ask, what's the problem? If convertor sales are permissible, why not other cable boxes? The answer is that widespread retail sales of legal cable boxes will lead to widespread sales of illegal descramblers. This is what happened with the easily-defeated backyard satellite dish descramblers.

Cable scrambling is even more easily defeated. While Radio Shack and Circuit City are not likely to start selling illegal descramblers, the many small mom-and-pop television repair shops are more likely candidates.

Today, pirate descramblers are sold furtively by local pirate installers who advertise by word-of-mouth, and also through mail order sales. But not in retail stores. There is little demand for the plain convertors that Radio Shack carries, so there is little incentive for retailers to advertise and sell "cable boxes." If that changes, and retailers start to carry cable boxes, then some will start to carry pirate descramblers as well.

There are pirate descramblers being sold today that are carefully camouflaged to look like plain convertors. The cable subscriber, when he buys the box, is given a secret, four-digit password. If he switches to a scrambled channel and does not enter the password, it does not descramble. This works pretty well to foil enforcement efforts.

And it would be the perfect design to support sales of illegal descramblers by small electronics shops that would already be selling legal cable boxes. Those retailers have no interest in selling legal cable boxes today, because there is no market demand.

Pirates have no problem with analog

Way off in the future, when most cable video will be delivered in digital format, secure digital encryption may make it unnecessary to worry about cable piracy. We'll see how long DirecTv can withstand the hackers. But today's analog cable environment will stay with us for many years, and pirates have no problem defeating analog video scrambling techniques.

Is it possible to reconcile the conflict between promoting retail sales of cable boxes and maintaining cable system security? I don't know.

What I do know is that the Federal Communications Commission seems to be promoting retail sales of cable boxes without any investigation of the piracy risk. And that is simply wrong. CED

Cities of light for our age

By Tom Robinson, Director of Regulatory Affairs and Technology Development, River Oaks Communications Corp.

"Let there be light."

It's a proclamation that has been made a number of times, for a variety of reasons, down through history. In order of importance of those making such a proclamation, it would be proper to start with God and rank folks like Thomas Edison (for inventing commercial electric lights) and Congress (regarding deployment of multiple competing fiber optic systems throughout the nation) somewhere down the totem pole.

Although perhaps not readily apparent, there is a common thread between the actions of these three entities. All were or are involved in some type of creation designed to benefit the people, or "the public." (Alternatively, I could list a number of inherent differences between God and Congress, but I think they are self-evident, and one should be as prudent as possible when addressing religion or politics.)

This concept of what benefits the public–in other words, what is truly in the public interest–as it relates to the evolution of cable television and telecommunications networks, is part of what I will explore in this and succeeding bimonthly columns.

It's been said by some industry observers that network and applications developers are so consumed in the pursuit of new "means" that they're taking for granted that the "ends" will find public acceptance. Thus, it is wise to remember that, whether it's an attempt to market new profit-making services or to develop public services, unless the public finds a benefit in such offerings, these efforts will not meet with success.

History indicates that defining the public interest has not always been an easy task and has often been the subject of intense debate. Congress ran into this conundrum early on when it worked to enact legislation regulating the fledgling radio broadcasting industry of the 1920s. At that time, radio broadcasting was a fast growing industry, but was fraught with technical problems which created significant interference between stations. Congress was urged to take action to solve these problems while not inhibiting the ability of the industry to grow and thrive.

Congress responded with the Radio Act of 1927 which, for the first time, codified the requirement that a broadcast licensee serve the public interest, convenience and necessity. This requirement continued to evolve in the Communications Act of 1934. It has, decades later, become, in whole or in part, widely used (and widely interpreted) at the federal, state and local levels as the core service requirement for a commercial communications provider that uses public resources (the public airwaves, public right-of-way, etc.). The fact that everything from airwave auctions to channel capacity for electronic classroom applications can be seen as serving the public interest demonstrates the wide range of thinking on this challenging, critical concept.

One problem faced by Congress in 1927 was that it was largely in a reactive mode and thus was required to construct public policy by overhauling or renovating the communications environment. In a growing and changing communications climate such as radio presented then, and the broader fields of cable television and telecommunications present now, there may never be an opportunity to start with a truly clean slate. However, taking a cue from history, an ever increasing number of cities are working to shape their telecommunications environments in a proactive manner, thereby laying a framework that can realistically support the achievement of solid public interest goals.

A local infrastructure

Two cities that immediately come to mind are Austin, Texas and Seattle, Wash. Both cities have invested considerable time and talent in a request for information and proposals (or strategic partners) process designed to promote development of a comprehensive local information infrastructure that will serve all residents, businesses and institutions within their jurisdictions. To meet the telecommunications needs of such a large and diverse populace, this infrastructure would necessarily incorporate several fundamental network design features, including:

✔ Universal availability of, and universal access to, advanced telecommunications services.

✔ An open platform that provides for technical compatibility, interconnection to other networks and equal access for all service providers.

✔ Timely deployment of advanced telecommunications systems. Both cities envision a broadband network that supports two-way voice, data, video and multimedia communications. Such a network will likely be largely fiber optics-based; Austin stipulates the need for a switched digital network.

✔ Abundant bandwidth. Although inherent in both cities' requests, Austin specifically stipulates this requirement, knowing that communications network capacity has historically constrained network advancement.

✔ A variety of other qualities. Certain other key network features include upgradeability, backward compatibility, high reliability through redundancy and fault recovery, integrated and comprehensive network management, and significant mechanisms to protect network security and personal privacy.

If these network features are achieved, then both cities believe several broader public interest goals will be achieved, including:

✔ Competition. The network, as envisioned, would support a number of information and service providers

which would act to increase service diversity and drive down costs.

✔ Economic development. Similar to the increase in economic development opportunities that occurred with the advancement of road infrastructures 30 to 40 years ago, advancement of the local information infrastructure is seen as today's dominant force in spurring local economic development.

✔ Enhancement of government and education services. Austin, through an interconnect with its Greater Austin Area Telecommunications Network, and Seattle, through the potential provision of a public agency network that would connect public institutions and governmental agencies as part of the overall local information infrastructure, both seek to provide better, faster and more efficient services to their scholastic communities and general citizenry.

✔ Positive environmental impact. Both cities seek to minimize an adverse impact on the cities' rights-of-way, while fostering an enhancement of other environmental aspects, such as improving air quality by substituting telecommuting for transportation-based physical commuting.

✔ Public-private partnership. Both cities believe that a cooperative effort on the part of government and industry would best serve to enhance the public and private interest simultaneously.

At this writing, Austin is evaluating a number of recently received comprehensive proposals. Seattle, after discussions with three network proposers, is working through several difficult core issues, including design and availability of set-top terminal devices, the inclusion of a number of proprietary network components, the validity of aggressive market share assumptions, and the appropriate mix of digital and analog system capacity, before making a final determination on the future direction of its local information infrastructure.

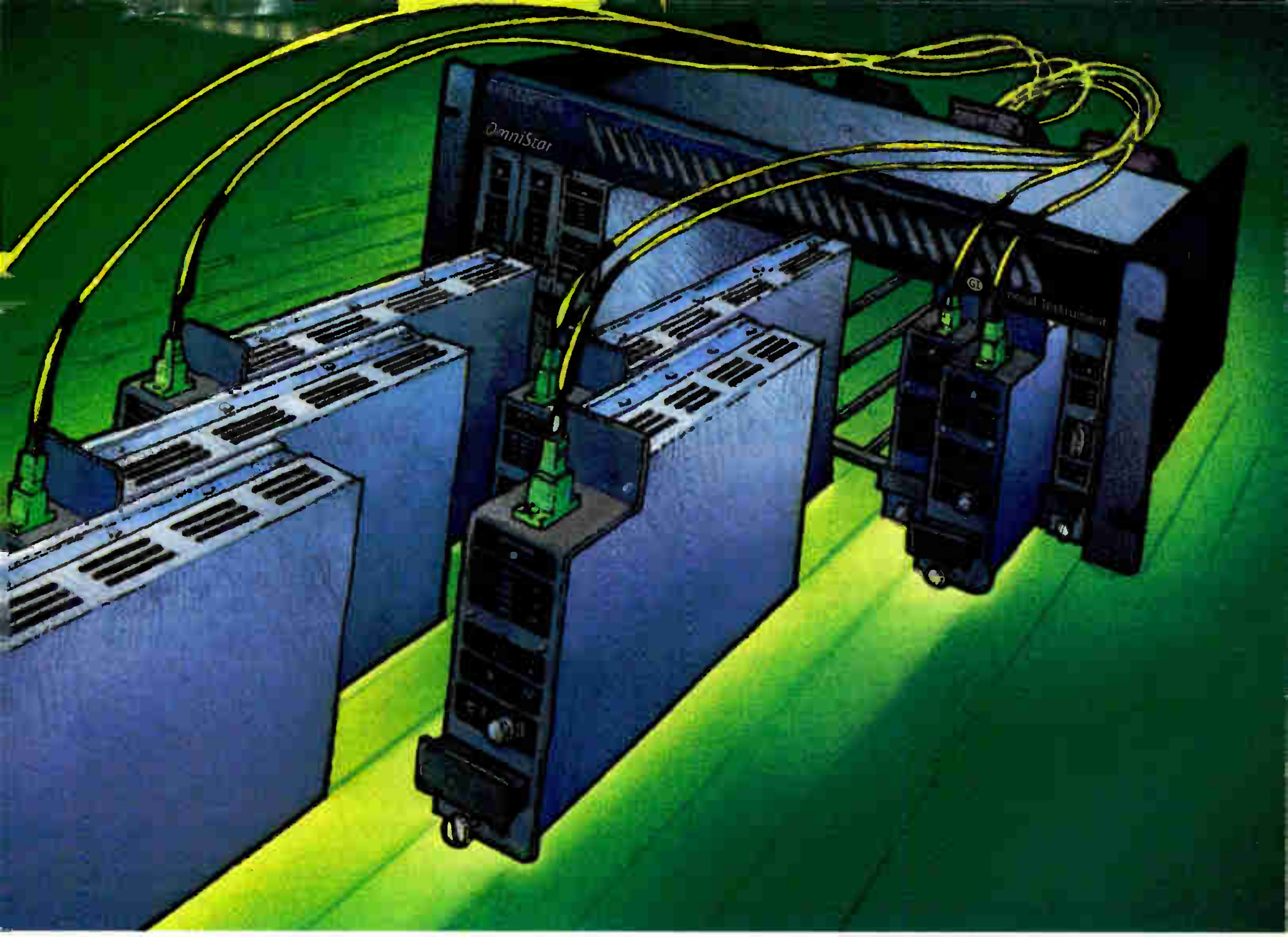
Regardless of the initial outcome of the proposal process, Austin and Seattle are certain that their efforts will ultimately serve to enhance the development of the local information infrastructure. A number of other cities are equally certain and are becoming involved in the infrastructure development process. What is certain to me is that these cities, by thoughtfully and proactively establishing a framework that advances the telecommunications infrastructure for everyone, will ensure that the public interest, convenience and necessity are properly defined for their jurisdictions and that such requirements will ultimately be met.

Skeptics, using Edison as an example, may state that his marvelous inventions of large-scale power generation and distribution and commercial lighting illustrate that the public interest can be served without government mandates and guidelines. However, that particular historical perspective would be incomplete if it didn't also note that it was municipal power companies that worked cooperatively with Edison and others to incorporate their inventions into local infrastructures so that electric power and light could truly be brought to the people. These cities facilitated a critical progression of the American public power industry and were thought of as the "cities of light" of their day.

History ultimately will also reflect that cities which acted proactively to foster a renaissance in the telecommunications environment significantly advanced their local information infrastructure and the quality of life for all their citizens, and pointed the way for other cities to do the same. They will be seen as the "cities of light" for this age. CED

About the author

Robinson is a consultant on cable television and telecommunications regulatory and policy matters, technology, system operations and network development. He welcomes input and can be reached by phone at (303) 721-0653, by fax at (303) 721-1746, or by E-mail at tomgrob@teleriver.com.



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object-based. But it's very easy to put an object-based veneer on top of a relational database, and that's what's happening," said Wattawa. "An object front-end to a relational database becomes very easy to integrate with other systems."

The exchange of information via data warehouses "turns out to be a powerful tool for reengineering businesses–for people understanding business processes and making changes in them," Wattawa observed. With this clarity of vision, "executives can get involved, becoming subject-matter experts about their own parts of the business."

In the future, broadband carriers will compete using pretty much the same hardware, Wattawa said, adding: "The real war, in three to five years, will be a software war."

An example would be how MCI's "Friends and Family" program–"essentially a more interesting billing package"–became a major strategic weapon, he explained.

Cable's immediate focus, he added, should be on "applying enterprise management tools to areas like workforce management and customer care–to systems that already exist and are being upgraded, or that will appear in the next year or two."

Increasingly, MSOs will manage their networks from centralized network operations centers, or NOCs

Increasingly, MSOs will manage their networks from centralized network operations centers, otherwise known as NOCs. Wattawa predicted: "The thrust of this technology is to bring control back to corporate headquarters."

With an increasing convergence onto enterprise management, Scott Bachman, vice president, Operations Technologies Projects, has been adding resource competencies in the Integrated Network Management Systems (INMS) project area.

Pam Anderson, project manager, Enterprise Management Technologies, has recently joined the CableLabs Operations Technologies Projects (OTP) department. Anderson's primary focus is on the analysis, design and deployment of information systems and architectures necessary to facilitate enterprise management.

Information Technology connections

In addition, CableLabs has focused on the information technology community. CableLabs created the Cable/Information Technology (IT) Convergence Forum. Among its goals, the forum is meant to facilitate contact between cable and the IT industry in many areas. The IT industry is a key source of INMS expertise. CED

This article was written especially for CED *on behalf of Cable Television Laboratories Inc.*

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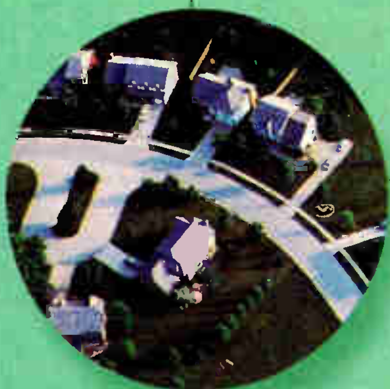

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The 53 minute yardstick

Recently, there has been considerable focus on the reliability of fiber/coax networks. From the telephony perspective, a reliability yardstick that is often quoted is the telco target of 53 minutes per year, per line, of downtime, or a minimum service availability objective of 99.99 percent. Unfortunately, when the 53 minute figure is quoted, it is not always with an understanding of exactly what network elements are included in the reliability equation, and what weight each network element contributes to the total 53 minute number.

One example of this is your "In Perspective" column in the June 1995 issue of *CED* (page 10). Your statement that the 53 minute number does not include the telephone instrument or inside wiring is correct, but you are not correct when you further state that the 53 minute number does not include the wiring between the central office and the home.

In fact, the Bellcore technical reference (TR-NWT-000418, Issue 2, December 1992) that addresses the reliability of transport systems (and networks) is very specific in the network elements that are included in the 53 minute reliability figure and includes "all equipment and media between the CO switch and the customer's premise (CP)."

The Bellcore document describes each network element that is included and the allocated downtime contribution of each element due to all causes to the total 53 minute reliability target.

BellSouth and Bellcore are presently conducting a reliability study of the fiber/coax network based on the same methodology as suggested in TR-NWT-000418. The purpose is to ensure that the fiber/coax network is analyzed in a manner consistent with the TR-NWT-000418 methodology so that the two networks can be compared from a service perspective and, most importantly, to understand how the fiber/coax network reliability relates to the existing telephony network and the 53 minute target reliability number.

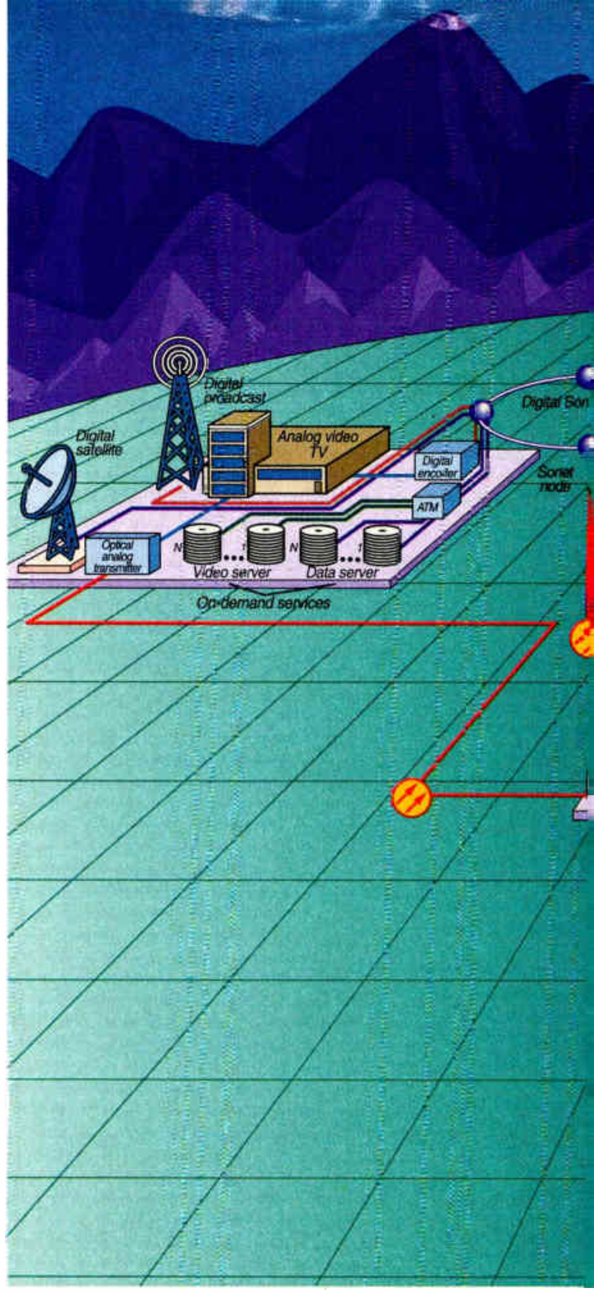
Early results indicate that it may be difficult to achieve the same level of reliability with any reasonable cost-effective cascade of RF devices. The Time Warner amplifier cascade reliability data included in the "Full Service Network" presentation at the SCTE 1994 Conference on Emerging Technologies tends to support this conclusion. This has not necessarily been the perception given when the 53 minute target number has been used out of context.

Beyond the ability to provide a valid reliability comparison between the existing telephony network and the emerging fiber/coax network, the real question is what level of reliability is expected by the consumer for a particular service.

The 53 minute telco reliability target number may not necessarily be the right answer for all services, or even for competitive telephony for that matter, but if it is used as a comparative figure of merit for telephony network applications, it is important to use it in the context in which it was derived. To facilitate this, I would be glad to provide the appropriate contacts at Bellcore to anyone who is interested in discussing the methodology of the Bellcore reliability study.

Bob Mauney
Residential Broadband Group
BellSouth Telecommunications

SDV: delivering multimedia to the home



Network builders face a call to action

By Don McCullough, Product Line Manager, BroadBand Technologies Inc.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The multimedia services race is on: Internet, digital satellite TV, video-on-demand, interactive games, targeted advertising, CD-ROMs, work-at-home; consumers are spending increasing amounts of their time and money on multimedia products. Yet while customers find their own ways to bring these services to their homes, network operators are frozen in a modern-day debate over how many angels can stand on the head of a pin.

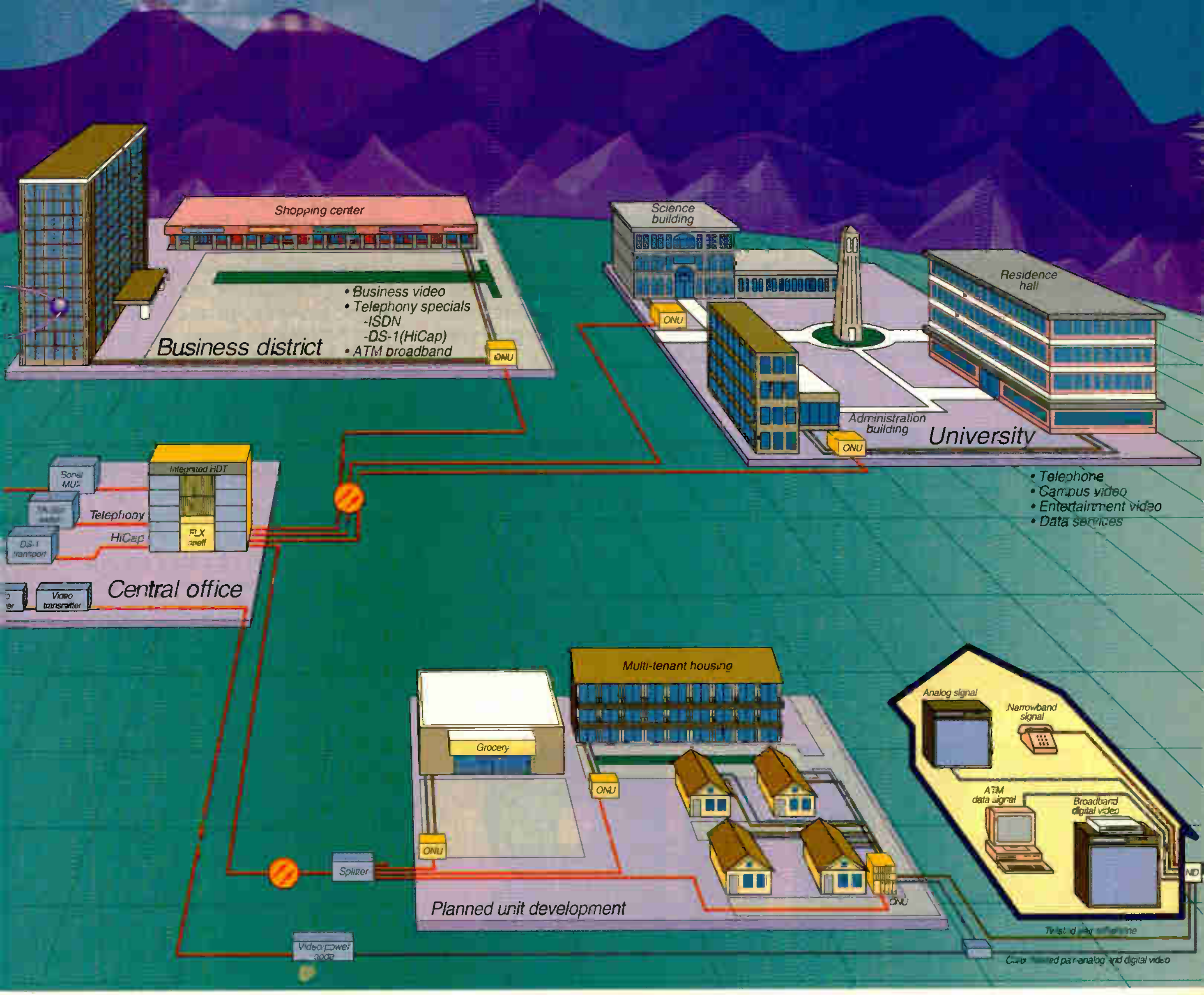
The subject of this debate is which technology to use in building the information superhighway. Which is the right technology for the broadband local loop? Is it hybrid fiber/coax? Switched digital video? Wireless cable? Telephone companies have spent countless staff-hours and dollars to decide this issue. Given the various filings, refilings and withdrawn filings in the FCC 214 process, it seems as if the answers change by the day.

But while the debaters debate, others are acting. Several network builders, including some telephone companies, are committing to this huge, evolving multimedia market by building several city-sized networks using several different technologies and letting the market decide the debate.

This article is not meant to contribute to the debate. It is meant to describe one of the potential network technologies–switched digital video–that is being deployed by aggressive network builders. It is further meant to show how this technology meets the requirements that the new multimedia services demand of a network. Finally, it is meant as a call to action for network builders to stop debating and start meeting the demands of this new market.

More than just video

Each service puts specific demands on a network. Figure 1 (page 42) summarizes these demands for each service in two domains, bandwidth downstream and bandwidth upstream. Let's consider the bandwidth and



End-to-end diagram including key elements–host digital terminal, optical network unit and system/services software.

other requirements for Internet service, digital satellite TV, video-on-demand, targeted advertising, CD-ROMs and work-at-home. These become the demands that the service imposes on the network.

Internet service via on-line services is approaching 25 million users. This number has increased ten-fold since 1990. While Internet access is handled today on the existing telephone network, World Wide Web and other browsers are slow because of bandwidth limitations of the standard 64 kbps twisted pair telephone wire. High-speed Internet with download data rates of more than 1 Mbps (megabits per second) are being developed using cable modems.

The characteristics of high-speed Internet are at least 1 Mbps downstream, 128 kbps to 1 Mbps upstream, tolerance for some latency delays because the computer can mask them, and access security to prevent service theft. With the immense popularity of Internet chat lines and Web sites, sheer capacity is also a concern. Peak periods, not average capacity requirements, represent the bottleneck that the network must overcome.

Digital satellite TV, under the product name DirecTv, has sold more than 1 million units since its introduction in June 1994. The price for the satellite dish and set-top is around $1,000–and the monthly fee is approximately $30 per month. The service offers 160 digital (MPEG) channels with no upstream interactivity.

The characteristics of digital satellite are at least 160 MPEG channels delivered on a broadcast basis to homes. Signal theft has not been a problem so far, but may become larger if cable TV experience is any guide. The Office of Cable Signal Theft in Washington, D.C. estimates that over 14 percent of revenues for both basic and premium services are stolen each year in today's cable TV systems.

Video-on-demand and interactive games are in trials right now. The requirement of these services is dedicated bandwidth to each home in the range of 1.5 to 6

ously with minimal changes to the network,
✔ Availability must be in 1995 or 1996 to meet the window of opportunity.

The switched digital video (SDV) network meets these requirements. Such an SDV network is based on telephony standards for next generation digital loop carrier (NGDLC) and for fiber-in-the-loop (FITL). The most pertinent standards document is Bellcore's TR-TSY-000909. Using a FITL system as a base, the enhanced SDV system provides a fiber link from the central office (CO) to a point within 1,000 feet of the home. The unit which terminates the fiber is called an optical network unit (ONU).

Figure 2 (page 42) shows a typical SDV system. The host digital terminal (HDT) is installed in the CO. It provides interfaces to the telephony network, to the DS-1 high-capacity (hi-cap) network, and to the digital video network via 16 OC-3c ATM Sonet data streams. The interactive signaling is also carried in the Sonet data streams. A pair of single-mode fibers extends from the HDT to each of up to 160 ONUs. Each fiber pair may be split up to four times via a passive optical splitter. The ONU provides the optical terminations and interfaces to the homes.

For telephony, standard channel units are plugged in at the ONU, and twisted pair wire extends to the home. For DS-1 hi-cap service, specialized channel units are plugged in at the ONU. For digital video service, broadband transceivers are plugged in at the ONU. Twisted pair wires extend from the ONU carrying the digital video payload to the home. It is possible to combine the digital video and the analog video close to the home so that the coax cable coming into the home carries both the digital video and the analog video.

The system shown in Figure 2 offers the following features and benefits:

✔ 51 Mbps downstream and up to 1.62 Mbps upstream at every home, in addition to the telephony and DS-1 hi-capacity service that is also available. Bandwidth assignment is all software provisionable. The bandwidth is dedicated from the HDT to the home, not shared, because of the star topology employed by the system.

✔ Low latency (response of under 250 milliseconds) is provided via the software in the HDT. For requests that must be sent upstream, latency is reduced because the HDT does not perform protocol conversions.

✔ The switching fabric architecture provides exceptionally tight security. The switches in the HDT are controlled from commands issued from the upstream video providers. These switches only respond to requests from the viewer if the services have been pre-authorized from the video providers. A data stream never leaves the HDT if the home is not authorized to see it. In other words, unauthorized signals are never there to steal.

✔ The network provides service independence by delivering a standardized–not proprietary–ATM packetized signal to the home. ATM is an open standard for transporting any type of digital data. Any service provider can easily adapt its specialized home terminals to accept an ATM input using currently available chip sets. The availability of the chip sets and the standard compliant interface will speed the availability of services. The result will be that consumers will be able to purchase different types of services more quickly.

Other technologies such as hybrid fiber/coax, wireless cable (MMDS), and digital satellite promise to meet some of the require-

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ments for the broadband multimedia network. These technologies will also meet the availability window of opportunity. But in each case, there are limitations in the fundamental network architecture that limit its ability to meet all of the requirements.

Hybrid fiber/coax systems are a bus architecture in which all signals are on the same coax cable, raising congestion and security issues. Wireless cable has limited bandwidth downstream and no upstream bandwidth. Digital satellite service does not have an upstream data link. All of these technologies have their place and will be deployed in the next few years, but in the end, many operators expect their applications to be limited.

In the past, the issue with SDV has been price. But several network operators have taken that issue off the table. It now appears that when compared on an "apples-to-apples" basis in terms of a full set of services, SDV networks cost the same or less than networks built with other technologies.

Figure 3 shows the composite results of network cost studies conducted by several telephone companies. These cost studies assumed a full service network, with telephone, analog video and interactive digital video services. It shows that both SDV and HFC technologies cost about $900 to $1,000 per home passed on an installed first cost basis. These costs were end-to-end installed cost, but did not include the set-top. The base model assumed that digital video penetration would be 15 percent.

The studies then varied that penetration. If penetration was below 15 percent, HFC technology was less expensive. But if penetration rose above 15 percent, SDV became less expensive. After conducting these cost studies, the telephone companies decided that it was their business case that would decide which technology best met their requirements for service capability and costs.

SDV is one of several architectures that is available to telephone companies and other network operators to meet the multimedia services challenge. This architecture also meets all of the technological and service requirements for a multimedia network architecture. It is ready to provide service.

The convergence of market demand and technology is no coincidence–vendors and pioneering network operators have been preparing for this link up. It is now time for the network operators to start building. In the end, building a network and serving customers in the market is the only way to decide which technology is the best. The time to build is now. CED

Figure 1: *Upstream and downstream bandwidth requirement for services on the full service network*

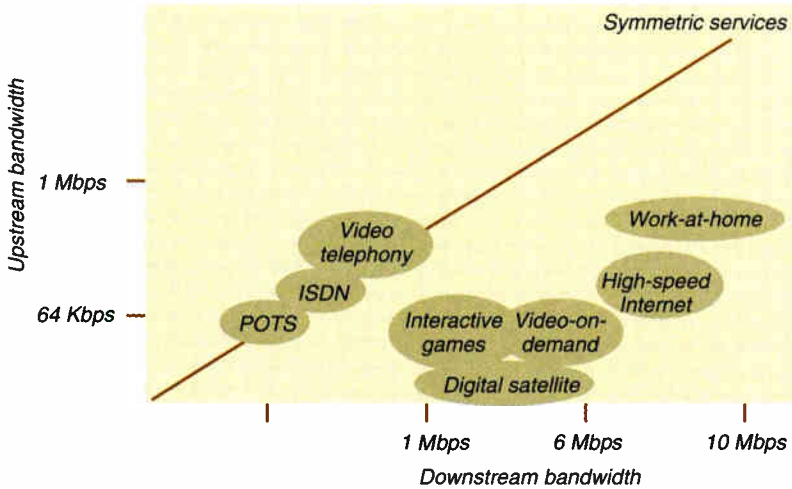


Figure 2: *Fiber-to-the-curb architecture*

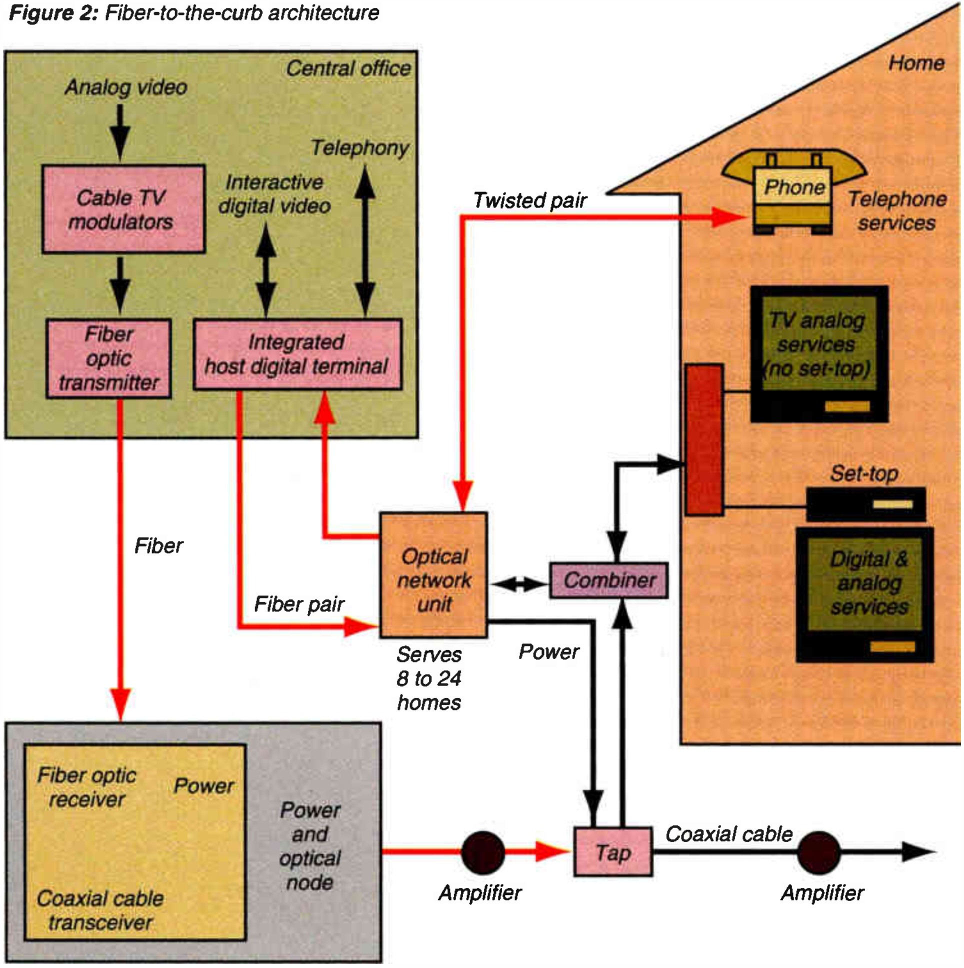
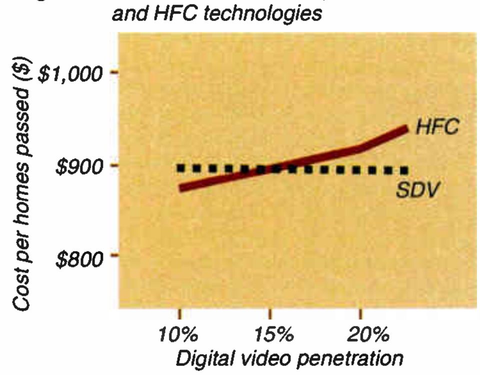


Figure 3: *Installed first cost comparison of SDV and HFC technologies*



Cable has a head-start The info highway: Who's going to be first?

Figure 1: HFC/SDV access selection

Decision factor	HFC	SDV
Support for full service strategy	+	+
Installed first cost	+	
Incremental digital video services cost		+
Operations savings	+	
System availability schedule	+	
Fit to embedded plant	+	
Fiber deeper in network		+
Network intelligence deeper in network	+	
Bandwidth deeper in network	+	
Early ATM connectivity		+
Evolutionary potential	+	+

By Robert Stanzione, Vice President, Consumer Broadband Networks, AT&T Network Systems

The long and intense debate over which broadband system architecture reigns supreme may seem more confusing than ever. Some local exchange carriers (LECs) are siding with one architecture, then another, in hopes of selecting the perfect solution. From the multiple system operator's (MSO's) perspective, however, the architecture of choice is more clear; the imbedded base sets the stage. MSOs have the unique advantage of being able to move forward quickly in the deployment of their broadband networks. In fact, MSOs can most likely put telephony services on their networks far quicker than their competitors can deploy video services by simply building on what's already there.

The debate on how to best achieve this "full service" capability revolves around two relatively new technologies–hybrid fiber/coax (HFC) and switched digital video (SDV). HFC closely resembles the fiber-coax architecture already in use today by MSOs, while SDV is similar to the fiber-to-the-curb architecture familiar to many LECs.

Both architectures have relative strengths and weaknesses; the choice between them will no doubt be heavily influenced by a service provider's weighting of the importance of such factors as "installed first cost," "fit to embedded plant," "low incremental digital video service cost" and "fiber deeper in the network" (see Figure 1). Those LECs that favor SDV, for example, are particularly interested in the latter two of these factors. (Note: Figure lists the relative strengths of the two architectures as they might appear to an MSO engineer.)

Nuts and bolts

The HFC architecture provides significant upstream bandwidth in the 5 MHz to 40 MHz band for a wide array of communications (see Figure 2). For example, at the headend, a host digital terminal (HDT) could provide an efficient concentrated TR-303 interface to the local digital telephony switch. From the headend, various arrangements of protected and unprotected linear lightwave transmission equipment would be used to transport telephony, narrow and wideband data, high-speed data, switched digital video and broadcast analog and digital video to a fiber node typically serving up to 500 homes.

From the fiber node, HFC systems transmit bidirectionally over coaxial cable tree-and-branch buses to electronic modules called network interface units (NIUs) which may economically serve a very small group of homes–or often a single home. In a single-home application, the NIU is mounted on the wall of the residence.

Curb or pole-mounted NIUs typically serve four to eight homes, and in special applications such as high-rise apartments, larger NIUs may be used. At the curbside or wall of the home, telephony signals are encoded/decoded and placed on conventional twisted-pair inside wiring to the terminal equipment such as phones, faxes and modems. In addition, telephone signaling and power are provided by the NIU.

Broadband signals are carried into the home on coaxial cable for distribution to cable-ready TVs, analog and/or digital home entertainment terminals, cable data modems or other RF terminal appliances. A virtue of this technology is that digital signals are only encoded and decoded once at the HDT and at the NIU or other terminal device, using modulation techniques proven in previous generations of digital radio systems.

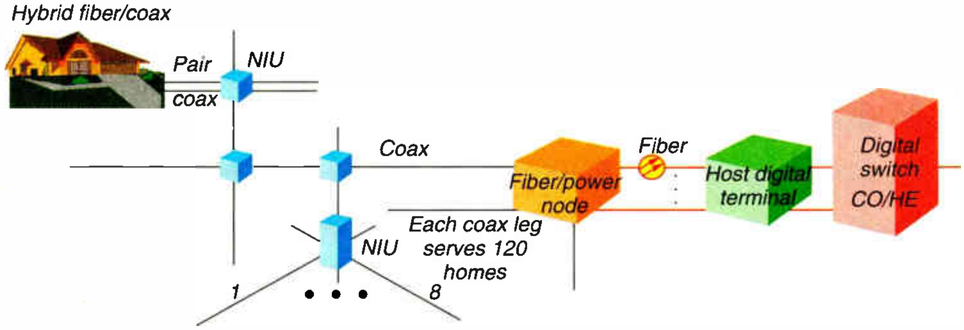
Switched digital

With SDV, all traffic except analog video is carried from the headend to optical network units (ONUs) located deep in the plant over fiber facilities (see Figure 3). An ONU might serve from four to 48 homes. At the headend, an HDT provides a concentrating TR-303 interface for telephony traffic into the local digital switch, and an OC-3 interface for digital video and data traffic to and from the network. These signals are multiplexed together at the HDT and switched to appropriate transceivers for transport over fiber to the ONUs.

Several subscribers (typically 16 to 48) can share ONUs whenever they are within the effective range of the digital drop transmission technology. A further economy with SDV can be achieved through optical splitting of the fiber between the HDT and ONU; two- and four-way splits are common. These electrical

Figure 2: AT&T HFC broadband access system

Hybrid fiber/coax



and optical sharing strategies convert the point-to-point star architecture–possible with SDV technology–into a point-to-multipoint bus architecture which then must be traffic engineered in the same manner as an HFC architecture. The need to power the ONUs and the need to transport broadcast analog cable TV must be taken into account when considering this architecture.

To solve these two problems, it is recommended that practical SDV systems be built with an HFC underlay to carry power and analog cable TV channels.

At the SDV ONU, telephony signals, ringing signals and telephone power are placed on traditional twisted-pair cables and drops to each residence served. The digital video signals destined to a particular residence are modulated onto twisted-pair, coax or hybrid twisted-pair/coax drops. Hybrid twisted-pair/coax drops are most commonly used to carry the digital video signal from the ONU to a distribution terminal. At a tap no more than 500 feet away, an impedance-matcher and RF combiner place the digital video signal in the 5 MHz to 40 MHz band on the coaxial drop carrying the analog cable TV signal.

Room to grow

Most MSOs will be faced with one of three scenarios when planning for the deployment of broadband systems: expansion, refurbishment or augmentation. With expansion, the MSO is taking on new territory and starting from scratch. Refurbishment is necessary when the MSO has a cable plant that is aging or lacks sufficient bandwidth. Augmentation presents itself when the MSO has a perfectly good network but wants to add new services, such as telephony, which require significant modification. Because of the modularity of the HFC architecture, the MSO can incrementally address any of these situations today, while still protecting its strategic objectives for network evolution.

Because HFC distribution systems integrate all traffic–both analog and digital–onto the coaxial cable, adding telephony or data service to a bidirectional cable TV network only requires the addition of the appropriate terminal equipment at the headend and the addition of associated set-top boxes and/or NIUs at the subscriber's home or business. As with traditional analog video distribution, only those customers who actually subscribe to a service need to be provided with terminal equipment. If subscriber power is used for the device, power distribution on the coaxial cable need only account for the additional upstream optical elements and amplifiers on the coaxial bus. Alternatively, powering of the NIU can be done by the network, as well.

With SDV, an MSO that anticipates a very low subscription rate for the complement of digital services can install ONUs only where and when required. For most situations, however, the entire SDV network would need to be deployed–even with relatively small service subscription rates. Because each ONU is positioned to serve 16 to 48 homes, at least one or two homes can be expected to subscribe per ONU if 10 percent or more of these customers, for example, subscribed to a digital service. As such, installation of all ONUs is required.

The initial cost of installing a traditional cable TV system is often expressed as the total cost of the installation, divided by the total number of homes passed by the distribution. For example, if a system costing $500,000 passed 1,000 homes, the cost per home passed would be $500.

However, if only half of the homes actually subscribed to the service, the actual cost of the network per home served would be $1,000 [$500,000/(0.5 x 1,000)].

For new incremental services to be added to an existing network, only the cost per home served with those services needs to be considered, because the basic transport capability is available to all homes passed and is accounted for in the initial cost of the network build. For example, an MSO might calculate that the addition of basic telephony to an existing network using HFC technology would cost $500 per home served. If 10 percent of the 1,000 homes already passed by the system subscribed to this service, the total cost of the augmented network would be $550,000 [$500,000 + (100 x $500)], for an average of $550 per home passed and $1,100 per home served. The most significant factor in an incremental upgrade is the incremental cost vs. the incremental revenue on a per home-served basis. Because an SDV system would need to be almost fully built out in order to serve this same 10 percent of the customer base with a new service, this option would be too cost-prohibitive for a cable TV service provider to consider.

Because of their large bus architecture, MSOs are afforded numerous cost-saving advantages through the deployment of an

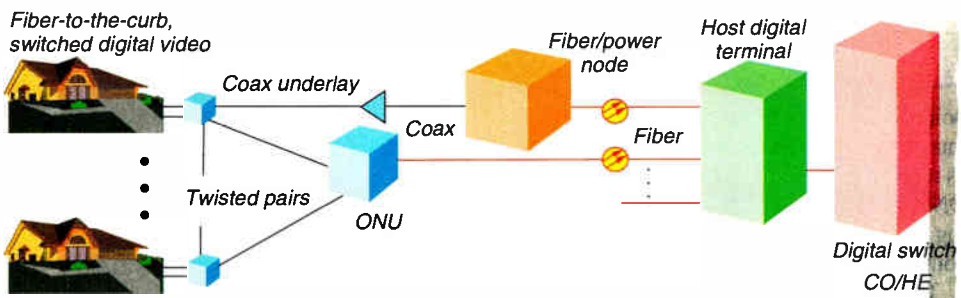
HFC system:

✔ Traffic engineering and subscription rates. By taking advantage of the large number of people in a pool who subscribe to a service, as well as their associated usage pattern for each type of service offered, the MSO is able to derive a significant advantage through traffic statistics. For example, knowing that every subscriber won't be using the phone at the same time, more service capability can be provided with less infrastructure.

✔ Ubiquitous service availability. By adding the equipment at the headend, the MSO is positioned to offer new service to all customers across the network in a cost-effective manner; only the addition of a set-top box and/or NIU is required. Because terminal equipment must be placed in the vicinity of every 16 homes with an SDV system, a much larger investment to reach the same number of customers as HFC would be required. It might also encourage targeted (non-ubiquitous) deployment.

✔ Enhanced operations capabilities. The electronic provisioning, performance monitoring, remote line testing and remote activation/deactivation of service capabilities of an HFC system not only save the MSO money by streamlining trouble-shooting and reducing dispatches, they also enhance reliability. Similar features can also be available on SDV systems out to the ONU, but the critical link from the ONU to the actual customer is not as "network intelligent."

Figure 3: *Broadband access architecture choices. AT&T/BroadBand Technologies SDV architecture*



More than enough

At the center of the debate between HFC and SDV is capacity. Will HFC leave the MSO stranded at a certain service level, while SDV could provide additional service capacity? In reality, the MSO deploying either HFC or SDV will have more than enough capacity for provisioning all the services its subscribers could ever want. The difference lies in the business plan: how soon does an MSO predict new revenue-generating services will begin to pay for the network upgrade?

When calculating the amount of capacity available in a broadband network, three factors will help determine how much of a particular service can be carried:

✔ How much bandwidth is allocated to the service?

✔ How efficiently will the bandwidth be used? (a function of the modulation schemes)

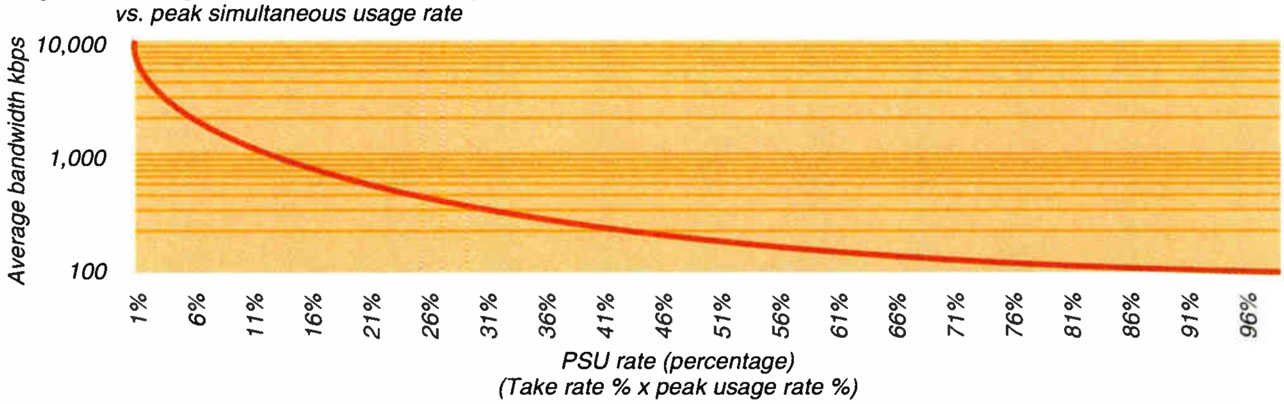
✔ Will enough bandwidth be provided to carry all the simultaneous traffic required? (a function of subscription rate and peak simultaneous utilization rate).

When planning for interactive digital video-on-demand, for example, the MSO might assume that in a network of 10,000 homes, 50 percent of the homes passed subscribe to a broadcast video service such as cable TV. Among these subscribers, perhaps 50 percent will subscribe to interactive digital video, with 10 percent of these customers using the service at the same moment. The number of digital video channels which must be available to each of the 20, 500-home fiber nodes in support of this service is 13 [(500 x 50%) x 50% x 10%]. At eight digital video channels per analog channel, the service will require the equivalent of less than two analog channels to offer this level of interactive video service.

The large bus structure of the HFC network provides a great deal of bandwidth for high-speed data, as well (see Figure 4). If 50 percent of the cable TV homes subscribe to high-speed data, with 40 percent using the service at the same moment, the peak simultaneous utilization rate would be 10 percent [(50% x 50%) x 40%].

At this utilization, the average data rate per subscriber of 1 Mbps could conservatively be supported in a typical HFC network with 500-home nodes.

Figure 4: *Average data services bandwidth per home served vs. peak simultaneous usage rate*



One solution

The MSO, like everyone else, has an opportunity to generate additional revenues through the deployment of broadband services. The difference is that the architecture of its existing plant is similar to that of the full-service HFC network. This distinct advantage–in terms of cost, operations and capacity alone–makes it clear that HFC is the right choice for the MSO to cost-effectively deliver new services.

Since an HFC system will have adequate capacity for all of the services that can be envisioned well into the future, MSOs ought to take advantage of their head-start and be the first to give customers what they want. CED

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HFC, SDV cost differential still muddy

A maze of variables

By Leslie Ellis, Contributing Editor

Network operators seeking a quick answer to the architectural cost question between hybrid fiber/coax and fiber-to-the-curb should probably pack a lunch and sharpen several pencils.

The answer lies somewhere in a maze of variables, mostly related to existing network architecture and deployment plans, according to executives from three companies that have examined the issues carefully. The three include: BroadBand Technologies Inc., which makes switched digital video gear for FTTC networks; AT&T Network Systems, which provides components for both topologies; and Pacific Bell, which is aggressively building HFC networks.

Outside of agreeing that the answer is elusive, the three share little common ground. "There's really no way to craft an apples-to-apples comparison model when you're trying to decide between HFC and FTTC," says Harry Bosco, chief architect of global public networks for AT&T Network Systems. He made his comments during a recent press briefing at Pacific Bell's Concord, Calif. broadband laboratory.

AT&T almost has to sit on the fence for the FTTC/HFC debate, however, because it serves as an integrator of both topologies.

The reason for the cost obscurity? Wide differences in existing plant conditions and the amount of fiber optic cable–including associated labor costs–that needs to be installed make it difficult, if not impossible, to develop a "typical" economic model, Bosco says.

Table 1: Cost of LEC HFC and FTTC networks, by equipment category, 1995

	LEC HFC Video overlay	LEC HFC Integrated voice and video	LEC FTTC
Per home passed			
Electronic equipment			
Headend	$50	$50	$50
Host Digital Terminal	-	140	110
Fiber node	15	125	230
Digital video	40	15	-
Power	15	30	50
Total electronic	120	360	440
Media	110	120	70
Installation	100	110	280
Total per home passed	330	590	790
Per subscriber			
Network Interface Device	-	100	-
Media	10	30	30
Installation	30	30	120
Total per subscriber	40	160	150
Total excluding set-top	370	750	940
Analog set-top	120	120	-
Digital set-top	330	330	330
Cable modems	550	550	550

Source: Northern Business Information

"The cost considerations mainly come down to labor, because switched digital video plant requires [that] a lot more media goes into the ground than does fiber," Bosco says.

But BBT's executives are adamant that switched digital makes more financial sense. Defining a so-called "apples-to-apples" model with identical service sets and identical geographic coverage parameters, BBT's Don McCullough, product line manager for the manufacturer, says SDV's business case comes in at a lower price–assuming that more than 15 percent of the customers actually subscribe to interactive services.

"For an area that passes 900 homes, using a full service network design that includes telephony, analog video, digital video and interactive services, with more than 15 percent take rates on interactive video, SDV becomes less expensive," McCullough says, noting that "as penetration goes up, you get congestion [in HFC networks] on the coax and you have to start adding electronics and subdividing nodes."

Not surprisingly, engineers with Pacific Bell disagree with BBT's analysis. The telco, which has about 5.7 million feet of coaxial cable already hanging from poles and another 600,000 feet underground, says that it chose HFC because FTTC and switched digital video designs are at least 30 percent higher in cost than the tried-and-true HFC topology.

Huge savings can be incurred in laser costs alone, notes Keith Cambron, chief network architect and director of systems engineering for the telco. For example, PacBell's cost per home comes in at roughly $36, while the lasers used in SDV networks cost $54 per home.

"HFC is not a religion for us–it's simply the right technology, at the right price, and at the right time," Cambron says of PacBell's HFC decisions.

However, PacBell's business model still roughly fits BBT's philosophy. Although PacBell executives wouldn't venture a guess on penetration rates for interactive video services, the telco is admittedly using HFC to bring down the costs of delivering residential telephone–and doesn't expect to snap off big analog or digital TV penetration rates right away, executives said during a briefing.

Never-ending debate

Who comes out on top of the topological debates? Equipment suppliers, according to a study performed by Northern Business Information. The NBI study, called "U.S. Broadband Equipment Report: 1995," says that local exchange carriers will increase their spending on HFC and FTTC gear, excluding cable modems and installation costs, from $79 million this year to $1.9 billion in 1999. Cable operators, on the other hand, will raise their antes on HFC networks, again not including cable modems and installation costs, from $110 million this year to $500 million in 1999.

Specifically, the report shows that the telcos pursuing HFC as an overlay to their existing

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twisted pair phone plant will spend about $330 per home passed. The integrated voice/video HFC topology runs that number up to $590 per home passed, and a full, switched digital system in an FTTC architecture costs $790 per home passed, the study shows.

Set-top terminals were excluded from those totals, but figure in at about $120 for analog devices, and about $330 for digital set-tops.

The study also notes that telcos will install many of the video network elements during initial builds, while they add drop cables, in-home wiring and set-tops as they pick up customers.

On the cable side, NBI's research shows that MSOs need only spend about $45 per home to upgrade existing HFC networks to a point where they can carry video-on-demand, excluding a $330 digital set-top box.

To deliver voice services, the study indicates that MSOs will need to spend about $415, which on a per-subscriber basis breaks out as follows:

- ✔ $175 for the telephone switch
- ✔ $100 for the host digital terminal (HDT)
- ✔ $100 for the network interface device mounted on the side of the home
- ✔ $10 for media
- ✔ $30 for installation.

Notably, NBI expects the cost of HDTs, fiber nodes, cable modems and digital set-tops to drop over the next five years, which applies to both the telco and cable models.

These kinds of architectural debates can go on and on, with no clear answer in sight. In a telco lineup, several RBOCs, including Ameritech, BellSouth, Nynex and independent telco GTE are constructing (or planning to construct) HFC video overlay networks. Bell Atlantic and SBC Communications (formerly Southwestern Bell) are shooting for switched digital video; PacBell and Southern New England Telephone will build integrated voice and video HFC networks, according to the NBI study.

NBI's analysis was performed independently through data collected from HFC and FTTC equipment makers, and is tied to a start date in the 1996-1997 time frame.

Also, NBI executives stress that the numbers listed are averages, and can sway based on the number of coaxial drops that need to be replaced, the percentage of customers located in apartment buildings, the number of homes served per fiber node, the number of lines per subscriber, and a fleet of other variables.

But, for cable companies to break into the lucrative telephony business, "they will need allies–or rapid deregulation of cable rates–to raise cash for networks," the study notes. Also, several unresolved issues need to be addressed, including number portability, interconnect charges, and co-location issues.

Still, more than 15 states have already passed laws letting MSOs into the telephony business; even PacBell notes that the primary goal of its HFC build in California is to shave operational expenses at a rate of $50 per line out of its primary telephony business.

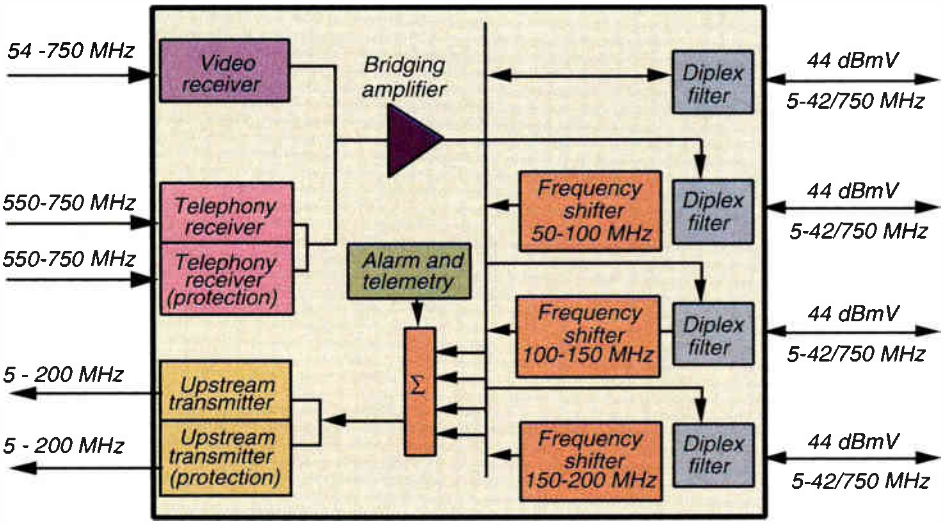
In the end, AT&T executives note, the architectural decisions will likely be performed on a case-by-case basis, where factors including subscriber density, existing network design, desired outcome and business model focus come into play.

"To date, nobody has come in to us with their system characteristics and asked us to do a side-by-side comparison," notes an AT&T spokesperson. CED

Future-proofing with hybrid fiber/coax

Expansion capacity

Figure 1: *Optical distribution node*



By John Frederick, Program Manager, Access Platforms Systems Division, ADC Telecommunications Inc.

As networks expand, and demand increases for telephone, interactive digital, and data-generating work-at-home services, hybrid fiber/coax (HFC) networks will be called upon to provide additional bandwidth. Today's HFC networks are being designed with plenty of expansion capacity, allowing them to be cost-effectively installed now, and economically augmented when necessary.

The basic design of HFC networks maximizes utilization of the installed bandwidth. For example, modulation techniques can allow up to 240 DS-0s per 6 MHz, and up to eight digital, 4.0 megabit channels per 6 MHz of spectrum. As service requirements grow, the first amplifier on each of the four legs of an optical node can, itself, become an optical node, extending the full 750 MHz bandwidth to the subscribers it serves. By reducing the service area of the optical node, the available bandwidth for each subscriber is effectively quadrupled.

Another often-cited concern is that of upstream capacity. This, too, can be increased by a factor of four, using frequency block shifting. Using these and other techniques, the carrying capacity of HFC networks can be easily expanded to support new services and increased demands. By deferring the expenditure until justified by revenue-producing demand, network providers can control today's costs without limiting performance.

Future demands on today's networks

As single function networks become competing, multi-service networks, each will carry a variety of services, and each will affect the network differently. Some, like digital video, will increase the demand for downstream bandwidth. Others, such as telephone service, high-speed data services, or interactive video, are more "symmetrical," using both upstream and downstream bandwidth.

Services that are broadcast, such as analog or digital video, are unaffected by the number of users. Individualized services, interactive video and telephony, for example, are affected by utilization. As more subscribers take and use interactive services, the load on the network will increase.

Strengths of hybrid fiber/coax

The HFC network is cost-effective to build, and relatively easy to install. Fiber provides high bandwidth, while coax keeps costs reasonable and eliminates the need for a separate power network. HFC uses a 750 MHz spectrum, allocating space for telephony, analog and digital video services, and future interactive services.

Digital modulation techniques let HFC carry digital signals, analog signals and power. Conversely, architectures such as switched digital video (SDV) need a primary network and an overlaid network to do the same. Expensive, specialized capabilities necessary to provide interactive video services have to be built into some systems. With HFC architectures, they can be added when and where needed.

Detractors have suggested that, once new services come online, today's HFC network will lack the capacity to deliver them. In fact, the ability to expand to many times the original installed capacity can be built into modern HFC networks. This expandable architecture has several advantages. It allows demand to drive the buildout of the network. Those areas that grow beyond expectations can be accommodated by expanding the local network capacity. Those that grow less, or where the demand for new services is smaller, may not have to be expanded at all. With HFC architectures, the cost of expansion can be modest and the changeover quick and non-disruptive.

HFC architecture

The modern HFC network uses a 750 MHz spectrum equivalent to 110 6-MHz downstream channels. Bandwidth from 5 MHz to 42 MHz is reserved for upstream signaling. The downstream portion of the spectrum supports a mix of analog video, digital broadcast, interactive video, telephone and data services. The network transports signals via optical fiber from the headend or central office to optical nodes. The optical node converts optical signals to electrical signals, and distributes them among four coaxial RF legs, or trunks. Each leg employs a bus architecture to distribute signals to end users.

Node sizing

The number of subscribers served at each node will depend on the services offered. Traditional cable TV installations have used nodes serving 2,000 homes or more. Today, factors including the lower cost of optics have reduced the number of homes passed to about 500 per node. Telcos or local exchange carri-

ers tend to serve fewer homes per node, due to a near 100 percent take rate for telephony service. Telco optical nodes usually range in size from 100 to 500 homes.

As networks change and services converge, a number of factors will determine node size, including:

✔ housing density
✔ services offered
✔ take rates for services
✔ power requirements.

In planning for growth, designers often use an interval of 15 years, the typical time between significant network rebuilds. Projecting over that interval, it makes sense to install basic infrastructure initially, adding equipment needed for emerging services as required. This will be particularly true of modulation and encoding for interactive video.

In an HFC network, modulation and encoding can be added on a per-channel basis as interactive revenue grows. SDV architectures, on the other hand, require that the network be fully equipped for high interactive service take rates at initial deployment. The flexibility of the HFC architecture lets the network be engineered to fit its application. Individual nodes can be configured to suit the local demand, both in terms of specific services offered and in carrying capacity.

Figure 2: *Digital video modulation techniques*

	4-VSB	64-QAM	16-VSB	256-QAM
Number of movie channels (@ 1.5 Mbps video compression)	11	17	23	24+
Number of video channels (@ 4.0 Mbps video compression)	3	6	8	8+
Number of high motion channels (@ 6.0 Mbps video compression)	2	4	6	6+
Number of HDTV channels (@ 18 Mbps video compression)	—	1	2	2

Figure 3: *Future service assumptions*

Services	Assumptions
Telephony	• 1.8 lines per home • Non-concentrated
Videophone	• DS-1 (1.544 Mbps) connection • 10% take rate, 6ccs
Entertainment video	
Analog broadcast	• 60 NTSC channels
Digital broadcast/NVOD	• 240 digital channels @ 4.0 Mbps MPEG
Interactive digital video	• 25% take rate/25% peak rate @ 4.0 Mbps MPEG
Data-based services	• 1/2 DS-1 (770 Kbps) per home • Dedicated/not shared

Increasing upstream capacities

As usage of symmetrical services—telephone and data services—increases, the first section of the spectrum to feel the pinch will be the relatively small upstream segment at the low end of the spectrum. Historically, it was allocated for reverse signaling because channel 2, at the low end of the analog broadcast band, begins just above it. That does not mean, however, that upstream capacity must remain limited.

By using frequency block shifting, upstream traffic from each of the node's four legs is shifted to form a composite occupying the 0-200 MHz band on the fiber link between the node and the serving hub. Each leg, for purposes of upstream signaling, becomes a virtual node.

Optional frequency shifters (see Figure 1) are placed in the optical node. These block upconvertors, which plug into the RF amplifier board, shift the reverse path signal and frequency-division multiplex it for transmission to the serving hub. There, block downconvertors return the signal to its original 5 to 42 MHz band for transport to the central office. This approach can quadruple upstream capacity with no change in the existing coaxial plant. Addition of frequency shifters is fast and easy, with no major preconfiguration or reworking required.

Migration to smaller nodes

A 15-year planning window is desirable, but even the best laid plans can be exceeded. Neighborhoods develop, and service take rates exceed expectation. For these and a variety of other reasons, network segments can become crowded. On HFC networks, the solution quadruples network capacity for services such as interactive video.

Each of the four legs of an HFC optical node has an initial RF amplifier, which can be designed for conversion to an optical node. This extends fiber farther into the network, quartering the customer coverage of each optical node. Essentially, a single node serving 200 homes can become four nodes, each serving 50. Each 50 homes now has access to the full 750 MHz bandwidth, instead of just a share of that spectrum.

Obviously, when customer bases are subdivided this way, the total bandwidth of broadcast services is unchanged, because the same channels are being broadcast. For subscriber-dedicated services, such as interactive video, new bandwidth becomes available when the optical node is divided. For example, if the original optical node had 200 MHz of bandwidth available for interactive services, the provider can effectively add 600 MHz of capacity serving the subscribers on the original node. As noted earlier, this increase applies to both upstream and downstream traffic.

The process is relatively simple. With the addition of an "optical lid" to the RF amplifier, along with modular optical receivers that plug into the optical lid, the amplifier becomes a functioning optical node. Both forward and reverse path capacities are quadrupled with no major change to the coaxial plant required. Combined with frequency block shifting, this modification increases total upstream capacity to 16 times that available on the original optical node.

Maximizing capacity

Because telephony take rates are high and the demand for data services is likely to increase sharply, it is critical that both make efficient use of available bandwidth.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Modulation techniques that place digital signals onto an RF carrier have a large effect on efficiency. HFC telephony is typically placed in the 550 to 750 MHz range of the available spectrum, by modulating digital signals onto an RF carrier. The number of DS-0s carried within a 6 MHz channel can vary substantially. Systems using orthogonal frequency division multiplexing (OFDM) can transport 240 DS-0s per channel; other transmission schemes, such as QPSK, transmit as few as 120.

As with telephony services, the efficient use of bandwidth for delivery of video services depends on the modulation scheme. A variety of modulation schemes are available, and each is affected by the MPEG rate, which controls the degree of compression (see Figure 2). A typical combination would be 16-VSB or 256-QAM modulation with 4.0 Mbps MPEG compression. This would be suitable for all but very high-motion video.

Such a combination would allow eight digital channels per 6 MHz analog channel. A typical network might carry 240 digital broadcast channels and 60 analog broadcast channels, as well as dedicated interactive video channels. It is likely that future technology will allow even more efficient modulation.

Future HFC service delivery

To demonstrate the carrying capacity of the HFC network, compare the capacity of today's typical 750 MHz network segment against the future demands of 200 households served by an optical node. Using the suggested planning range of 15 years, assume the following requirements per household in the year 2010 (see Figure 3):

Telephony: 1.8 DS-0s, non-concentrated. Today, the typical household has 1.2 DS-0s. Some analysts suggest that this number of DS-0s per home passed will actually decrease as the number of competitors increases, but in the interest of a challenging test, assume an increase. Note that telephony traffic is symmetrical, upstream and downstream.

Videophone: 1 DS-1. Assume a 10 percent take rate and a busy hour usage rate of six ccs, or approximately 17 percent.

Broadcast analog video: 60 channels. This is what most networks carry today. It is unlikely to increase; in fact, most forecasts predict that analog broadcasting will decrease, as it is slowly replaced by digital channels.

Digital broadcast video: 240 channels. This assumes use for near-video-on-demand. Specifically, it is the top 20 movies, each showing from the beginning at 10-minute intervals. Assume that each runs two hours, and that a 4.0 Mbps MPEG rate is used.

Interactive digital video: 25 percent take rate, 25 percent peak utilization. The 25/25 assumption is very liberal. Most experts consider a 15/15 utilization rate more realistic. Again, assume a 4.0 Mbps MPEG rate.

Data: One-half DS-1, dedicated. This is a generous estimate of the amount of data an average household will generate. Actually, data would tend to produce more traffic downstream than up, but again, to keep the test interesting, assume symmetry. One-half DS-1 approximates the throughput on a 10 megabit shared Ethernet.

Note that each DS-1 is converted to 24 DS-0s. Assume a modulation efficiency of 240 DS-0s per 6 MHz channel for telephony and data traffic. Also assume use of 16-VSB or 256-QAM modulation for digital video services, providing eight digital channels per 6 MHz. Note that the assumed upstream requirement of 8 MHz for entertainment video is very high. Typical upstream bandwidth required by digital set-top boxes is projected to be 2 MHz over 200 homes.

Adding the total load for each of 200 households yields the totals shown (see Figure 4 and Figure 5). Total downstream bandwidth is 104 6-MHz channels. Total upstream bandwidth is 80 MHz.

***Figure 4:** Downstream bandwidth required*

Services	Bandwidth requirement*
Telephony	360 DS-0s
Videophone	82 DS-0s
Entertainment video	
Analog broadcast	60 6-MHz channels
Digital broadcast/NVOD	30 6-MHz channels
Interactive digital video	2 6-MHz channels
Data-based services	2,400 DS-0s

Total downstream bandwidth required: 104 6-MHz channels

**Per 200-home optical node*

Capacity to spare

In the above test, no expansion of downstream capacity was required. Because the standard spectrum offers 37 MHz of upstream capacity, and the total upstream demand was 80 MHz, frequency block shifters were employed. As shown in Figure 5, this increases the upstream capacity to 148 MHz, almost double that required. Although unnecessary in this case, the optical node could be segmented up to four ways, allowing that 148 MHz of upstream capacity to serve as few as 50 homes, instead of 200. And, of course, there is the significant likelihood that, in future years, new technologies will allow denser compression of signals on existing HFC networks.

Summary

There are a number of network architectures available today. Those that configure fiber throughout the network and which are fully digital tend to be expensive and relatively inflexible. The HFC architecture is substantially less expensive.

***Figure 5:** Upstream bandwidth required*

Services	Upstream bandwidth requirement*
Entertainment video	8 MHz
Telephony, videophone & data	72 MHz

Total upstream bandwidth required: 80 MHz

Total upstream bandwidth available:

37 MHz
x 4 Frequency block shifters
148 MHz

**Per 200-home optical node*

HFC lets expenditures for interactive video services be deferred, with equipment being added on a per-channel basis as demand grows. Competing architectures require that expenditures of $100 to $200 per home passed be made systemwide before interactive video services can be provided.

Suggestions that HFC architectures cannot support the demands for emerging services have little basis. In fact, HFC networks have enormous capacity for growth. As shown in the year 2010 analysis, even 15 years in the future, current HFC networks will have expansion capacity to spare.

The largest single demand–analog broadcast video–will not increase at all. Digital video services, using sophisticated compression schemes, will allow a large number of channels to utilize small amounts of bandwidth. Available technology allows telephony service to be densely packed for efficient transport.

Those optical nodes that do become overloaded can be easily subdivided into as many as four segments without recabling. Subdivision–in which RF amplifiers are upgraded to independent optical nodes–instantly makes four times as much bandwidth available to each subscriber. If additional upstream capacity is required, the need can be met with frequency block shifting. When the various expansion capabilities of HFC networks are used, even extreme estimates of traffic demand do not approach the capacities of the network.

Suggestions that HFC architectures cannot support the demands for emerging services have little basis

Hybrid fiber/coax networks can be extremely flexible in the services and traffic volumes they support. Concerns for their traffic-handling capacities ignore the flexibility of the HFC architecture. Once an HFC network has been installed, there are few obstacles to growth, including cost.

At the same time, HFC networks offer important advantages over fiber-based, fully digital networks. They are less expensive to install, a critical factor in an increasingly competitive environment. Capabilities such as interactive video can be added as necessary. Other network architectures require far more anticipatory building, absorbing capital and generating carrying costs for demands that may materialize only slowly.

Switched digital video networks require expensive set-tops or costly overlay networks for the delivery of modern analog channels. There are more than 200 million analog devices that will have to be addressed until they are replaced with fully digital devices. There is no agreement on how long this will take. This kind of expense can be particularly painful for network providers, because it requires an investment now, while new, digital services may not generate revenue for years.

The HFC network, on the other hand, requires no set-top for delivery of analog services. It will require a set-top when digital services come online, but that cost will be offset by the revenue from the digital services themselves. Based on the benefits HFC offers, and because the perceived limitations of its capacity are, in fact, incorrect, it is an obvious choice among network architectures, particularly if "future-proofing" is the goal. CED

When HFC goes FTTC

Properly designed, a hybrid fiber/coax (HFC) network has far more expansion capacity than many users realize. The combination of fiber to the optical node and coax to the curb is both economical and effective. Nevertheless, there are a number of good reasons that a user might, over a period of years, wish to extend fiber to the curb.

First, when–and if–the traffic on a network becomes purely digital, it may be advantageous to convert to an all-digital transport solution such as fiber-to-the-curb. There are plenty of opinions as to how soon this may happen. In the meantime, analog video is universally in demand, and shows no signs of going away.

Second, there is the remote possibility that, despite the elasticity of an HFC architecture, its capacity could be exceeded (see article, page 52). If this were to happen, it is more likely to occur in specific segments of a network, rather than systemwide.

Finally, there is the simple philosophical decision to extend fiber as far as possible. This is a perfectly legitimate choice, especially if it can be implemented when justified by revenue. In short, FTTC is a functional choice, with both advantages and costs. What it isn't is a must-have technology, without which networks cannot function.

The good news for HFC users is the ease with which it can be converted to FTTC. The better news is that the conversion has a minimal cost penalty. The best news is that an HFC network, converted at a future time, can actually extend fiber all the way to the curb, unlike an FTTC network installed today. The reason for this seeming contradiction is that most of today's so-called fiber-to-the-curb architectures actually stop well short of the curb. The fiber portion of most typical FTTC networks terminates at the optical networking unit, or ONU (see Figure 1a). This device typically serves 20 to 40 subscribers.

In an office or apartment building, the ONU location will essentially be the curb; however, in most residential areas, an ONU will serve an entire neighborhood. From the ONU, signals are carried by copper twisted pair distribution plant to a pedestal. From the pedestal, a twisted pair drop carries signals to the home. Digital signals are transported across twisted pair using CAP-16 or a similar modulation technique. If power or analog signals are to be accommodated, a redundant coaxial network has to be configured.

In a modern HFC network (see Figure 2a), an optical node serves as the optical-to-electrical signal conversion point. While the optical node can serve from 50 to 500 subscribers, in a typical full-

Continued on page 62

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Figure 1a: *FTTC network today*

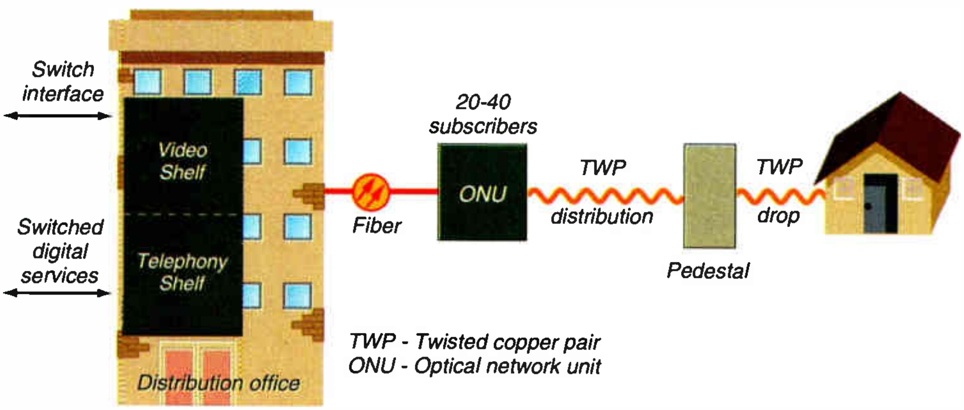


Figure 2a: *Full service HFC network today*

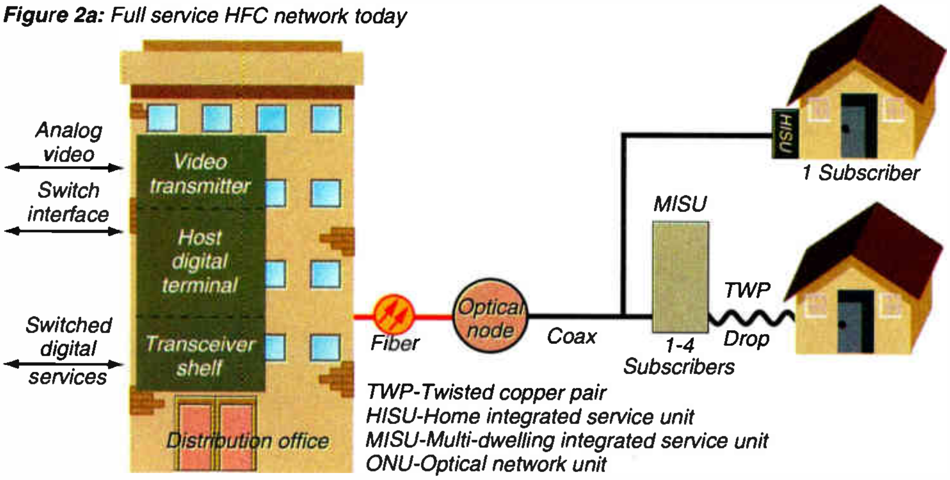
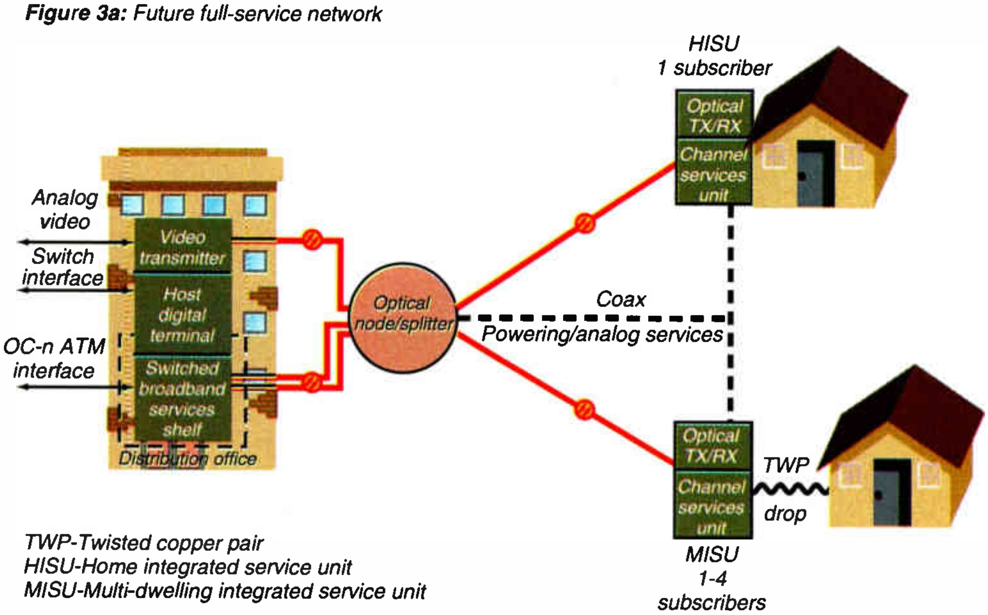


Figure 3a: *Future full-service network*



Continued from page 58

service environment it is likely to serve about 200. From the optical node, coax carries signals to an integrated service unit (ISU). A home ISU (HISU) serves a single subscriber; a multi-dwelling ISU (MISU) serves several. The architecture uses no twisted pair, except for the drop. This brings the broadband pipe closer to the customer, and eliminates the cost of maintaining twisted pair distribution plant.

As cited earlier, there are several reasons to convert HFC to FTTC. It can be done systemwide or just in those segments where it is justified by revenue. In either case, it is a relatively straightforward conversion (see Figure 3a). The distribution office is equipped for pure digital transport. The optical node is modified to incorporate splitters, allowing it to output multiple optical signals rather than electrical. Each ISU, in turn, is converted to a dedicated ONU, and fiber is run from the converted optical node to the ISU.

Unlike today's FTTC networks, this architecture brings fiber literally to the curb, with fiber-served ISUs for each dwelling. The pre-existing coax remains in place to carry power, so infrastructure is augmented, rather than replaced. If the FTTC conversion takes place before the total phase-out of analog services, the coax can also carry analog signals, avoiding the need for expensive conversion.

The actual changeover from HFC to FTTC can be paced by a number of factors, depending on the network builder's business needs. In any case, the conversion yields a true FTTC configuration, with more fiber and less copper than today's FTTC architectures. It allows today's builder to install with confidence, knowing that the HFC architecture completely eliminates twisted pair distribution, and keeps all options open. —J.F.

The survivable network's next question

Which fiber design is best?

By Jonathan A. Morgan, Manager, Strategic Planning, Fujitsu Network Transmission Systems Inc.

There's a reason why the expression "use the right tool for the job" is well-known. It's because the idiom holds true whether the speaker is a mechanic discussing the removal of spark plugs from a car engine or a gourmet chef preparing a prime rib dinner.

When it comes to the telecommunications industry, the expression is also valid. With cable service providers concerned about establishing survivable networks in an increasingly competitive telecommunications environment, it is vital the networks being deployed use the right architecture for the application.

Synchronous optical network (Sonet) transmissions have already proven themselves to provide the most reliable, survivable network architecture for voice communications. Telephone companies, both long distance carriers and local carriers, have made deploying Sonet equipment a priority in the 1990s. Cable companies are beginning to follow suit as all telecommunications service providers shoot for the 99.99 percent reliability goal.

Once a cable service provider has made the decision to make Sonet the transmission method of choice, the company faces the same decisions the telcos have been grappling with for years: What type of network architecture do I need?

The answer is not an easy one. As is the case with any new technology, prior to choosing an architecture, the implementor should consider what the application requires. Once the application needs are outlined, then the proper decisions can be made to determine what type of Sonet configuration is necessary. It's simply a matter of getting the right tool for the job. And when it comes to survivable networks in this era of heightened telecommunications competition, there's precious little room for error.

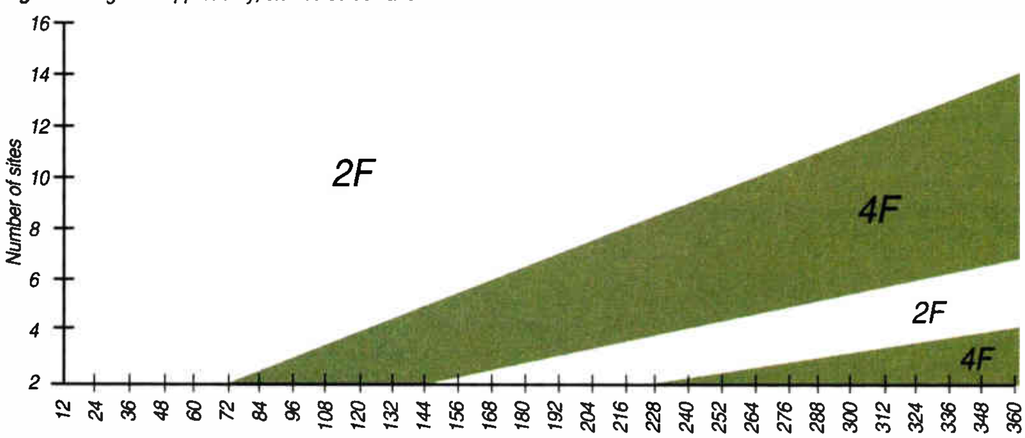
To UPSR or BLSR, that is the first question. If survivability is the objective, the first task is deciding which of the various architectures makes the most sense. There has been much debate across the telecom industry on the merits of unidirectional path switched rings, or UPSR, and bidirectional line switched rings, known as BLSR. Until recently, the debate has focused on comparing UPSR and BLSR, and the product choices relied on two-fiber cables for each ring span.

In general, UPSR is best for applications where traffic homes to a particular location, and for interconnected rings where a great deal of traffic crosses the rings. UPSR is also a simpler, more mature technology to deploy and has gained broad acceptance among telephone companies and competitive access providers because of the revenue opportunities due to its survivability. Cable companies also are using UPSR technology to interconnect headends in a survivable configuration. On the other hand, BLSR has matured more recently and, in certain applications, offers bandwidth advantages when it comes to distributed traffic in single ring architectures.

Should a service provider decide to implement UPSR, changes in traffic distribution may make it practical to migrate to a BLSR architecture. Therefore, one consideration is the capability of the Sonet equipment to migrate without having to be replaced. Fortunately, Sonet equipment is available that provides in-service migration.

While the reasons for using UPSR and BLSR are well-known, expect to hear disagreement when the topic shifts to two-fiber BLSR vs. four-fiber BLSR–a BLSR architecture with four fibers in each ring span. Some service providers believe that four-fiber BLSR is the best answer for all interoffice ring networks. This misconception stems from the thought that it is less expensive than two-fiber BLSR, and that four-fiber BLSR is more reliable. That may not be true. When factors such as traffic load and distribution pattern, cost, network design, reliability and flexibility are considered, two-fiber BLSR might be the best answer in the majority of applications.

Figure 1: Region of applicability, distributed demand



The region of applicability for the distributed demand pattern shows the region improves for four-fiber BLSR compared with the centralized demand pattern. The x-axis is the number of DS-3s, and the y-axis is the number of sites that contain network elements. Two-fiber BLSR is still favorable in 66 percent of the points up to 384 DS-3s. Up to 192 DS-3s, the two-fiber BLSR is generally economical, while both architectures have an equal number of applications beyond that point.

Sharpening the focus on BLSR

Now that BLSR standards have matured, a new focus is being placed on this particular architecture. While some service providers in the telecommunications industry are positioned to use both UPSR and BLSR configurations, the question remains which BLSR configuration should be chosen.

In a two-fiber BLSR design, the two fibers carry working traffic between two sites. One half of the bandwidth in each fiber is dedicated to working traffic, while the other half is reserved for protection. In the event of a network failure, loopback switching ensures survivability. In loopback switching, also

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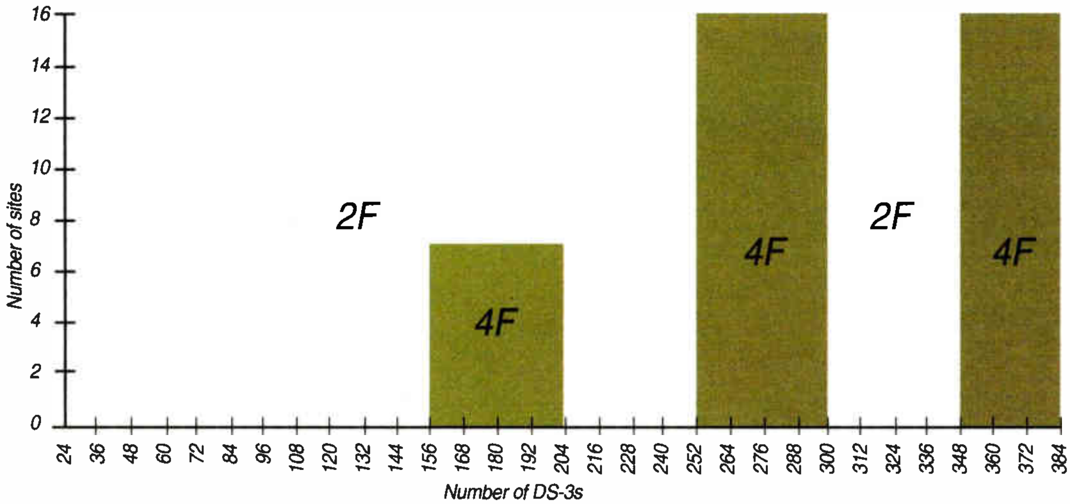
Figure 2: *Region of applicability, centralized demand*



The region of applicability for the centralized demand pattern indicates under what conditions the two-fiber and four-fiber BLSR are economical. The x-axis is the number of DS-3s, and the y-axis is the number of sites that contain network elements (NEs). The white areas show when the two-fiber BLSR is economical, while the green areas show when the four-fiber BLSR is economical. The results show the region of applicability for the two-fiber BLSR is much larger than the four-fiber BLSR. For up to 384 DS-3s, 78 percent of the points on the graph favor the two-fiber BLSR, and 22 percent favor the four-fiber BLSR.

known as ring switching, the protection switching takes place in the nodes adjacent to the failure. Traffic being carried on a working channel toward the failure is looped back to the protection channel and routed around the other side of the ring. The switching is coordinated through signaling in the Sonet overhead channel.

With four-fiber BLSR, two fibers between each site are dedicated to working traffic, and two fibers are reserved for protection. This doubles the bandwidth available, and also allows for the option of span switching–moving traffic to the protection fibers of the same span when a failure takes place on the working fibers–as well as loopback switching. In its most robust physical network design, a four-fiber BLSR can sustain failures on multiple working fibers without losing traffic. However, since four-fiber BLSR makes span switching a priority over loopback switching, the four-fiber BLSR cannot survive a working fiber failure and a complete cable cut in which both working and protection fibers fail.

What some companies don't realize is that the cost of high-speed equipment for a single four-fiber BLSR node is almost twice as much as the cost of a two-fiber BLSR node. Therefore, two-fiber BLSR is much more economical to implement for networks where traffic demand only requires a single two-fiber ring. As the traffic demands exhaust the individual spans of a two-fiber network, a second ring–or overlay–can be deployed to economically increase the capacity of the two-fiber BLSR. Typically, the capital outlay for a second two-fiber ring is still lower than the initial cost of a four-fiber BLSR. Should traffic increase to the point where a second ring becomes necessary in a four-fiber configuration, expect the company CFO to race from his office seconds after the requisition order is placed.

That's why it's important to analyze everything from traffic load to network design before choosing which architecture will be deployed. Guaranteeing a survivable network is one thing. Providing that survivability at a cost that won't put the company out of business is another.

Cost is always a factor

Whether the issue is deploying Sonet rings, upgrading from one architecture to another, or simply adding The Golf Channel, cost considerations are not ignored for long. With cost always a primary concern, it is vital to know when conditions would favor a two-fiber BLSR or a four-fiber BLSR.

To unearth this information, a cost analysis was completed by Fujitsu Network Transmission Systems to determine when each architecture is economically viable. Market research indicates the cost of a four-fiber BLSR node is 1.8 times the cost of similar equipment in a two-fiber node.

Using this as a backdrop, the cost analysis focused on three parameters: traffic demand pattern, number of sites, and the number of DS-3 (45 Megabits per second) signals. When the capacity of the ring was used up, an overlay ring was added. In an overlay ring, additional nodes are placed in offices where the fiber or node is exhausted. Fujitsu's study analyzed three traffic demand patterns.

✔ Centralized demand pattern–Similar to a hubbing or homing pattern, all traffic homes in on a single hub or central office.

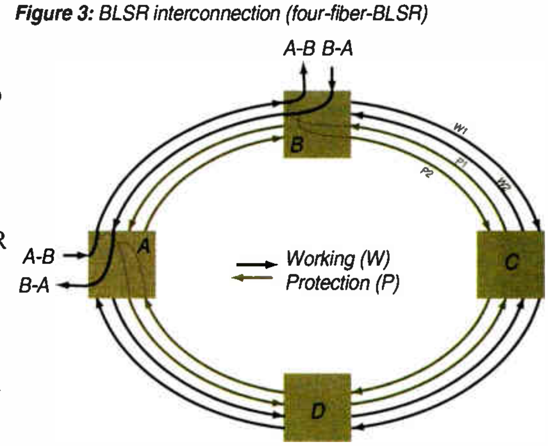
✔ Distributed demand pattern–Similar to point-to-point communications in which all traffic terminates at an adjacent node.

✔ Mesh demand pattern–Traffic is distributed uniformly between all nodes on the ring.

In each pattern, the results indicated a two-fiber BLSR configuration is less expensive in the majority of scenarios. As the number of DS-3s increased, two-fiber remained a more cost-effective architecture 78 percent of the time in the centralized pattern and 66 percent of the time in a distributed pattern. While an overlay ring is required sooner using the two-fiber design, often the cost remained less to deploy the overlay ring than the initial cost of a four-fiber ring.

When the results were compiled, the analysis indicated the cost benefits of two-fiber and four-fiber BLSR are directly linked to the number of nodes, the number of DS-3s and the demand pattern. While there are applications where it was advantageous to deploy a four-

Figure 3: *BLSR interconnection (four-fiber-BLSR)*



In a four-fiber BLSR, two fibers carry working traffic, and two fibers are reserved for protection. This effectively doubles the bandwidth over two-fiber BLSR. However, the four-BLSR also requires twice the optics. A key difference between the two BLSRs is the four-fiber performs span switching and loopback switching, while two-fiber does just the latter. Span switching provides the capability to switch to the protection fibers, over the same span, when a failure occurs that only affects the working fibers. The four-fiber BLSR allows multiple working fiber failures to occur without loss of traffic.

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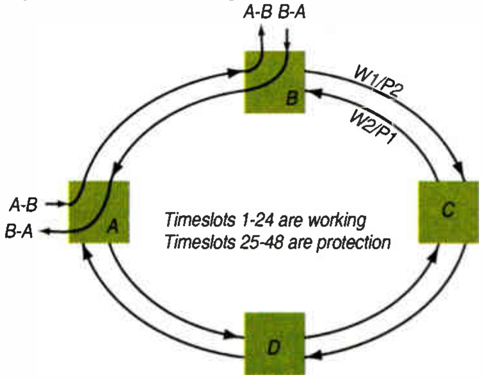
Figure 4: Two-fiber BLSR diagram



fiber BLSR architecture, the applications were not as numerous as they were for a two-fiber design. The four-fiber configuration had most application possibilities in the distributed traffic scenario, yet the two-fiber BLSR still outdistanced the four-fiber in this test, particularly at lower demand levels.

In addition, the cost analysis did not include the expense of the fiber itself. Because diverse routing of the working fibers and the protection fibers are the key to four-fiber BLSR's increased reliability over two-fiber BLSR and UPSR, additional fiber is necessary. This extra fiber raises the overall expense of the four-fiber architecture. Studies indicate the cost of a ring with diverse routing methods is about 13-18 percent greater than a ring without them. And when it comes to cost, nothing can be forgotten.

Survivable, reliable, flexible

It's no secret that survivability and reliability are the reasons anyone planning to offer broadband services anytime soon is moving toward Sonet ring architectures. The switching techniques in the ring design have helped telcos nationwide reach 99.99 percent reliability. Telephone customers expect to receive a dial tone the instant they pick up the phone. With Sonet rings being deployed, cable service providers can make the same claim.

Of course, the reliability and potential down time is different, depending on whether two-fiber or four-fiber BLSR is used. First, the span switching technique in four-fiber BLSR has higher priority than loopback switching. Therefore, if the working and protection fibers are not diversely routed, there are a number of double failure scenarios that would not be survivable in a four-fiber architecture. These scenarios would not affect the reliability of the two-fiber BLSR, however. Second, if the working and protection fibers are not diversely routed in a four-fiber design, and the span switching feature is disabled, the reliability is further reduced. The disastrous effect on network reliability is obvious.

In every scenario, the reliability analysis indicated that the two-fiber BLSR was more reliable than a four-fiber BLSR that did not diversely route working and protection fibers. As the number of nodes and distance between nodes increases, the reliability of the two-fiber BLSR increases over its four-fiber cousin. Conversely, when the working and protection fibers are diversely routed in a four-fiber BLSR, it is more reliable than the two-fiber BLSR in every scenario tested. This holds true as the number of nodes and the distance between nodes increases. For smaller rings, however, the reliability of one architecture over the other is negligible. The analysis concluded that four-fiber BLSR had a clear advantage for large rings such as in long-distance carrier networks when diverse routing was

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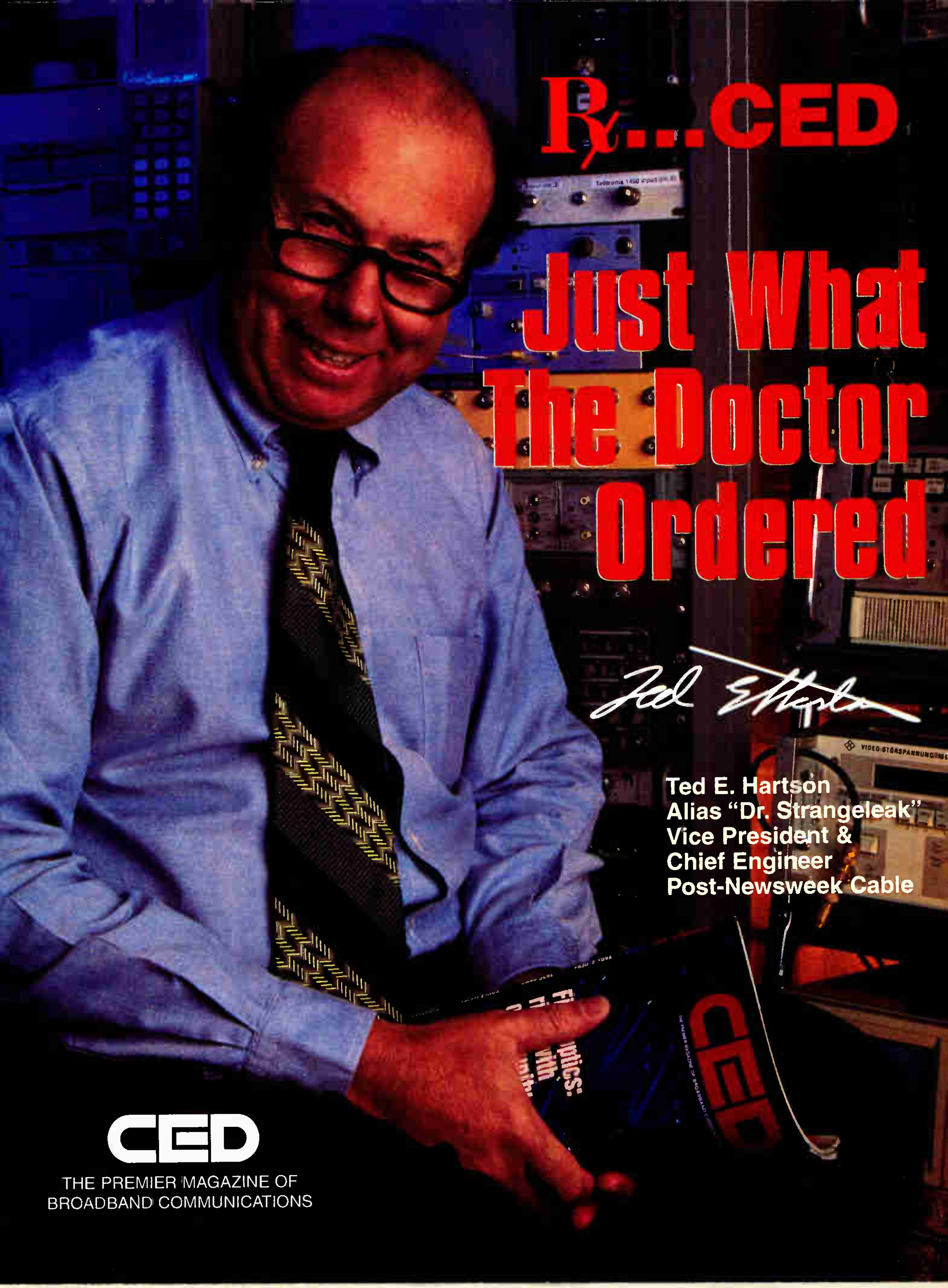
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Laser chirp in linear fiber optic links

How to manage the trade-offs

By Dr. Hank Blauvelt, Vice President, Fiber Optic Technologies, Ortel Corp.

Chirp is an important characteristic of fiber optic transmitters. The vast majority of fiber optic transmitters are based on intensity modulating an optical signal. In this case, the original RF signal is recovered by direct detection with a linear, high-speed photodiode. In the process of producing intensity modulated light, most transmitters produce modulation of the optical wavelength. This modulation of the wavelength is referred to as chirp.

Chirp has a significant impact on both the carrier-to-noise ratio (CNR) and the linearity of fiber optic links. As it turns out, high chirp is good for CNR, but bad for CSO. To optimize the quality of the signals transmitted through the fiber link, it is necessary to use lasers within a range of chirp levels. It is also desirable to maintain tight tolerances for the laser wavelength.

CNR is affected due to a phenomenon known as interferometric intensity noise (IIN). Distortion is affected due to the combination of chirp and fiber dispersion. Chirp primarily affects CSO, but can also degrade CTB, if the chirp and dispersion is sufficiently high. Although chirp is often characterized by the frequency shift per milliamp (mA) of current change (for example 100 MHz/mA), the relevant factor for both IIN and distortion is the total chirp due to all of the channels. This can be characterized either as an RMS chirp due to all of the channels or as a full width half maximum (FWHM) of the optical linewidth. The total RMS chirp is given by:

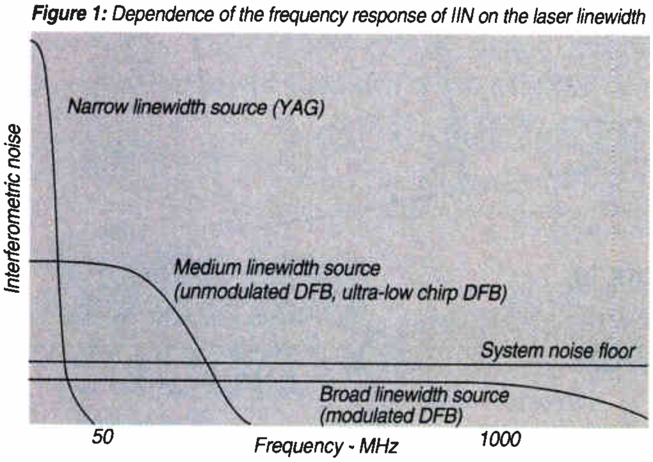
$$RMS\ Chirp = OMI(I-I_{th})(N/2)^{1/2}C$$

Where OMI is the optical modulation index, $(I-I_{th})$ is the laser bias current above threshold, N is the number of channels, and C is the chirp in MHz/mA. The FWHM chirp is approximately 2.35 times the RMS value for multichannel modulation.

In intensity modulated, direct detection fiber optic links, the RF current out of the photodiode is proportional to the optical power incident on the photodiode. The optical power is proportional to the square of the magnitude of the electric field of the optical signal. Thus, although photodiodes are very linear devices in terms of the output current being proportional to the input power, they are extremely nonlinear in terms of the response to the electric field.

In most situations, the important property is the fact that they linearly convert optical power to electrical current. This is because optical transmitters have a complementary property; that is, they linearly convert electrical current to optical power. The situation becomes more complicated, however, if the optical signal contains more than one wavelength or optical frequency.

Figure 1: *Dependence of the frequency response of IIN on the laser linewidth*



When the optical signal contains two wavelengths, the electric field has components at the optical frequencies corresponding to those wavelengths. The property that the output current is proportional to the square of the electric field means the photodiode acts like a mixer. The output current contains a DC component and a component at the difference frequency between the two optical signals. In most linear fiber optic links, the fiber is carrying light from a single transmitter. The situation described above of beating between two wavelengths does not directly occur. However, in links with optical reflections, a related phenomenon does occur due to beating between directly transmitted light and light that has been twice reflected. This is the source of interferometric intensity noise.

Interferometric intensity noise refers to the signals produced by the mixing in the photodiode of light directly transmitted through the fiber with light that is reflected twice within the fiber. If the laser wavelength was perfectly stable with time, then there would be no difference in the wavelength of the directly transmitted light and the doubly reflected light. In this case, the effect of IIN would be to change the DC level.

In reality, the wavelength of the source laser does change with time. The result is that IIN is produced, which extends out in RF frequency to a value corresponding to the maximum difference in the optical frequency of the directly transmitted and doubly reflected optical signals. The extent of the deviations in optical frequency, or the optical linewidth, is thus an important factor in IIN.

To produce IIN, there must be double reflection of the optical signal. Such reflections are unavoidable as a result of backscattering within the fiber itself. IIN can be enhanced if optical components with poor optical return loss are used, but the impact of discrete optical reflections is negligible with high return loss components. The total amount of IIN, summed over all RF frequencies, depends only on the levels of the directly transmitted and doubly reflected light levels. However, the frequency dependence of this noise is determined by the optical linewidth.

This is illustrated in Figure 1. When a narrow linewidth source is used (such as a YAG laser), the IIN level is high at low frequencies, but falls off to negligible levels below the cable TV band. When a broad linewidth source (such as a modulated DFB laser) is used, the IIN is nearly independent of frequency across the cable TV band. The linewidth of a modulated DFB laser is determined by the chirp level. The more chirp the laser has, the wider the linewidth and the lower the noise per unit frequency within the cable TV band.

From the standpoint of CNR, it is therefore desirable to have chirp that is either extremely low, so that all noise is below the cable TV

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Figure 2: CNR vs. link length for three different levels of chirp

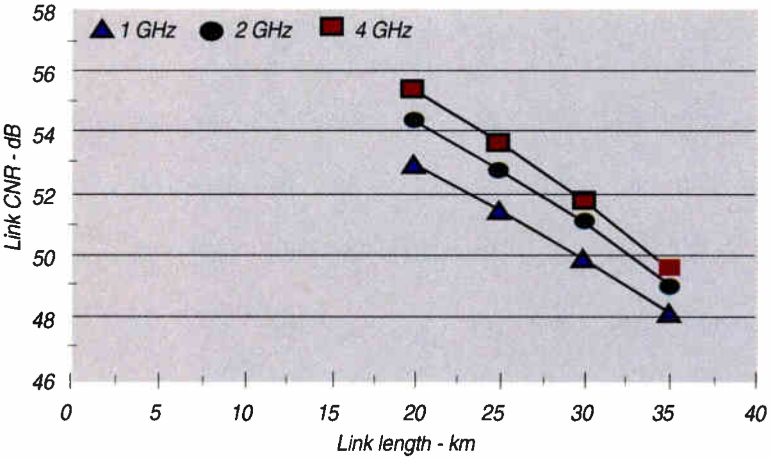
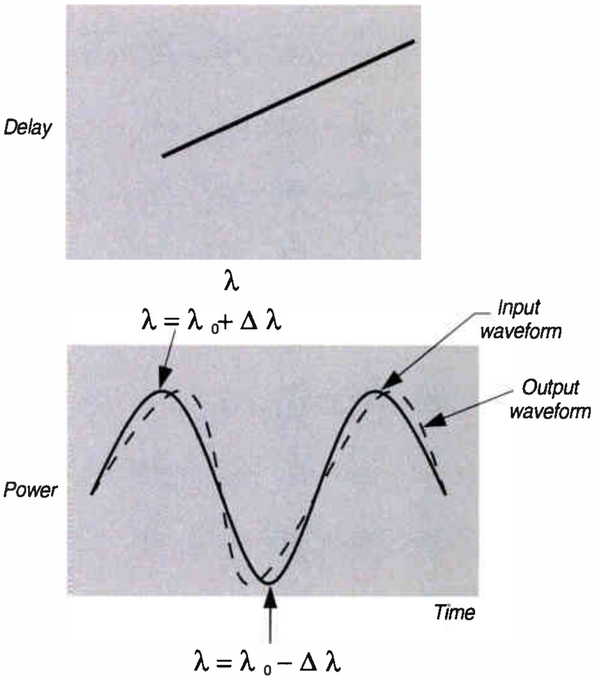


Figure 3: Distortion of a sinusoidal signal due to chirp and dispersion



band, or else very high to spread the noise over a wide frequency interval. The extremely low chirp case is not attainable with directly modulated DFB lasers. Thus, for links with directly modulated DFBs, the higher the chirp, the better the CNR. Figure 2 shows the CNR vs. distance for DFB links with three different levels of chirp[1,2]. In all cases, a 10 mW laser was assumed with an optical modulation index (OMI) of four percent and a receiver noise of 7 pA/Hz$^{1/2}$. The parameter in these graphs is the total RMS chirp due to all of the channels.

Chirp and dispersion

In the previous section, the benefits of high chirp to link CNR were discussed. Unfortunately, because of fiber dispersion, distortion is produced within the fiber link, which increases with laser chirp. To avoid excessive CSO from chirp and dispersion, an upper limit should be imposed on the laser chirp.

Dispersion of optical fibers refers to the property that the speed of light within the fiber depends on wavelength. Dispersion measures the rate of change in the transmission time with wavelength. Standard fiber has a zero dispersion wavelength of about 1310 nm. Near the zero dispersion point, the transmission time does not vary with wavelength. Away from the zero dispersion point, the dispersion increases approximately linearly with wavelength.

The signal distorting properties of chirp and dispersion are illustrated in Figure 3. In this case, the laser center wavelength is such that the transmission time increases as the wavelength increases from chirp. This laser also has the property that the wavelength at the peaks in the optical signal is greater than when the optical signal is at a minimum.

The lower part of Figure 3 shows what happens to this signal after it is transmitted through the fiber. At the output of the fiber, the peaks and valleys of the signal are shifted in time by different amounts, resulting in a distorted output waveform. This distortion results primarily in CSO[1,3]. The resulting second order distortion has a strong frequency dependence, being proportional to the square of the frequency of the distortion.

The CSO resulting from chirp and dispersion depends on the channel frequency and on the chirp and dispersion. The dispersion, in turn, depends on the fiber length and the deviation of the laser wavelength from the zero dispersion point. The level of second-order distortion varies as the square of four parameters: the channel frequency; laser chirp; fiber link length; and the deviation of the laser wavelength from the zero dispersion point. As might be expected, depending on the values of these four quantities, CSO from chirp and dispersion can vary from negligible levels in some links to being the dominant source of CSO in other cases. This effect is the reason direct modulation of 1550 DFB lasers is not viable for AM video transmission. It can also be the dominant source of CSO in links operating near 1310 nm, unless some precautions are taken. If reasonable precautions are taken, then chirp and dispersion will have minimal impact on link CSO.

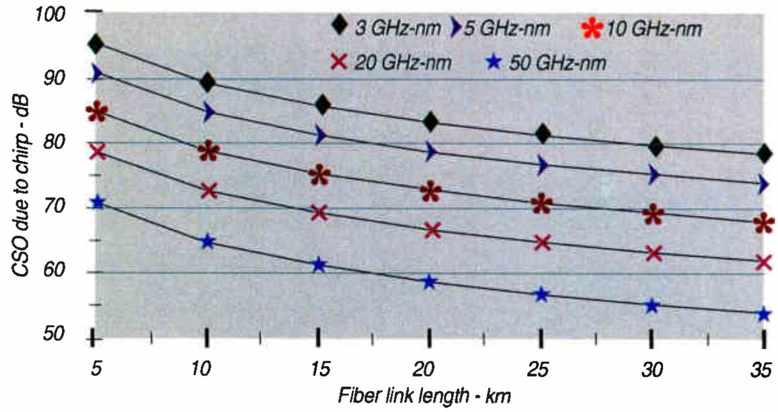
The CSO due solely to chirp and dispersion is shown in Figure 4. All lasers will exhibit additional second-order distortion resulting from other mechanisms which will add to the distortion from chirp and dispersion. On average, the CSO will add according to a 10 log rule, but a specific laser can have either more favorable or less favorable distortion addition. The parameter in Figure 4 is the product of the total RMS laser chirp in gigahertz and the offset between the laser wavelength and the zero dispersion wavelength in nanometers.

The graph is for the channel with the most distortion from chirp and dispersion, which for an 80-channel link is the CSO at 548.5 MHz. As can be seen, when the product of RMS chirp and wavelength offset is less than 10 GHz-nm, then the link is relatively immune from dispersion effects. At 20 GHz-nm, chirp is becoming important for longer links, and at 50 GHz-nm, chirp and dispersion will be the dominant CSO mechanism for longer link lengths. For lasers with high chirp and a loose tolerance for the wavelength, the product of RMS chirp and wavelength offset can potentially approach 100 GHz-nm, which would result in unacceptable CSO, even for relatively short links.

Most transmitters for AM video now incorporate predistortion to linearize the DFB lasers. Like other distortion mechanisms, CSO resulting from chirp and dispersion can be corrected by predistortion. However, unlike other mechanisms, the CSO from chirp and dispersion depends on the fiber used during the measurement.

When a predistorter is aligned, it is fairly easy to cancel the distortion introduced by the fiber used during the alignment. The problem is that the transmitter will eventually be deployed with a different fiber which can have a different level of dispersion. If the fiber dispersion is different, for example, because of a different link length or different zero dispersion wavelength, then the predistorter will not

Figure 4: CSO at 548.5 MHz vs. link length for different levels of chirp and dispersion



be optimally aligned and the CSO of the link will be degraded from the value measured during the production testing. Since it is generally not practical to realign the predistorter for each fiber in the field, it is necessary to ensure that the amount of CSO because of dispersion will always be low. To do this requires controlling the laser wavelength so that it is close to the nominal zero dispersion point and setting a maximum limit for the laser chirp.

Because of the contradictory requirements on chirp related to IIN and CSO, some compromises must be made, particularly for long links. If the maximum allowed chirp level is set very low, then CSO degradation can always be avoided, but the CNR will be seriously degraded from IIN. If high chirp levels are allowed, then better CNR is achieved, but there is a risk of significant CSO degradation if the laser is installed on a fiber with a different amount of dispersion than the one used for production testing.

The most practical approach is to allow moderate levels of chirp, which minimizes (but doesn't eliminate) the chances for CSO degradation without causing severe CNR degradation from IIN. For this reason, the author's employer, a supplier of linear lasers, generally recommends restricting RMS chirp to no more than 2 GHz (4.7 GHz full width half maximum). For links beyond 25 km, it is also recommended to impose a tighter limit on laser wavelength of 1310 ± 5 nm. With these guidelines, high CNR can be achieved with minimal risk for CSO degradation. **CED**

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Bandwidth management in an HFC network

Satisfying growing service demands

By G. Keith Cambron, Director of Systems Engineering for Consumer Broadband Services, Pacific Bell, and Fred Kemmerer, Technical Manager, Consumer Broadband Networks, AT&T Bell Laboratories

Pacific Bell's Consumer Broadband Network (CBN) is a hybrid fiber/coax (HFC) design capable of responding to varying service demands. CBN is a full service network capable of providing broadcast analog video, MPEG digital video, interactive multimedia, narrowband telephony, ISDN and wideband data (LAN) to consumer and small business markets.

This article is based upon our experience in the design and construction of the network, which now passes over 80,000 homes, and will pass 500,000 by year-end 1995. The article describes the base architecture and how extensions to that architecture and improvements in transmission techniques are used to satisfy growing demands over the life of the network.

An order of magnitude increase

Pacific Bell's CBN is based on AT&T's HFC-2000 design serving 480 homes from each fiber node; each node is further subdivided into 120-home quadrants for the reverse path design. The fiber nodes have 750 MHz of forward bandwidth and 35 MHz of reverse bandwidth. This base design offers an order of magnitude increase in bandwidth to the home over our traditional copper network. Built into the base design are options for bandwidth expansion that are used to serve high bandwidth demand customers. The following sections describe those options, and how they are implemented.

One set of options, described in the first section, relies on improvements in bandwidth efficiency and management. The second set of options are architectural extensions which push fiber deeper into the network to focus increased bandwidth to a specific customer location.

Our penetration assumption for digital services is 60 percent of homes passed with simultaneous usage of 50 percent. Those are conservative assumptions; cable TV operators today average 60 percent penetration for analog service in a non-competitive environment. Our penetration assumption of 60 percent is ambitious in any competitive environment. A simultaneous usage of 50 percent is also unlikely where analog broadcast services are provided.

A base assumption of 70 analog channels and 108 digital broadcast channels is used throughout the analysis. Our method is to hold those services constant and compare the design alternatives by focusing on digital narrowcast bandwidth. In practice, digital narrowcast bandwidth can be allocated to digital broadcast channels, interactive services, data services or video telephony.

Telephony traffic demand is also assumed to be constant at 1 DS-0/home. This is a conservative design assumption. A concentration ratio of 4:1 will generally yield a blocking probability of P01 or better in the residential

Figure 1: Base node design

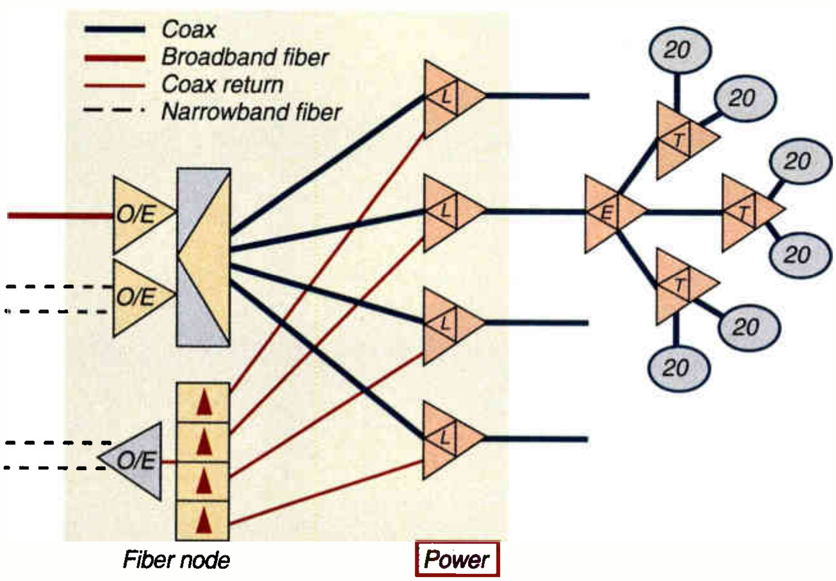

Table 1: Base node

Service	Available bandwidth (MHz)	Bandwidth per home served
Downstream 480 homes passed		
AM broadcast	444	70 channels
Telephony	48	1.6 DS-0s
Digital broadcast	72	108 channels
Digital narrowcast	120	2.4 DS-1s
Upstream 120 homes passed		
Telephony	12	1.0 DS-0
Digital narrowcast	10	139 kbps

Table 2: Base node with improved modulation figures

Service	Available bandwidth (MHz)	Bandwidth per home served
Downstream 480 homes passed		
AM broadcast	444	70 channels
Telephony	48	1.6 DS-0s
Digital broadcast	48	108 channels
Digital narrowcast	144	4.4 DS-1s
Upstream 120 homes passed		
Telephony	12	1.0 DS-0
Digital narrowcast	10	278 kbps

Editor's note: *from conference proceedings of the Second International Workshop on Community Networking, 1995.*

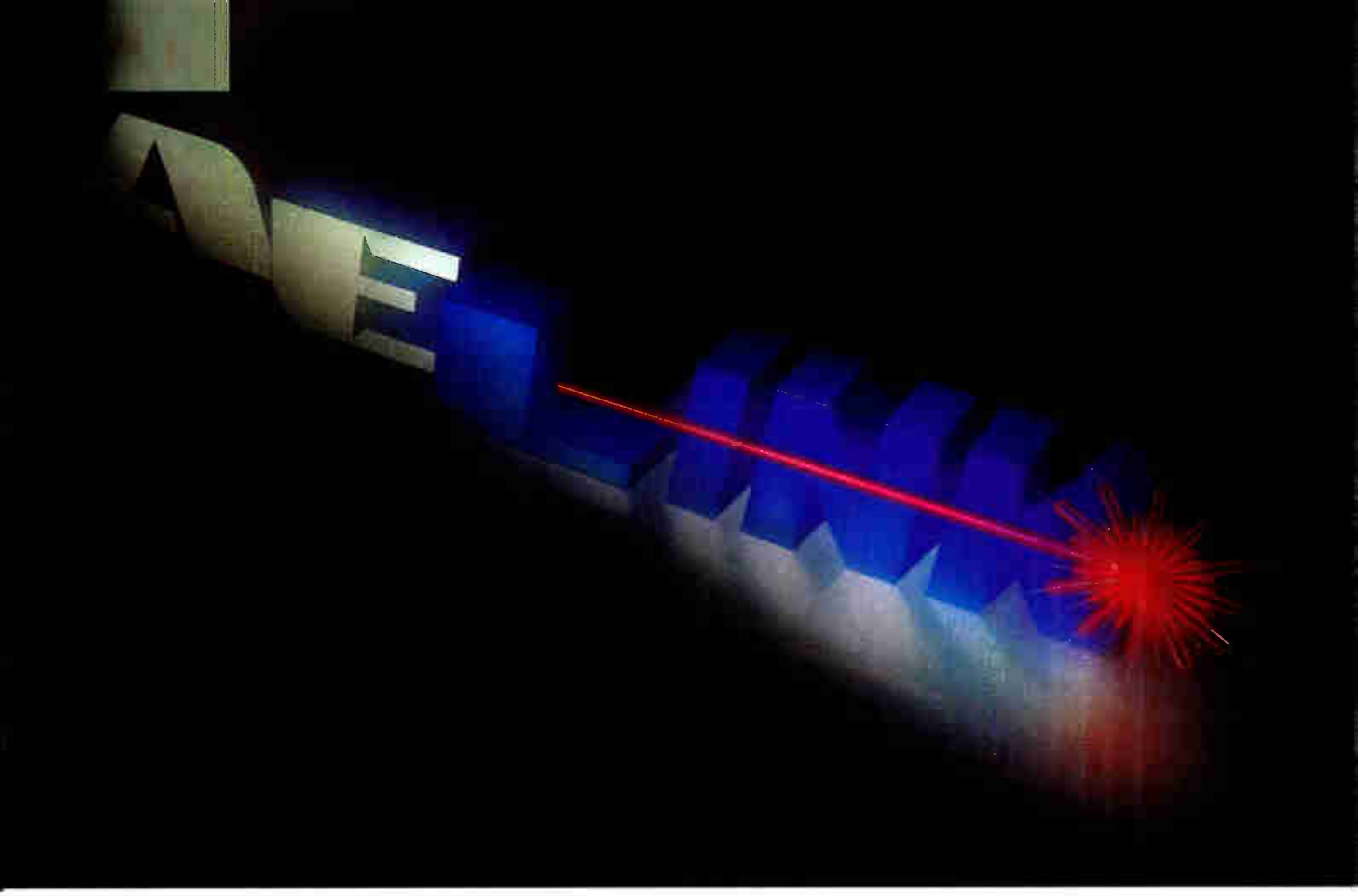

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Figure 2: Dual node design

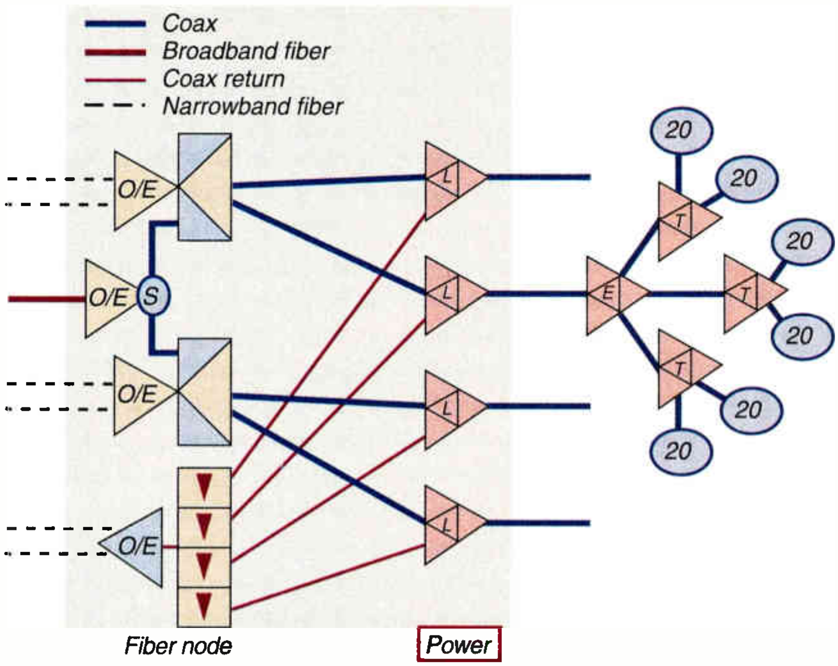


Table 3: Dual node

Service	Available bandwidth (MHz)	Bandwidth per home served
Downstream 240 homes passed		
AM broadcast	444	70 channels
Telephony	24	1.6 DS-0s
Digital broadcast	72	108 channels
Digital narrowcast	144	5.8 DS-1s
Upstream 120 homes passed		
Telephony	12	1.0 DS-0
Digital narrowcast	10	139 kbps

Table 4: Dual node with improved modulation

Service	Available bandwidth (MHz)	Bandwidth per home served
Downstream 240 homes passed		
AM broadcast	444	70 channels
Telephony	24	1.6 DS-0s
Digital broadcast	48	108 channels
Digital narrowcast	168	10.2 DS-1s
Upstream 120 homes passed		
Telephony	12	1.0 DS-0
Digital narrowcast	10	278 kbps

market. Our design assumption accommodates ISDN penetration and non-switched specials without increased bandwidth. In our computer simulations, we use a base case assumption of 6 DS-1 non-switched specials in each 480-home serving area.

The bandwidth of each downstream digital video channel is assumed at 3 Mbps. Quadrature Amplitude Modulation (QAM) is used for digital downstream services in the base design; each 64 QAM modulator has a bandwidth of 27 Mbps and occupies 6 MHz of bandwidth, or the equivalent of one AM-VSB analog video channel.

Of the available 35 MHz in the reverse 5 to 40 MHz passband, we have assumed 22 MHz is available. And 13 MHz is assumed unusable, or degraded because of poor signal-to-noise ratio characteristics, filter crossover or other factors. Upstream telephony channels require 2 MHz/channel, with each channel providing 20 DS-0s. We are reserving a 2 MHz telephony channel for agile operation. This channel is used in the event of single frequency interference. Upstream efficiency for telephony is 1 bit/Hz, and the efficiency for other services is 0.5 bits/Hz when an error correction scheme is used.

Increasing bandwidth

There are two general ways of increasing bandwidth: improved bandwidth efficiency and consolidated bandwidth management. We will address bandwidth efficiency first.

An improvement underway in the industry is the move from 64 QAM to 256 QAM. While 64 QAM has an efficiency of approximately 4 bits/Hz, 256 QAM achieves approximately 6 bits/Hz. So, with no additional initiatives, we can realize a 50 percent improvement in the downstream direction within two years.

Upstream transmission in the initial deployment is Quadrature Phase Shift Keying (QPSK) or a variant of QPSK. Because the HFC network is a point-to-multipoint architecture, Time Division Multiple Access (TDMA) is used in the upstream path to manage channel contention for most services. The TDMA scheme employed for telephony is more efficient than the one used for interactive services; however, the reverse interactive service channel is undergoing design improvement and should move to the 1 bit/Hz efficiency of the telephony channel within about a year.

Consolidated bandwidth management offers additional improvements. Services on the CBN are provisioned using a combination of Frequency Division Multiplexing (FDM) and Time Division Multiplexing (TDM). Using this basic scheme, we are serving a mix of synchronous transfer and asynchronous transfer based systems. The FDM/TDM scheme has the advantage that each transport system is optimized for the application it is supporting. There are, however, disadvantages:

The FDM/TDM scheme has the advantage that each transport system is optimized for the application it is supporting

✔ Each service reserves a portion of the available spectrum, and that resource is unavailable for use by other services, even when it is idle.

✔ There is a proliferation of modems for the various schemes.

✔ Reallocation of bandwidth for shifting service needs requires network rearrangements.

By consolidated information transfer under a common transport protocol, we can achieve higher network utilization and easily shift spectrum resources among services. The side of the home Network Interface Unit (NIU) used in CBN can evolve to a home bandwidth manager. Such a manager can support synchronous and asynchronous traffic, by dynamically re-partitioning the boundary between ATM and STM services. AT&T studies to date indicate improvements of up to 10:1 are achievable over the current FDM/TDMA scheme.

Architectural extensions

Figure 1 illustrates the base design of the CBN. Five fibers are fed from the central office (CO) to the fiber node. The node serves four 120-home quadrants. A single broadband fiber provides downstream signaling in the 54-550 MHz spectrum; it serves analog (AM-VSB) NTSC video broadcast and digital (MPEG) broadcast services. Duplex downstream fibers operate in the 550-750 MHz spectrum and serve narrowcast services, including digital video, telephony and data services. The coaxial RF plant is a super distribution design in which an express amplifier typically serves three tap amps, with multiple tap legs served by each tap amp.

In the figure, two legs of 20 homes each are served by each tap amp. From Table 1, we see that each home has full access to 70 channels of analog broadcast service and 108 channels of digital broadcast service. The average home also has a dedicated DS-0 for telephony service in this configuration. More typically we need to engineer fewer than 60 DS-0s in each quadrant, using a total of 6 MHz of the return spectrum. In our traffic simulations of worst-case quadrants, we have not exceeded 8 MHz in the return path, with an additional 2 MHz reserved for agility.

Using our base modulation efficiency of 0.5 bits/Hz for the digital services return and our penetration and simultaneous usage assumptions, we find there are 139 kbps available in the return path for each home served, if the available spectrum is fully equipped. Allocating 120 MHz for narrowcast digital services yields an equivalent downstream bandwidth of 2.4 DS-1s, or 3.7 Mbps for each home served.

Using this same base design, but changing the downstream non-telephony modulation to 256 QAM and improving the efficiency of the upstream modulation to 1 bit/Hz, we attain the capacities shown in Table 2.

Dual node design

The dual node design increases the downstream digital bandwidth by splitting the digital downstream distribution into two, 240-home nodes, as shown in Figure 2. The design is appropriate if asymmetrical digital narrowcast services are in great demand. The advantage of the design is its ease of implementation. Only the fiber node and central office are affected; two additional optical transceivers are needed, and the RF combining circuitry for the downstream path must be re-arranged. Shelf space is available in our current design for this upgrade, and the transceivers are the same as we use in the basic node design.

This approach, and the use of a bandwidth manager, bring the return capacity into the range of 5-10 Mbps for each home

Table 3 lists the capacity of this design. As shown, the only change is in digital narrowcast bandwidth. By splitting the node, we can reduce the telephony allocation from 48 MHz to 24 MHz, gaining 24 MHz of downstream spectrum. We can also re-use the digital narrowcast bandwidth. The resulting 144 MHz, when spread over half as many homes as the base design, results in an available bandwidth of 5.8 DS-1s for each home served. Stated another way, this provides a digital video channel capacity of three channels for each home served.

Using improved modulation techniques with the dual node design, we achieve the capacity shown in Table 4.

This design offers extraordinary in-home capacity for digital downstream services. Four narrowcast video services can be supported simultaneously with an additional 3.7 Mbps data session. The upstream capacity of 278 kbps accompanies the increased downstream capacity.

Mini node design

This design moves the fiber node deeper into the network. In essence, the express amplifier becomes the fiber node. In our base node design the express amp serves a trident of three tap amps, each of which serves two legs of 20 homes on tap lines. To upgrade the base design, work must be done at the original

Figure 3: Tandem and mini node designs

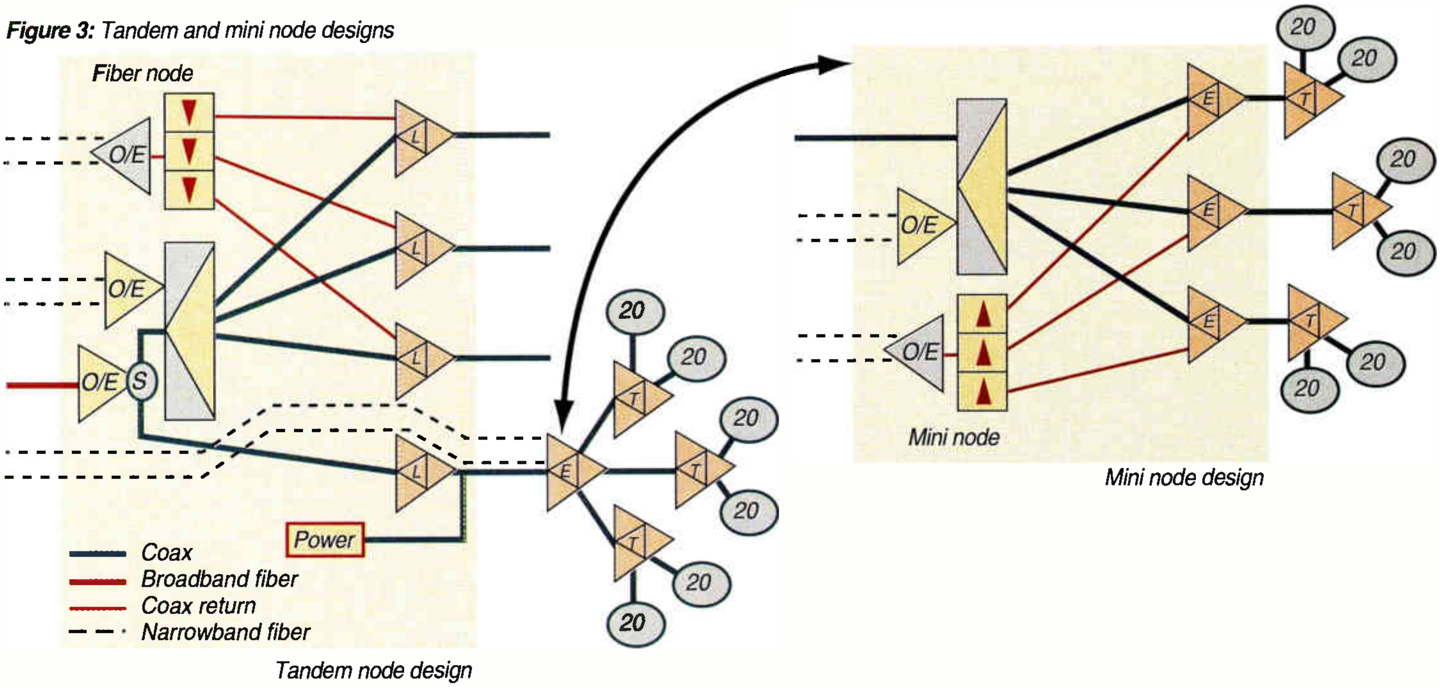


Table 5: Mini node

Service	Available bandwidth (MHz)	Bandwidth per home served
Downstream 120 homes passed		
AM broadcast	444	70 channels
Telephony	12	1.6 DS-0s
Digital broadcast	72	108 channels
Digital narrowcast	156	12.6 DS-1s
Upstream 40 homes passed		
Telephony	4	1.0 DS-0
Digital narrowcast	18	750 kbps

Table 6: Mini node with improved modulation

Service	Available bandwidth (MHz)	Bandwidth per home served
Downstream 120 homes passed		
AM broadcast	444	70 channels
Telephony	12	1.6 DS-0s
Digital broadcast	48	108 channels
Digital narrowcast	180	21.9 DS-1s
Upstream 40 homes passed		
Telephony	4	1.0 DS-0
Digital narrowcast	18	1,500 kbps

fiber node, shown in Figure 3 as the tandem node.

Re-arrangements must also be undertaken at the express amplifier, shown as the mini node in Figure 3. At the tandem node, the existing broadband feed is split at the optical receiver and fed into the launch amplifier independently of its current feed to the combining and splitting circuitry. The launch amplifier and the express coaxial cable are left in place and used as a trunk feed for the broadcast (54-550 MHz) spectrum.

Digital narrowcast signals in the 550-750 MHz spectrum are delivered over independent fibers to the mini node and combined with the broadcast signals. The return is collected independently from each leg of the trident prior to transport back to the central office via return lasers.

In the results shown in Table 5, we find a downstream narrowcast capacity of 12.6 DS-1s for each home served. This equates to over six simultaneous video sessions/home. Our bandwidth assignment is flexible, so we could have increased the number of digital broadcast channels and accepted the decrease in narrowcast digital bandwidth in the downstream direction.

In the upstream direction we have achieved a simultaneous 750 kbps data rate for each home served. This service compares favorably with 10 Mbps ethernet LANs. Because we have a high simultaneous usage assumption, 50 percent, typical throughput will be much higher.

Using improved modulation techniques with the mini node design, we obtain the capacity shown in Table 6.

This design offers 33.8 Mbps of downstream capacity and 1.5 Mbps of upstream capacity for each home served. The capacity available with this design is more typical of medium to large bandwidth business services than any consumer services on the horizon.

Other designs are certainly possible, including hypersplit designs which take fiber all the way to the last serving amplifier.

These designs offer an advantage in that no return diplex filters are needed in the amplifiers since coaxial cable is not used for the return path.

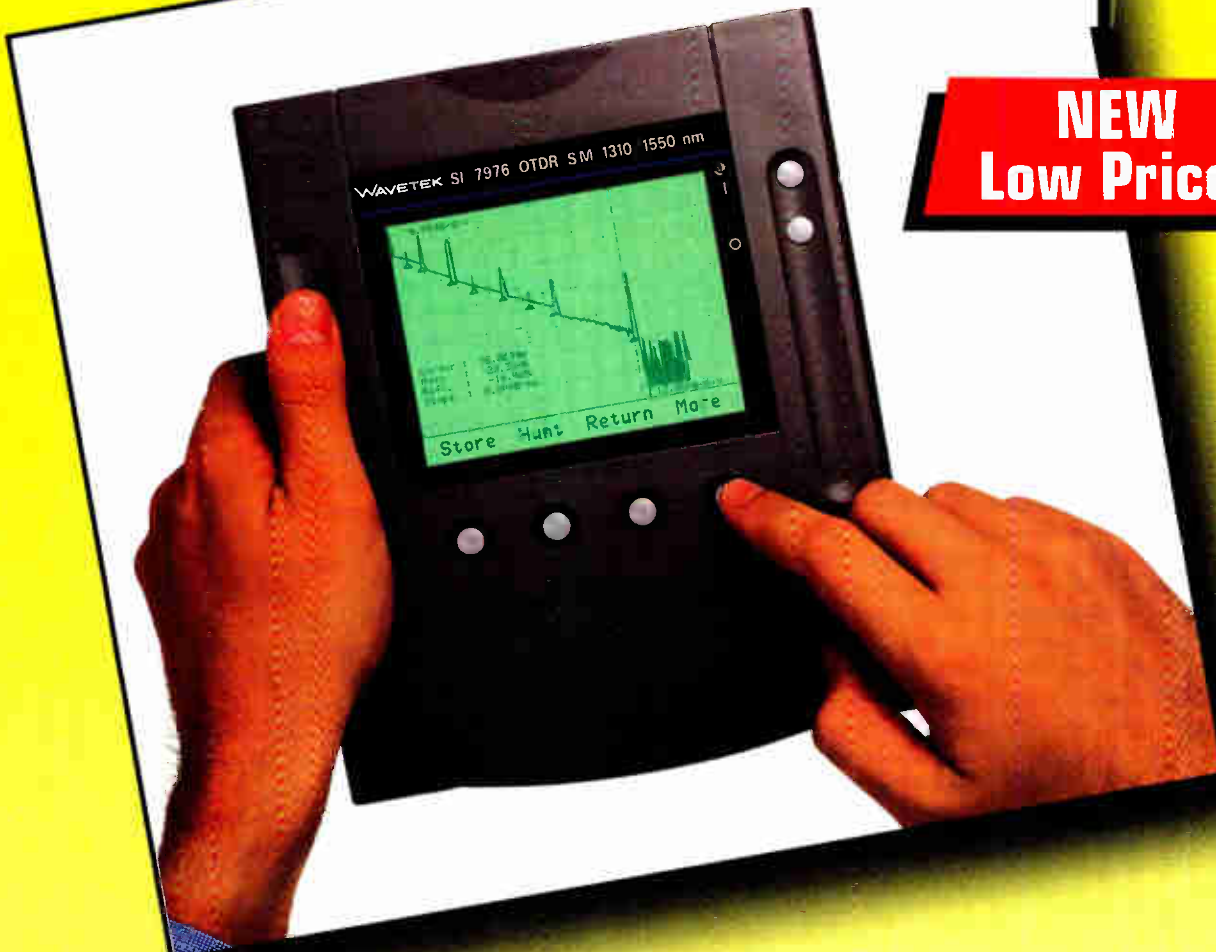
This approach, and the use of a consolidated bandwidth manager, bring the return path capacity into the range of 5-10 Mbps for each home served.

At present, there are no services justifying these designs as part of our standard service offering.

Conclusions

An HFC architecture was chosen for Pacific Bell's Consumer Broadband Network because it offers flexibility in meeting a range of customer service needs, while retaining the economic advantages of a single wire network. Video services are by their nature asymmetrical, and this network can be expanded to support service demands from 3 to 30 Mbps for each home served.

Network upgrades for this range of service are being designed in from the beginning and can be achieved with minimal initial investment. CED



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The return system: A historical perspective

Exploring uncharted territory

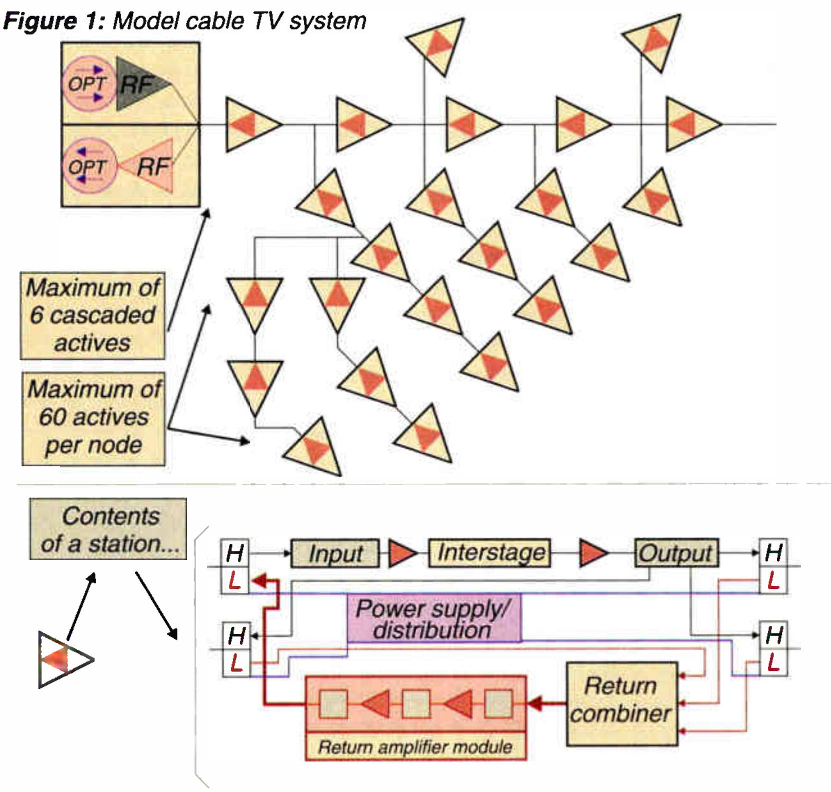
By Jerry Marketos, Design Engineer, Philips Broadband Networks Inc.

Once mainly a "background" topic, cable TV return systems are now receiving much attention in the marketplace. As reverse capability moves into the spotlight, it is worthwhile to review the return system's past, compare it with forward systems, and comment on the return system's content and future.

The past

The entire timespan is relatively small when one considers that the first cable TV systems didn't gain a foothold until the late 1950s or early 1960s. In those early days, the cable TV system consisted of a simple point of origin, with coaxial cable and a few RF amplifiers which brought some video channels to the home. These "points of origin" were quite often somebody's garage, or a small shack somewhere.

Figure 1: *Model cable TV system*



In the infancy of the cable television system, the subscriber obtained about 12 video channels in the forward path. A return path as we know it today was virtually nonexistent in the early days of 12 video channels, but the return system was not completely without concept.

In a relatively short period of time (by the mid- to late 1960s), diplex filters were utilized to segment a portion of the frequency spectrum for separate transmission; this transmission was for signals to travel "backwards," toward the point of origin.

In the earliest cable TV systems containing return transmission capability, the intent was mostly to offer transportation of locally injected signals (such as from schools or on-site broadcasts). Recall that the total number of subscribers on a cable TV system 25 years ago was a small fraction of current figures; in fact, cities with cable TV systems of any sort were the exception rather than the rule back then.

The return system remained a "background" feature, partly because of a learning curve, and partly because technology simply didn't provide a significant market for it. Utilization, expansion and evolution of the forward band had to come first, and the technological aspect of that proposition kept both the "audience" (subscribers) and the "performers" (cable TV service providers) well occupied.

In the roughly 20 years that passed from the inception of cable TV service, the forward band grew significantly in width and performance. Amplifiers evolved, and the industry had been identified by major component manufacturers as a solid market for the various components required to build cable TV equipment. One case in point is the cable TV amplifier gain block. Several major semiconductor manufacturers had responded to the market by offering a hybrid gain block optimized specifically for cable TV use, called, appropriately, the cable TV hybrid.

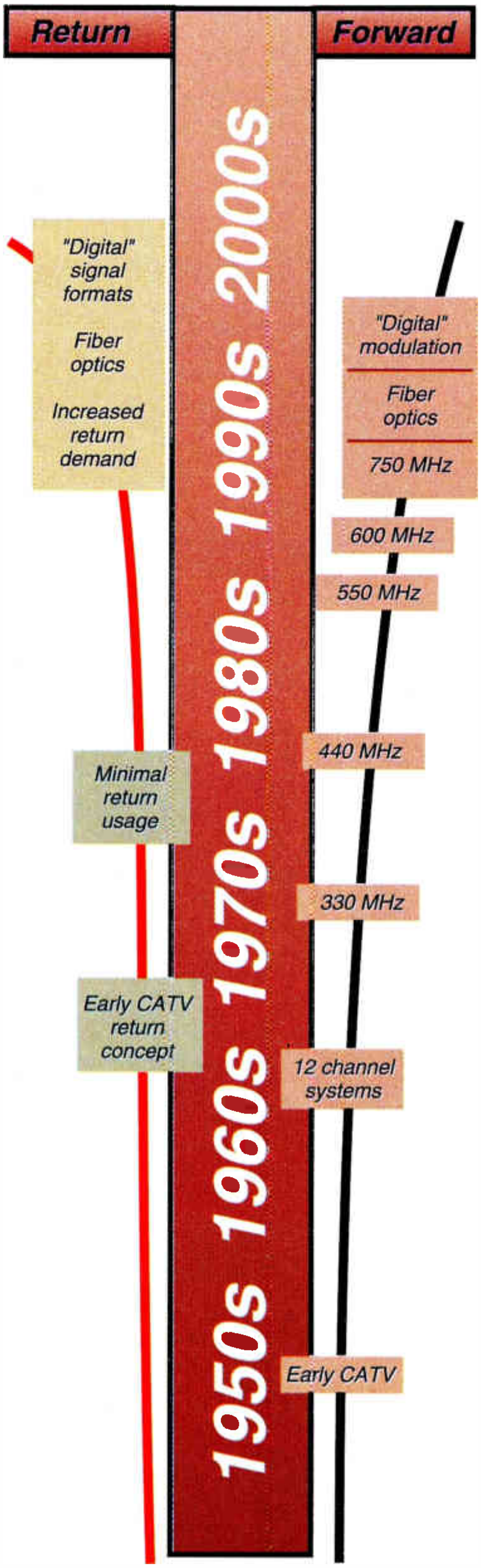
Evolution of the forward band continued; the upper bandwidth kept increasing, from 150 MHz, 200 MHz, 330 MHz to 440 MHz. By the mid-1980s, many cities had reasonably reliable cable television service. This allowed the subscriber to choose from 30 to 40 cable television channels.

The present

Because the time period from the mid-1980s to the mid-1990s is still in recent memory, it becomes a bit "smeared" on the timeline perspective. The mid- to late 1980s brought continued development of the forward bandwidth–440 MHz turned to 550 MHz, then to 600 MHz. The "bandwidth race" was a much studied (and much debated) issue. This continues today, as 750 MHz, 860 MHz and 1000 MHz are the hot topics.

Other technologies (such as signal compression and "digital modulation") also came into focus, in the interest of conserving bandwidth. Fiber optic components (the first to gain a real foothold being 1310 nm AM lasers) entered the market and drastically changed cable

Figure 2: Cable TV system development timeline



Lines indicate development trend

TV system architecture, while opening opportunities galore.

As one looks back over the most recent portion of the time line, it is apparent that the rate of progress is increasing, as is the scope of the development. More development and market identification/penetration have occurred over the past 10 years than during the previous 20 (or 30). This is an important observation where the return band is considered.

In the past 10 years (and really mostly in the past four or five years), the cable TV return band has become the subject of intense focus. The return system was typically a "back shelf" entity through the 1970s, seeing use mainly for occasional single video return feeds. In the early and mid 1980s, some cable TV return systems saw spotted activity when some MSOs offered services such as home intrusion alarms. These trials had mixed results, sometimes a function of system setup (treading "uncharted waters") in terms of frequency spectrum and its anomalies, and other times simply a function of system reliability.

The cable TV return system was recognized as important, but continued to develop through the 1980s at an average pace, as the definition for "payload" to be carried on a return system remained varied and nonspecific. Then, the explosion occurred.

Due in large part to the explosion of the personal computer and PC networking, demand for solid cable TV return systems has skyrocketed as the concept of the information superhighway progresses. A cable TV return system can serve as a significant portion of such a highway. This recognition, combined with the acknowledgment that the information superhighway is, indeed, a toll road, has sent demand for cable TV return system equipment beyond most forecasts.

To make the situation even more interesting, the fact that this demand has occurred during a period of ever-increasing rate of development in other areas has worked to further increase the "push" for cable TV return system development, as there are many subscribers who can utilize the return band.

Increasingly, there are more and more things to use the return band for. No longer just video feeds and occasional FSK carriers for things like home security systems, a return system can be used to transport "payloads" consisting of computer data (from many sources), telephony signals and many other items. The return system comes into vogue now, as several other technologies reach a point where a "return pipeline" becomes a necessity.

The future

It is fairly safe to suggest that the cable TV return system is here to stay. What becomes more difficult is to predict what form it will take in its final development. This is currently one of the highly debated subjects within the cable TV industry. Many suggestions exist: Some are visions of complete return systems which utilize the (approximate) 5 MHz to 40 MHz bandwidth as is indicated today. Other visions suggest a "forward duplicate" system, utilizing components similar or identical to the forward band, which send their signals on a separate path in the return direction, with separate subscriber interfaces for "forward" and "return."

More development and market identification/ penetration have occurred over the past 10 years than during the previous 20 or 30

Still other visions propose block conversion and return paths in the 900 MHz range. For the immediate future, it appears that the emphasis will remain on development of the return band as it has been known for many years.

Identity of the cable TV return system

Although the return band was identified many years ago, it was not developed actively at nearly the rate of the forward band. For this reason, the return band is considered by many to be an area of uncharted water in the cable TV system. One lesson learned very early is that the cable TV return system possesses a personality all its own. That personality contains a few traits not previously experienced with the forward band.

One fundamental difference stems from the very function of the two systems–the forward system generally contains one point of origin, with many destinations. Conversely, the return band has one point of destination with many points of origin.

This means that, in the return path, signals are transported by successive amplification and combination, which results in the noise addition effect known as "noise funneling." This funneling effect also helps to ensure that any undesired signals (ingress) introduced to the cable return system (anywhere) are combined together to produce maximum difficulty at the destination.

Of all the return system's specific traits, the issue of ingress appears to be the most troublesome from a system setup/operation point of view. What makes this more difficult is that the phenomenon of ingress is more a function of specific system conditions, rather than design.

Given a typical modern return system operating in the 5-40 MHz area, differential delay also becomes a point of concern; The return band is narrow enough that diplex filters introduce significant amounts of differential delay within the return bandwidth (mostly at the band edges). The distortion resulting from such delay can cause visible video/chroma shift in a video picture, and can degrade the ability of a digital carrier to transport error-free data (by introducing nonlinear phase shift).

Of all the return system's traits, ingress appears to be the most troublesome from a system setup/operation standpoint

Different signal formats within the same bandwidth have varied sensitivities to differential delay. This, combined with the fact that widespread implementation is not complete yet, leaves the ultimate effect of differential delay as another item in the return band which lacks complete definition.

The cable TV return system is similar to forward systems in that many critical performance parameters (distortion, carrier-to-noise, etc.) are shared. Differences between forward and reverse systems arise in how some of these parameters are applied. The narrower signal bandwidth and return noise funneling effect in current return systems provides the origin for some of these differences. Though ingress exists in both forward and return, the ingress issues experienced so far with return systems seem to indicate that return ingress is worth identifying as a unique topic for exploration.

One last item–the rate of development changes–also helps to increase confusion associated with the return system. Recall the development of the forward system, where items occurred over a period of about 25 years; with the return system, a tremendous amount of development and interest has been generated in just the past three or four years, and this interest occurs on many fronts simultaneously. Exploration of bandwidth, effects of delay, implementation of fiber optics, investigation of signal format and its effect on amplifier linearity requirements–all of these items are being pursued in parallel with the return system, and all over a very short timespan when compared with the forward band.

To be fair, it must be acknowledged that the pace of forward system development is increasing, as well. The explosion in return system development comes in part as "catch up" now that the marketplace has several concrete applications which require return capability. Continued cable TV service penetration, combined with identification of new uses for the return band, will help the cable TV return system to remain a point of focus for some time. Improvements resulting from research and development in the cable TV return band will help to perpetuate this. CED

Technology race tightens for MSOs, telcos

Progress toward digital

By Fred Dawson, Contributing Editor

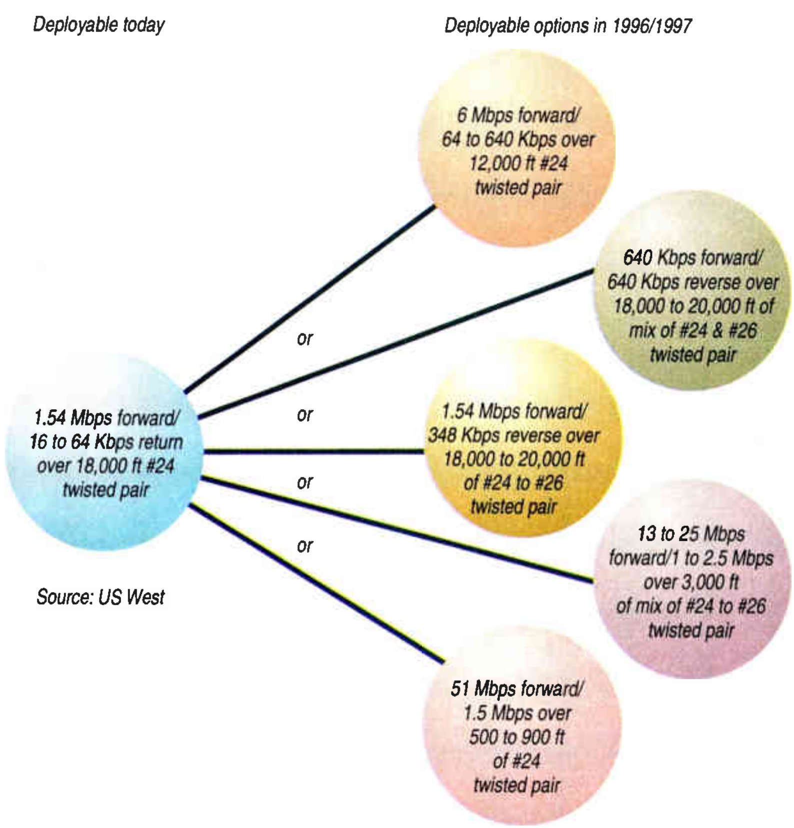
Advances across all fronts in the ramp-up to digital network deployment are making it harder than ever for cable and telco planners to find cost/performance advantages in one strategy over another.

In cable telephony, backers of HFC (hybrid fiber/coax) topology report technical goals for provisioning voice services are being met, lending support to large scale deployment schedules that, in some cases, could begin as early as the first half of next year. In telco video, network designers are finding short-term bridges to all-digital broadband in the form of digital MMDS and ADSL (asymmetrical digital subscriber line) as they move to implement HFC or more fiber-rich solutions over the next couple of decades.

And in the data services arena, advances in ADSL, which supports use of standard telco lines to launch all types of digital services, together with widescale implementation of ISDN (integrated services digital network) are fueling telco efforts just as cable operators are discovering the cable modem is a viable path into broadband data.

As the technology race tightens, the good news for everybody is that both industries appear to have about a year's time to fine tune strategies before they can really take each other on, thanks to similar timelines for silicon integration of myriad hardware components. The bad news is the variables are only likely to get more confusing as the moment of truth arrives for first-phase mass technology deployments.

Figure 1: ADSL evolution



Source: US West

Integration on silicon

The list of items expected to go into full production before the end of next year and, in some cases, much earlier, includes digital cable TV set-tops, telco TV set-tops, ADSL systems, cable modems, 150- to 300-channel digital MMDS systems and ever more varieties of digital satellite home terminals. Also significant in the eyes of a growing number of cable strategists, manufacturers say DVD (digital video disk) will be in production by mid '96, representing a potential factor in the cost, timing and design implementation of networked digital video.

"Integration on silicon is the issue everywhere you look," says a senior cable engineer, speaking on background. "When it comes to anything we're expecting to do, that's really the major technical issue now."

He notes that one of the most visible cases in point is digital cable set-tops. While cable operators had hoped to get into digital TV delivery much closer to day and date with DBS, it now looks like fulfillment of the first wave of advance orders won't begin until March or so. Wider scale fulfillment is expected to begin by mid-year.

But that's not all bad news, the engineering executive adds. "It gives us more time to sort the things out that we have on our plate, which include a lot of operational and marketing issues," he says.

Digital MMDS

Time is what everyone needs as they digest the latest results in several technology initiatives on the networking front. For example, where most people were giving little thought to MMDS, it now appears likely that digital MMDS will greatly expand the viability of that service in the wake of new trial results reported by an ad hoc industry group known as the Wireless Cable Digital Alliance.

At least two wireless cable companies plan to launch digital service as quickly as their chosen supplier can get them the gear, which in one case is slated for September of this year. And many others were preparing for digital launch early in '96 as more gear becomes available.

"We expect to be the leader in adopting digital capabilities, well before conventional cable," says Patrick McConnell, director of advanced technologies for

Impediments that have slowed growth of the wireless cable business may go away with digital

American Telecasting Inc., the leading wireless cable operator and one of six founding members in the digital alliance. The group announced results of its year-long series of field tests at the wireless cable conference in Washington in July, declaring that equipment had shown wireless systems will readily support 150 to 300 channels of service delivered at performance levels far superior to today's analog systems.

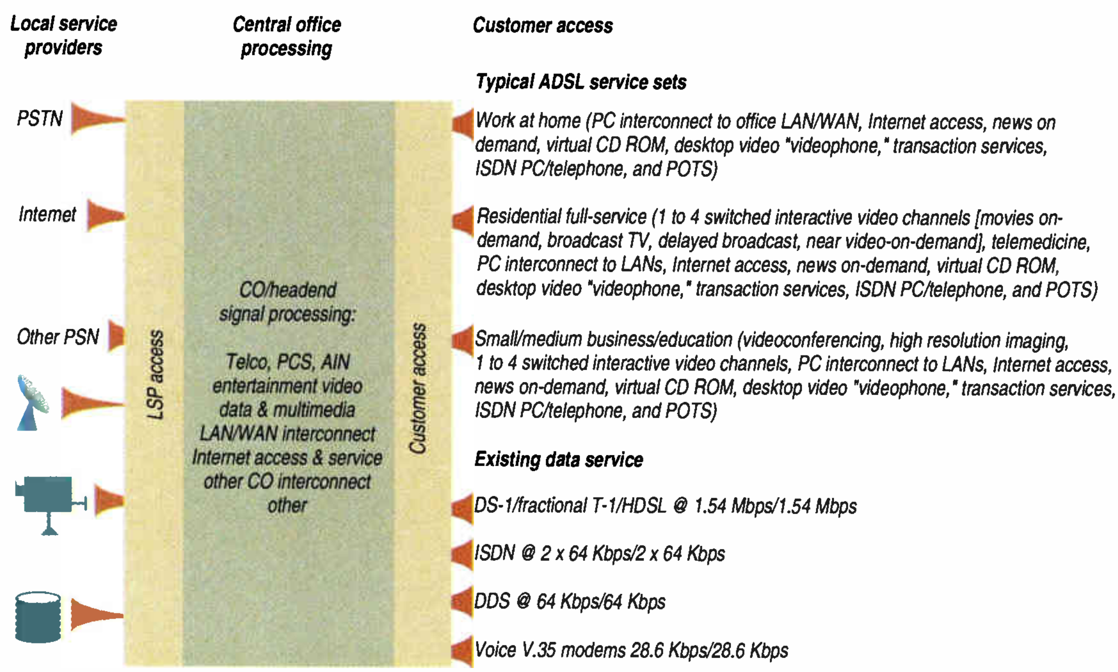
ATI, while participating with the alliance in a fourth-quarter, 50-home commercial trial of digital service, is also moving forward with commercial deployment of digital service in Fresno, Calif., a 270,000-household market, in the fourth quarter. The company is using gear supplied by Decathlon Communications Inc. of Denver, a four-year-old company devoted exclusively to developing wireless cable compression technology.

Early delivery

Decathlon is also shipping equipment to Group Videotron's wireless cable system in Tampa, Fla. this September, according to Eric Meltzer, a consultant for Decathlon. "We're able to hit these early delivery dates because we've been preparing for this a long time, whereas it wasn't until 90 days ago when telcos started buying into wireless cable that most other manufacturers began to take the digital wireless cable opportunity seriously," Meltzer says.

McConnell says ATI, which many observers expect will be acquired by a telephone company, chose Decathlon for Fresno because of the need for an early launch of digital there, but that the company will be looking at other suppliers as well for other markets.

Figure 2: Flexible access rates over copper



Source: US West

The wireless digital alliance field trials, taking place in Colorado Springs, Chicago, Orlando and Lakeland, Fla., are using digital headend and set-top gear supplied by Zenith Electronics Corp., which will also supply the fourth quarter commercial trial the alliance plans over ATI facilities.

Results from the field trials suggest many of the impediments that have slowed growth of the wireless cable business will go away with digital implementation, McConnell says. In each trial location, the alliance looked at worst-case situations, including dense foliage, other line-of-sight blockages, varying antenna elevations and situations where field-mounted signal boosters are required to reach "shadowed" areas.

McConnell says Zenith's digital transmission system using 4-VSB (vestigial sideband) modulation vastly outperformed today's wireless cable NTSC signals.

"To put it in perspective," he says, "the amount of transmitter power needed to obtain a perfect digital signal in any given situation is two percent of the power required to get an adequate analog signal."

While ATI is buying into a 64 QAM modulation approach in Fresno, McConnell said there appear to be clear advantages for VSB over QAM in the off-air environment. "VSB has an inherent advantage over QAM in terms of scalability," McConnell says.

Nonetheless, it remains to be seen whether the wireless industry will settle on Zenith's proprietary VSB approach or whether there will be two industry standards. Sources who have seen the Tele-TV RFP for wireless cable digital transmission equipment say telco officials appear to be leaning toward QAM, which is the approach taken by General Instrument Corp. and the other players besides Zenith who are offering wireless cable digital systems.

ADSL

An even greater boon to telcos than digital MMDS would be success at achieving cost-effective implementation of ADSL technology. Here, too, recent developments are forcing strategists in all camps to rethink the unfolding competitive scenario.

"We're reassessing how ADSL might affect telco activity in light of new developments," acknowledges a cable engineering executive, speaking on background. "The technology may be a lot stronger than we once thought."

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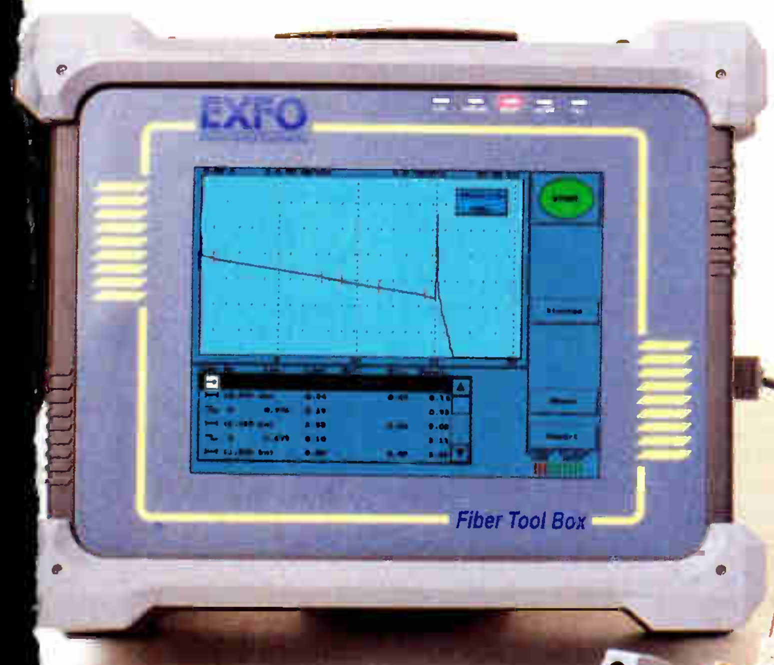

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Equally important, ADSL can be structured to supply high bit-rate data channels instead of TV.

"ADSL will be a factor," says Kim Maxwell, chairman of the ADSL Forum, an ad hoc international group working through a thicket of technical issues to reach agreement on standards. "But it won't be ready for deployment any sooner than anything else."

Chipsets will be available by early '96, Maxwell says, but adds that the industry target cost of $500 per line (including both ends) "is probably a 1997 event." The next-generation systems entering the field for early testing will probably run about $4,000 per line, he says.

AT&T Paradyne is already shipping a limited quantity of new 6 Mbps ADSL chipsets it calls "GlobeSpan" for use in customer field tests and will be prepared to go into volume production by the fourth quarter, says Clete Gardenhour, director of business planning.

The spring meeting of the ADSL forum in London was filled to capacity

The new system, which was co-developed with AT&T Bell Laboratories, differs from other ADSL systems in that the transmitter/receiver chipset has the built-in capability to support symmetrical high bit rate digital subscriber line (HDSL) service as well as ADSL. Where the company's ADSL transmission rates are slightly over 6 megabits per second in the downstream and 64 kilobits per second in the upstream, the HDSL rate is 2.048 Mbps in both directions.

Single-line configuration

HDSL, now widely used by telcos to provide T-1 services to business over standard telephone lines, has traditionally required two twisted pair lines, but is moving to a single-line configuration under auspices of telephone industry standards bodies. Gardenhour says AT&T Paradyne's chipset will support the single-line approach and will be available for implementation next year, with or without completion of the work by the standards groups.

Whether the chipset is used for ADSL or HDSL, the technology supports the digital applications simultaneously with use of the same line for analog POTS (plain old telephone service), Gardenhour notes. Bit rates vary as a function of line distance, but the system is spec'd to operate over standard phone lines at the given speeds at distances of up to 12,000 feet, which encompasses the majority of the nation's 130 million local telephone lines.

AT&T's move comes amid a general quickening of industrywide preparations for rollout of ADSL. Where, six months ago, telco interest had waned to the vanishing point, today, the performance of next-generation systems has rekindled enthusiasm, with manufacturers reporting orders for lab and field tests from the lion's share of the local exchange carriers.

"Interest in ADSL is a lot higher than ever before," says Rupert Baines, marketing executive at Analog Devices Inc., the Norwood, Mass.-based chip supplie which is teamed with Aware Inc., Westell, Newbridge Networks and NEC Australia in the manufacture and marketing of ADSL systems. Noting the spring mee of the ADSL Forum in London was filled to capacit Baines says, "We'll have a standards-based ADSL sy tem in silicon in the very near future that will suppo very large scale trials."

Another supplier gunning for an early lead in A is Orckit Communications Ltd., an Israel-based AD developer with U.S. headquarters in San Diego. "W anticipate the chipsets will be there to support fiel als by the fourth quarter," says Mark Handzel, dire of marketing and sales at Orckit.

Handzel says a number of large telephone comp nies are in line with orders to field test Orckit's sys which, unlike AT&T's, employs the modulation te nique known as DMT (discrete multitone) that has endorsed by the IEEE as the ADSL standard. "Peo are planning trials where lines will be picked rand to allow as full a demonstration of the technology' bility as possible," he says.

Unresolved issues

Maxwell is certain ADSL has a strong future through at least the two decades he says it will tak before telcos can fully deploy new networks. But l acknowledges the telephone industry has many iss to resolve before full-scale production can begin, v is going to take more commitment than he has see date.

"We still don't have the critical mass of interest U.S. telephone companies that we need in order t make ADSL a viable option," he says. While the t has made progress on some key issues, he adds, "r concern is that by the time it dawns on the industr ADSL is inevitable, there'll be delays in getting e ment because system development didn't proceed quickly as it might have if there had been stronger port early on."

But Maxwell sees the interest level rising as the technology begins to prove itself in field trials and telcos turn away from strategies that are overly de dent on delivery of entertainment services. "I think recent demonstration at US West blew a lot of peo minds," he says.

That demo, conducted in July, used gear supplie Orckit, Westel and others. "We ran ISDN, four TV video channels and POTS simultaneously without glitch," Handzel says. The ISDN demo included v conferencing between remote facilities that require tying long distance links together with the local AI loop.

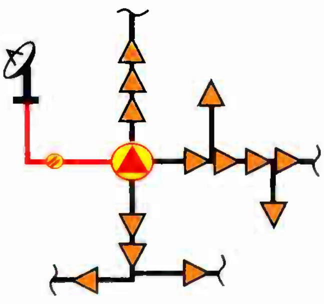
A big reason ADSL has taken on new life is that telcos realize the importance of offering high-speed data services as cable moves into that market. For such a service to succeed, it must be available over large terri-

1995-199

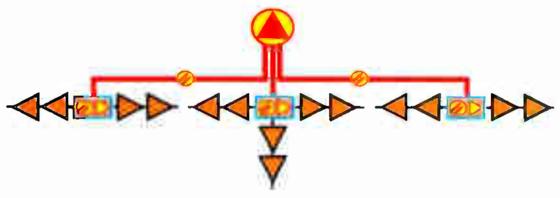
Fundamental fiber optic topologies for cable TV

Supertrunks

Transport high-quality video signals on a point-to-point basis. Examples include interconnects between remote antennas and headends, headend interconnects for program sharing and multiple system interconnects for advertising insertion. Also could be used to provide route diversity for data delivery, personal communications, alternate access, etc.

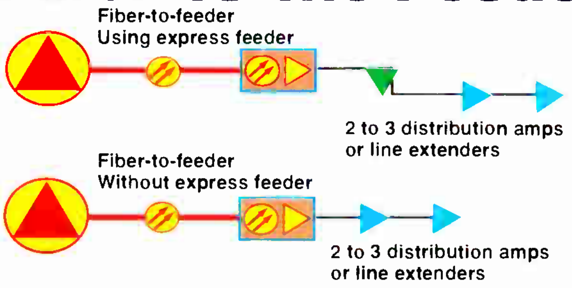


Fiber Backbone



Used primarily to reduce length of broadband amplifier cascades to improve carrier-to-noise ratio and distortion performance while reducing network maintenance. Designed for system upgrades and rebuilds to higher bandwidths. Defined by Time Warner Cable as having fewer than four amplifiers in cascade on any trunk run.

Hybrid Fiber/Coax, or Fiber-to-the-Feeder

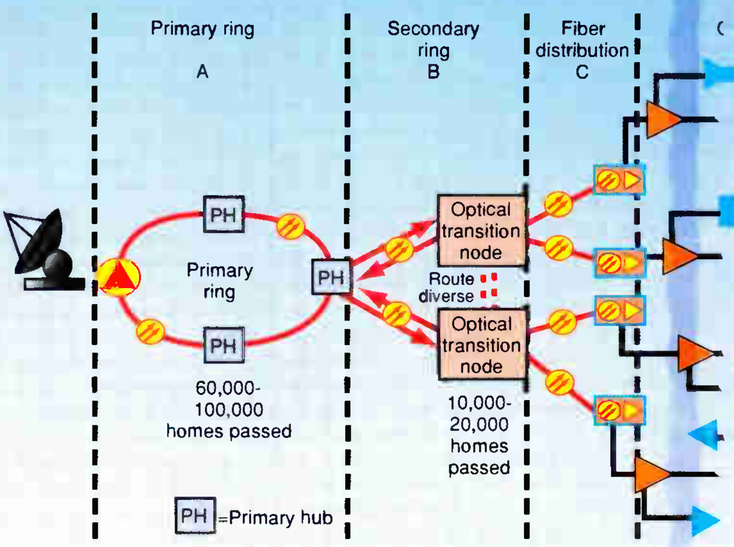


Originally designed for complete system rebuilds, now used increasingly in upgrades. Replaces nearly all coaxial trunk cable with fiber cable. Reduces amplifier cascades to no more than three active devices, typically. Coaxial "express" feeder serves area immediately adjacent to headend and optical receivers. Concept originally termed Fiber Trunk and Feeder by ATC engineers. Also known as All Fiber Trunk and Fiber to the Bridger.

Communications Engineering & Design Magazine
600 South Cherry Street, Suite 400, Denver CO 80222

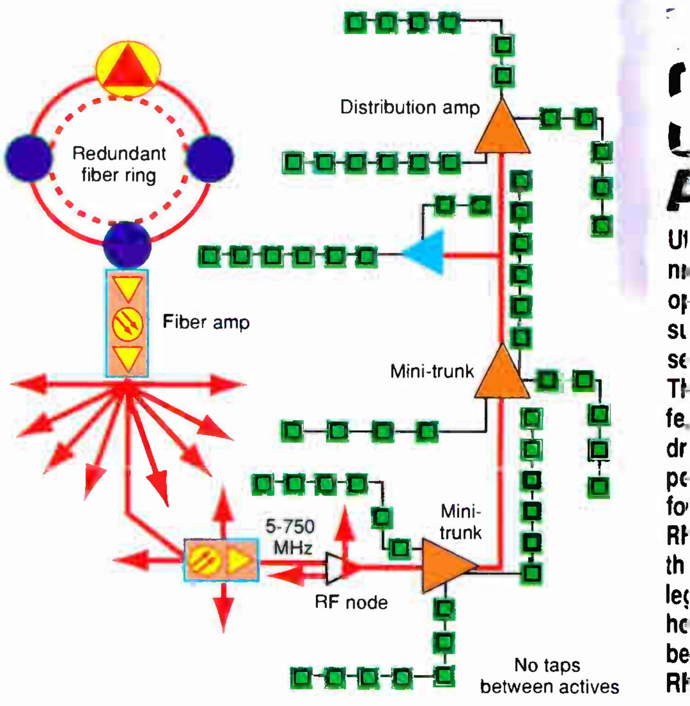
Legend

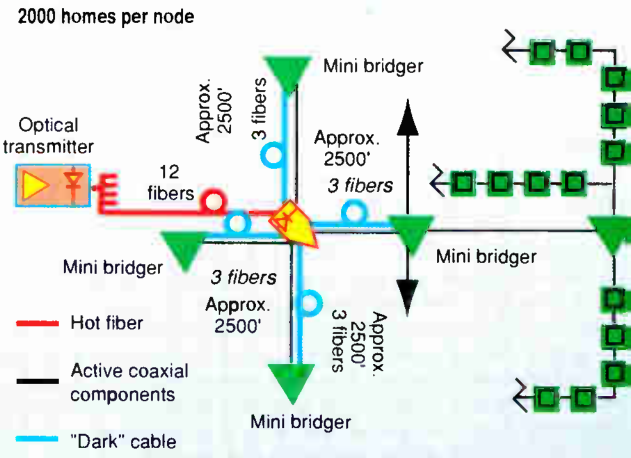
Headend	Fiber node	Bridger
Fiber cable	Secondary hub	Line extender
Coax cable	Trunk or distribution amp	Splitter
Cluster tap (64 port)	8 port tap	Standard tap



TCI's Dual Ring Star/bus

The network is best described as a scaleable architecture that is conf ring, star/bus. The primary ring (A) is either a Sonet-based or a propri technology. It feeds a route diverse Super AM ring for the secondary some markets this ring will also employ Sonet technology. The fiber t network (C) feeds scaleable optical nodes. These routes are selected cannot affect more than 4,000 homes passed. These nodes in turn fee limited to 300 homes passed. Each bus is configured so that it can be individual node.





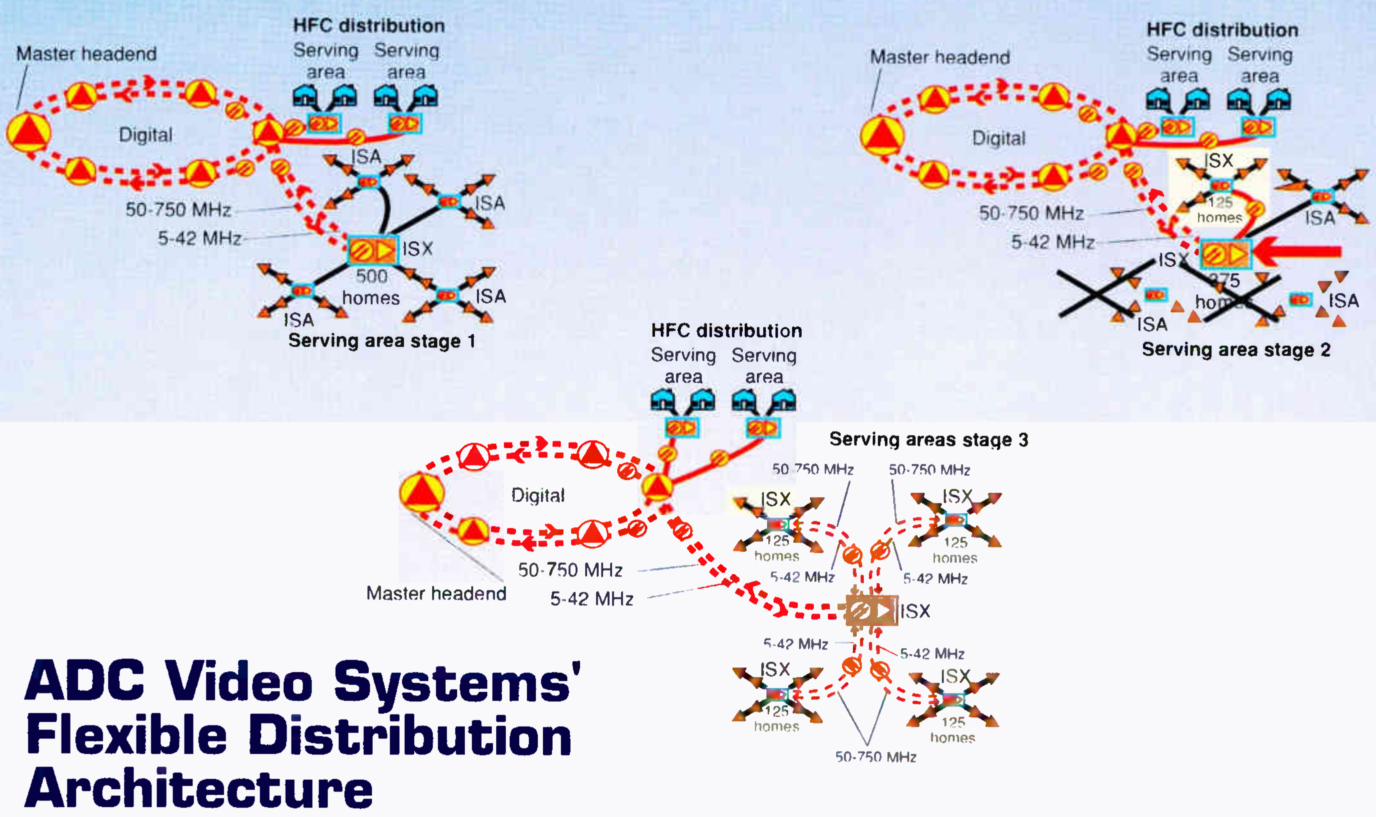
General Instrument's E Architecture

The BTA architecture was developed to minimize initial instal architecture is shown serving as many as 2,000 homes per n combined with the ability to migrate to smaller service areas

1995-96 CED Cable TV Fiber Topologies Comparison

The cable television industry first embraced fiber technology as a cost-effective upgrade to its traditional all-coaxial plant several years ago. Since then, cable television has become the fastest-growing market segment for sales of fiber optic cable. Operators and equipment vendors have since developed new and innovative methods to integrate fiber deeper into cable networks, bringing the benefits of lightwave technology ever closer to the home. This chart graphically illustrates how fiber started as a method to tie headends together, then rapidly became the transport method of choice for virtually every network operator.

omparison



ADC Video Systems' Flexible Distribution Architecture

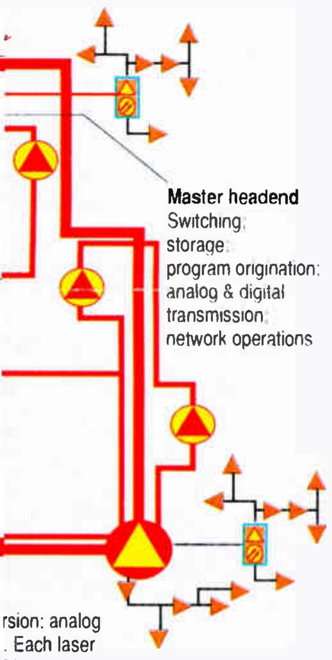
ISX makes flexible serving areas out of any topology.

ADC Video Systems' Flexible Distribution Architecture is designed to be future-proof, providing expandability in any capacity for any application.

Stage 1: ISX optical node and ISA RF amplifiers are deployed in initial serving area and deliver full 750 MHz forward path and 5-40 MHz reverse path capabilities.

Stage 2: When, for example, demand for bi-directional services exhausts local reverse path capacity, gate block convertor modules plugged into the ISX increase reverse path capacity by 300 percent without modifying cable plant. If demand for services such as video-on-demand exhausts forward path and constricts for the serving area, an ISA RF amplifier is upgraded to an ISX optical node by adding another lid. If necessary, all four ISAs may be upgraded to ISXs, increasing forward path capacity by 400 percent without coaxial plant modification.

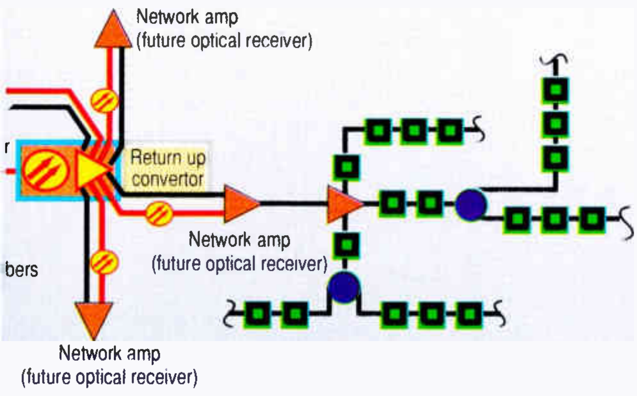
Stage 3: The original serving area is now four independent serving areas, each with four times the original forward and reverse path capacity.

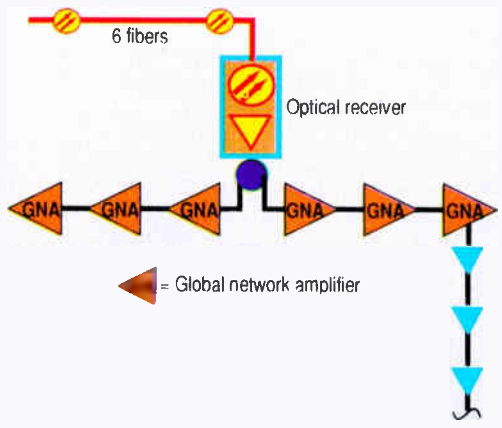


rsion: analog
. Each laser
f four node receivers.

Time Warner Cable's Residential Network Architecture

Time Warner Cable's Residential Network Architecture is designed to deliver analog video, voice and digital video and data services to customers. The architecture has been designed to allow a great deal of flexibility to expand the capacity of the network without significant amounts of additional fiber, and without the need to reconfigure the RF/coaxial portion of the network. In addition to the network illustrated, it is common for a second network, designed and constructed for business users, to share some of the routes and facilities shown in this diagram. Note: the combination of a node transmitter/receiver and the RF plant it feeds are typically referred to as HFC (hybrid fiber/coax) or Fiber Rich.





Broadband Networks' d Net Telecommunications k

ased on a cell size of 2,000 to 500 homes per node. It offers the flexibility re that meets the demands of the network.

Philips Broadband Networks Inc.

Philips Broadband Networks' Diamond Net Fiber Backbone

Network design to maintain existing trunk/bridger locations through a direct drop-in solution.

Diamond Net is trademarked to Philips Broadband Networks Inc.

6 Fiber To

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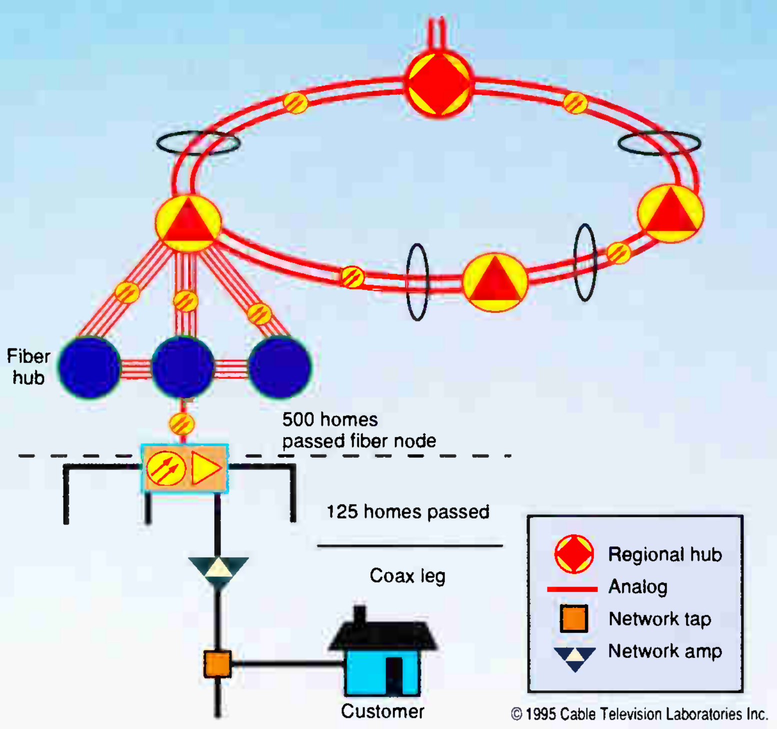
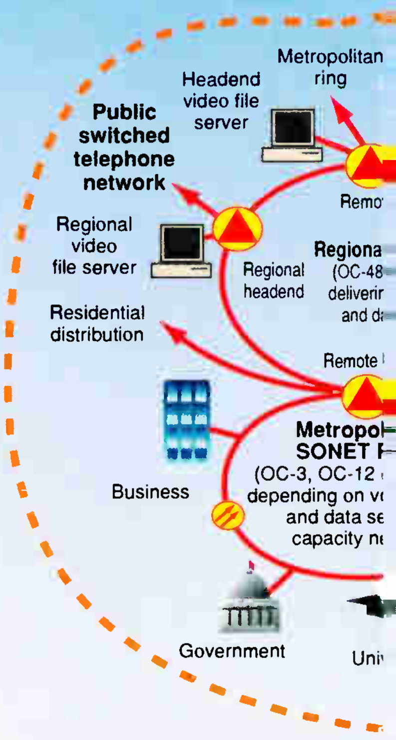


© 1995 Cable Television Laboratories Inc.

CableLabs' Active Coaxial Network Architecture

Designed by Cable Television Laboratories to accommodate a variety of network concepts to avoid making any existing networks obsolete while providing incremental upgrade path. Topology includes centralized "regional hub" to share the cost of advanced television and communication equipment among several operators as well as secondary fiber hubs. Connections between central headend and fiber hubs, as well as hub-to-hub interconnects, provide "virtual" ring capability and route diversity. Coaxial distribution to the home is active with a small number of amplifiers.



Antec's Cable Services Netw

ANTEC's CISN uses a building block
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services to businesses (e.g. telecom
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scan's l Network co/RF hitecture

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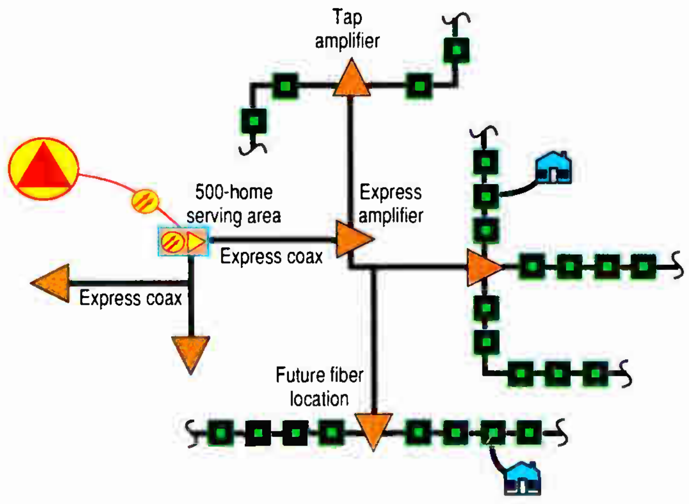
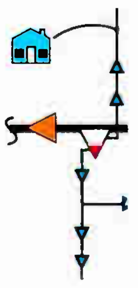


Scientific-Atlanta's FSA Mini-Star

The Fiber-to-the-Serving Area Mini-Star topology implements a passive cable design while containing fiber optic costs. The last amplifier position, designated as the tap amplifier, serves all subscriber taps. Coax express cables are used to interconnect the tap amps to the optical node. This approach removes the electrical/mechanical concerns between the actives and establishes a simple migration path to future fiber upgrades.



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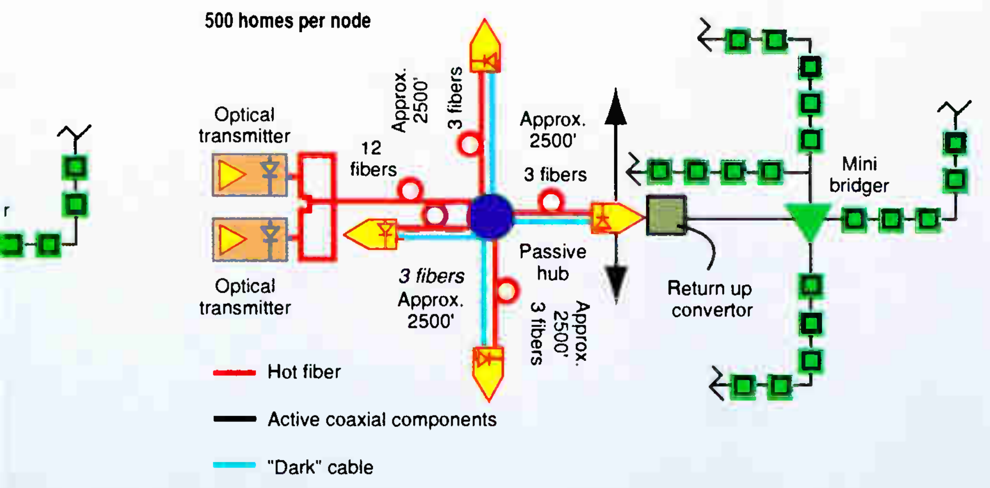
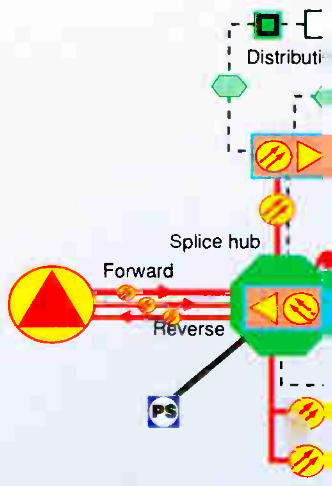


adband Telecommunications

costs while redefining system operational capacity without relocating devices or re-cabling. The
nd as few as 500 homes per node. The advantage of the BTA is an especially low active count,
h forward and reverse services, as the need arises.



Adelphia Ca

Designed by Adelphia Cable
network, the true passive arc
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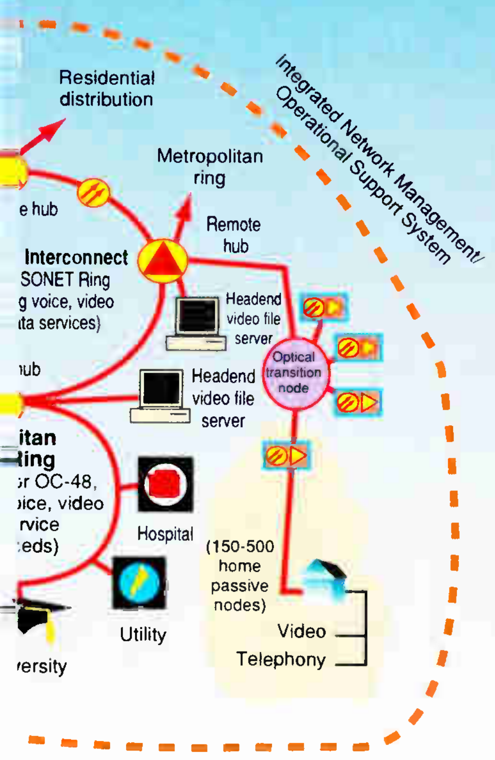
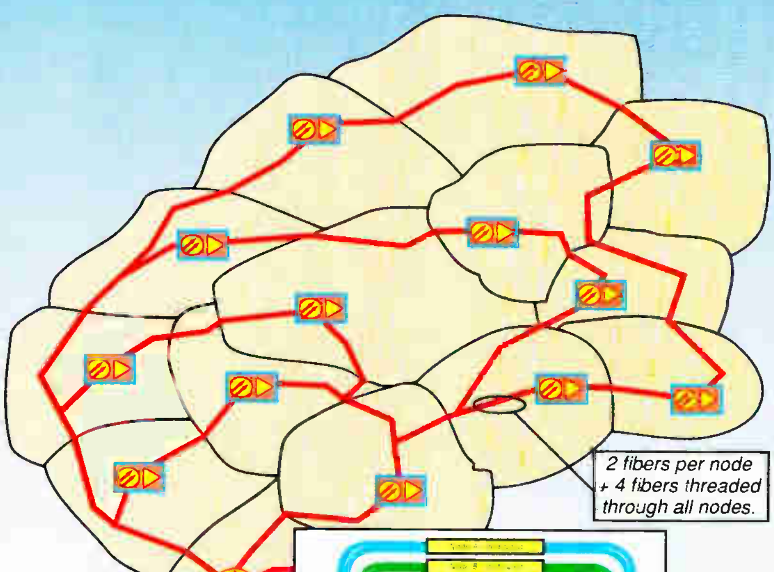
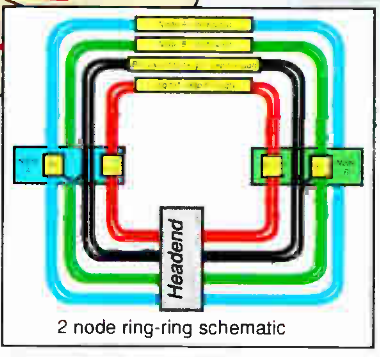


Integrated Network

approach based on new revenue streams (e.g. demand) and operational cost savings (e.g. economies of scale) to drive implementation of tan service areas provide robust interactive conferencing, telemedicine, interactive distance , CISN pre-provisions fiber to ultimately extend) with nodes sized from 150 to 500 homes, tely, the PON will provide 1 GHz bandwidth, for multimedia services.



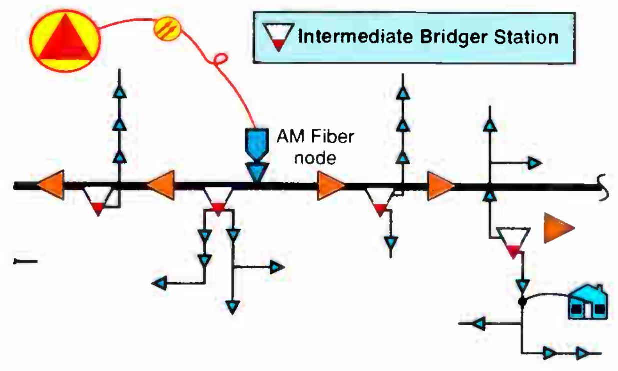


2 node ring-ring schematic

Cox's Ring-in-Ring

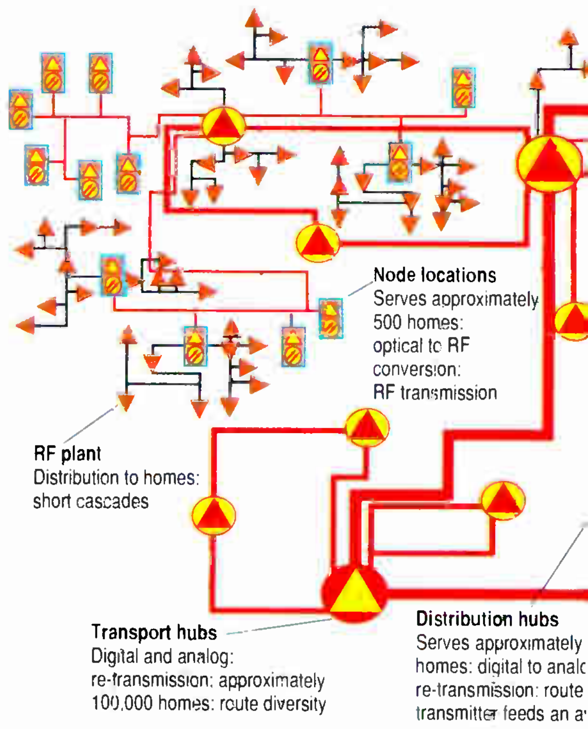
(Only one ring cluster shown)

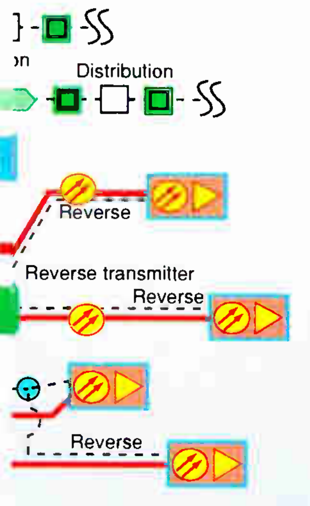
The Cox Communications "Ring-in-Ring" fiber architecture is an integration of a "dedicated" fiber ring and a "loop-through" fiber ring that gives operators a highly reliable and flexible network for the future. By using diverse routin redundant electronics, it can provide uninterrupted video, voice and data service to a node in the event of a fiber or electronic component failure. The dedicated ring carrie video to individual nodes, providing "broadcast" as well as programming and data ta to an individual node. The loop-through ring interconnects the nodes in a series fash delivering voice and data using an "add-drop" technique. The network is flexible eno allow subdividing nodes into smaller serving areas as demand for these new service results in the need for greater bandwidth.

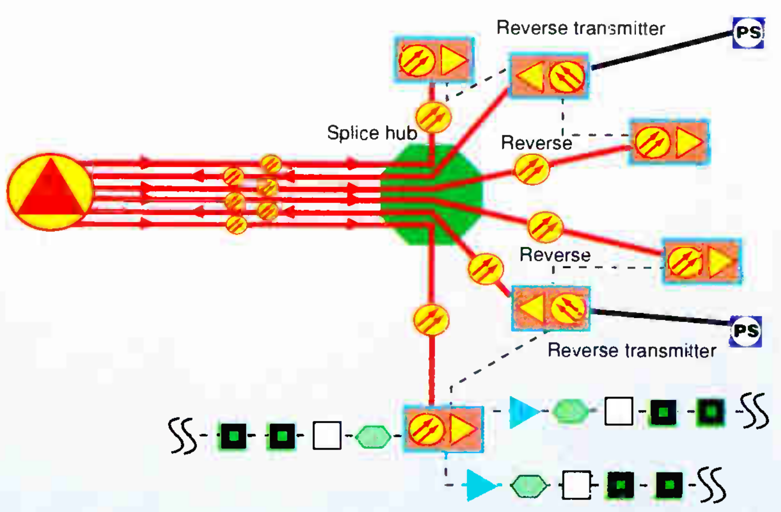


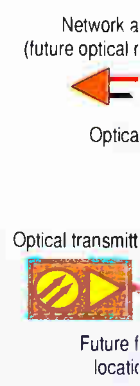
ntific-Atlanta's FITT

rd Intermediate/Terminating Trunk topology is similar to the one concept. The approach provides an upgrade path to apacity. Existing trunk locations are converted to FITT th dual output parallel hybrid bridgers. System or amplifiers are placed between FITT/bridger stations to ward signal amplification.









able's Passive Coaxial Network

Communications engineers to be a cost-effective method of eliminating all active components from the cable hitecture places a node every half-mile or so, while the modified design, above right, covers two miles of plant

Philip Diam Netw

This architectu to migrate to a

Diamond Net is traden

tories, which means telcos can't wait until they've deployed new networks, Maxwell notes.

Baines agrees. "The biggest market driver behind the telcos' shifting network strategy is data service," he says.

"People realize a huge market is developing for higher speed data access, and ADSL allows telephone companies to meet that demand without rebuilding their networks."

Cable modems

All of this makes cable's move into data a bit dicier than if cable were merely going up against ISDN, but the prognosis on costs, performance and timing for equipment supporting cable's initiative bodes well for MSOs. Judging by the state of telco ADSL preparations vs. cable's efforts in broadband data, the cable industry should have at least a six-month lead over telcos in broadband service offerings, though cable will find stiff ISDN competition in some areas, say industry leaders.

The prognosis on costs, performance and timing for equipment supporting cable's initiative bodes well for MSOs

While the cable industry has heard some promises that large-scale production of high-speed data modems will be underway by the first or second quarter of next year, the gear probably won't hit full production until the third or fourth quarter of next year, says Scott Bachman, vice president for operations technologies projects at Cable Television Laboratories.

"Most (RFP) respondents' plans point to sometime in the late first quarter or early second quarter as when early commercial production levels might be reached," Bachman adds. He predicts per-unit prices will hit $400-$600 in early production, falling to $200-$350 by the time 1 million units are sold.

Bachman's projections are based on early review of documents from 20 vendors who responded to CableLabs' RFP. By fall, he says, CableLabs will have an aggressive testing program underway in hopes of identifying the most effective end-to-end approach to delivering online services, Internet access and other data components to subscribers.

But even as cable races ahead of the telcos into high-speed data, there are outstanding issues that remain to be resolved, Bachman notes. For example, some vendors are suggesting prices in the range of $10,000 per RF termination unit at the headend, which is beyond expectations, Bachman says. In addition, prices for operating support systems "are all over the lot, which leaves us no understanding of what the real costs will turn out to be."

One factor supporting rapid ramp-up is growing industry consensus on key aspects of the data service support system, which extends beyond subscriber modems to include modulation, routing, network interface and other types of equipment as well as supporting software.

Bachman says industry thinking points to a two-phase implementation of broadband data technology, where the first-phase service would support a peak burst of anywhere from 10 to 30 megabits per second in the downstream, with the rate for upstream set at anywhere from 500 kilobits per second to 5 Mbps.

Later, in phase 2, equipment would support operations and billing for services that offer a symmetrical LAN extension to the home or office, where users can communicate with each other in collaborative computing and videoconferencing applications.

A minimum bit rate

A key issue for either type of service concerns the technical means by which operators will ensure a minimum bit rate per user at times of peak use, Bachman says. For example, a 6 MHz channel devoted to data service might deliver a 30 Mbps data stream to a coaxial serving area covering 500 households, which would mean the access rates would fall to under 1 Mbps if more than 30 users went online at once. It will take ATM (asynchronous transfer mode)-like capabilities in the signal routing process if operators are to guarantee users a minimum bit rate such as 1 Mbps in peak load situations, Bachman notes.

MSOs will be spending heavily on network upgrades throughout the coming year

While the industry's upbeat attitude toward the data service opportunity is driving vendor preparations at a furious pace, operators have much to learn before they can be sure broadband data is a business they want to get into. For example, notes one MSO CEO, asking not to be named, it is unclear whether the user community is large enough to generate the revenues necessary to support the operational infrastructure that the online business is likely to require.

So far, this executive says, field tests indicate the set-up at the customer's premises takes about two hours and requires far more knowhow on the part of technicians than is the case for traditional cable hookups. Moreover, he adds, upstream signal sensitivity to ingress and the poor condition of home wiring mean that technicians will be called on to fix leaks frequently, even in a state-of-the-art system.

"Anytime something goes wrong, even if it's an online service the operator has no control over, the local cable system will get the call, which could mean we have to devote considerable resources to customer service and maintenance in this area," the official says.

Strong demand for data

Such concerns are balanced by a sense among many strategists that there are enough potential early users out there who will take broadband data service at prices that will cover costs of an adequate operations infrastructure.

Hugo Davenport, chairman and CEO of Cambridge Cable in the U.K., says demand for high-speed data services proved so strong in his company's year-long interactive service trial that the firm has shifted its focus from interactive TV to data as the most promising new business opportunity.

"We're still offering movies, games and the like in the trial," Davenport says. "But it looks like the real opportunity that will support an interactive infrastructure is in the data area."

The key thing to understand in assessing cable's commitment to the data business is that strategic management is under the wing of MSO executives whose primary mandate is to launch wireline telephone services, notes a senior industry official, asking not to be named.

"If you were setting up to do nothing but data, maybe there would be a reason to get cold feet," he notes. "But we're going into competition with the telcos across all bases, and that means we'll pounce on data as an adjunct to everything else."

The California proving ground

One of the first tests of the cable industry's commitment to this strategy is likely to come in California, where state regulators have promulgated so-called "interim rules of competition" in hopes of opening the local exchange to newcomers by the beginning of next year. The incentive in California is especially strong, because Pacific Bell has won FCC authorization to proceed with its ambitious video dial tone plans.

"The state commissioners have kept to their word in trying to come out with rules supporting telephone competition," says Ann Burr, president of Time Warner Cable San Diego and chairwoman of the California Cable Television Association. "We're very encouraged."

Burr says high-level conversations within the cable industry signal that MSOs, already upgrading networks at a rapid clip, are ready to accelerate preparations of their networks for telephony as soon as they are comfortable with the rules of competition. While deployment of cablephone will begin gradually at a pace determined by equipment availability and the need for market experimentation, MSOs will be spending heavily on network upgrades throughout the coming year, officials say.

The equipment will be there

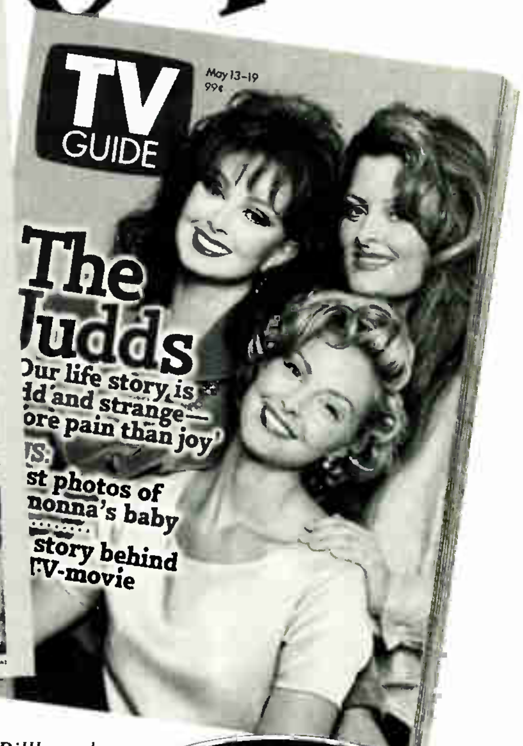
Notwithstanding unresolved issues, the interim orders, based on a "top-side" initial review, appear to meet the minimum standards Tele-Communications Inc. and its partners in the "NewTelco" venture have set for entry into telephony in California, says Tom Prevette, director of state regulatory affairs for the MSO.

"If, after further review, we feel the same way, I imagine the coalition will be prepared to enter service as quickly as possible," he says.

In California and elsewhere, the prognosis is that the equipment will be there to support cable's expansion onto telco turf. But with technology moving in support of telco expansion as well, strategists on both sides will have a lot to think about as they prepare to enter the brave new world of all-out broadband competition. CED

"For 2 out of 3 of us Judds, our first-read-of-the-day is Billboard...

Oops!"



Naomi tracks her and Wynonna's place on the charts with Billboard. (Actress Ashley makes a habit of Variety and The Hollywood Reporter.) Until they spot TV Guide's cover story on their moving NBC miniseries. But then it's back to their 'First Read.' And that's just fine with the more than 140 publishers of ABP, whose 800-plus trade journals keep America's executives ahead of the curve and on top of their industry.

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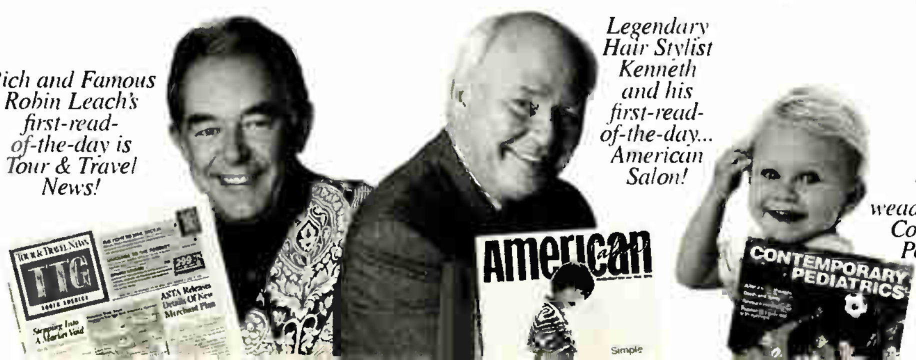

Rich and Famous Robin Leach's first-read-of-the-day is Tour & Travel News!

Legendary Hair Stylist Kenneth and his first-read-of-the-day... American Salon!

"My first-wead-of-the-day is Contemporary Pediatrics!"

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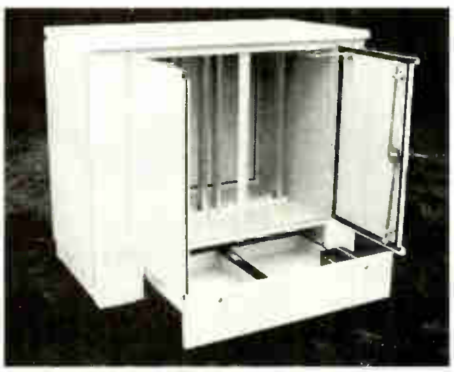

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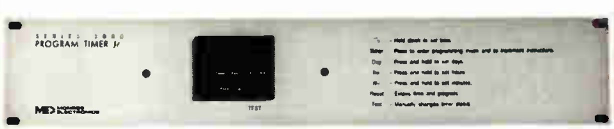

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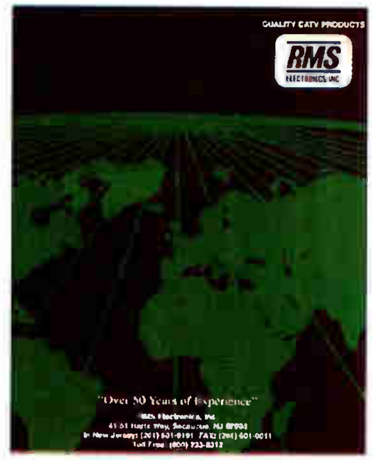

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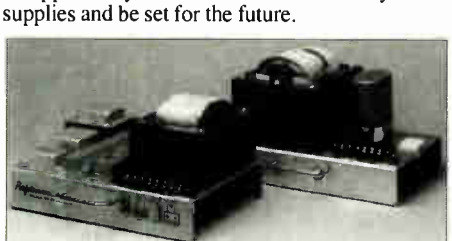

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September

1 Badger State SCTE Chapter, Technical Seminar & Testing Session. Location: Chula Vista Resort, Wisconsin Dells, Wis. Topic: "DBS and competing technologies, and EBS update," speaker TBA. BCT/E and Installer Certification exams to be administered. Call Brian Revak (608) 372-2999.

8 SCTE Satellite Tele-Seminar Program, to be transmitted on Galaxy 1R, Transponder 14, 2:30-3:30 p.m. Eastern time. Topic: "Meeting tomorrow's technical training needs," from Expo '94 in St. Louis. Call SCTE National Headquarters (610) 363-6888.

11-14 Antec Fiberworks Fiber Optic Systems Training (FOST). Location: Denver, Colo. Call Karen Olheiser at (800) FIBER-ME for more information.

12 Southeast Texas SCTE Chapter, Testing Session. BCT/E certification exams to be administered. Location: Walden, Texas. Call Richard Grahn (713) 579-6319.

12-14 Philips Mobile Training '95, produced by Philips Broadband Networks Inc. Location: Minneapolis, Minn. Call (800) 448-5171 (800-522-7464 in New York state) to register or for more information.

Trade shows

September

25-28 Convergence Interactive Television Conference and Expo, produced by Multichannel CommPerspectives. Held in conjunction with DAVID Developers Conference, produced by Microware. Location: San Jose Convention Center, San Jose, Calif. Fax registration to CommPerspectives at (303) 329-3453, or call Gary (303) 393-7449, ext. 225.

27-28 SCTE Northwest Mini-Expo. Location: Red Lion Inn, Kelso/Longview, Wash. Call Randy Love (503) 370-2745.

12-15 Fiber Optic Installation & Splicing, Maintenance and Restoration for CATV Applications, produced by Siecor Corp. Location: Keller, Texas. Call (800) SIECOR-1, ext. 5539 for more information.

14-15 Power & Communication Contractors Association (PCCA) Mid-Year Meeting. Location: Williamsburg Inn and Lodge, Williamsburg, Va. Call PCCA at (800) 542-7222 for more information, or to register for the meeting.

16 Chaparral SCTE Chapter, Technical Seminar. Topic: BCT/E Category III transportation tutorial. Location: Sandia Preparatory School, Albuquerque, N.M. Call Bob Wiseman (505) 761-6243.

18 Multicom Inc. Technical Seminar. Topic: Design, test and installation of cable systems. Location: Orlando, Fla. Included will be hands-on demos. Call Jordan Miller (800) 423-2594.

18-19 Antec Fiberworks Broadband Cable Television Technology (BCTT). Location: Atlanta, Ga. Call Karen Olheiser (800) FIBER-ME for more information.

18-20 Fiber Optics 1-2-3: Installation–Maintenance–Design, produced by The Light Brigade Inc. Location: Minneapolis, Minn. Call Valerie Johnsen (206) 251-1240.

19-21 Broadband Communications Technology, produced by C-COR Electronics. Location: Hartford, Conn. area. Call C-COR Technical Customer Services at (800) 233-2267, ext. 4422 for additional information.

19-21 Philips Mobile Training '95, produced by Philips Broadband Networks Inc. Location: St. Louis, Mo. Call (800) 448-5171 (800-522-7464 in New York state) to register.

20 Piedmont SCTE Chapter, Annual Vendor Show. Location: Hickory, N.C. area. Call Mark Eagle, chapter voice mail (919) 220-3889.

21 Penn–Ohio SCTE Chapter, Technical Seminar. Topic: "Safety–It's a must." Location: Sheraton Inn North, Pittsburgh, Pa. Call Marianne McClain (412) 531-5710.

25-26 Networking with Nortel–Fundamentals of the Digital Network. An in-depth seminar covering digital switching, transport and transmission, access, PCS and ATM. Location: Denver, Colo. Call (800) NT-TRAIN (688-7246) and select option 1, to register.

26 Sierra SCTE Chapter, Technical Seminar. Topic: "Sonet/ATM," with ADC. Location: Sacramento Cable Office, Sacramento, Calif. Call Patrick Furlong (916) 273-4866.

26-28 Philips Mobile Training '95, produced by Philips Broadband Networks Inc. Location: Lansing, Mich. Call (800) 448-5171 (800-522-7464 in New York state) to register.

26-28 Cable Television Technology, produced by C-COR Electronics. Location: Dallas, Texas area. Call C-COR Technical Customer Services at (800) 233-2267, ext. 4422.

27-28 Networking with Nortel–Fundamentals of the Digital Network. An in-depth seminar covering digital switching, transport and transmission, access, PCS and ATM. Location: Denver, Colo. Call (800) NT-TRAIN (688-7246) and select option 1, to register.

27-29 Hybrid Fiber/Coax Operation & Maintenance, produced by Scientific-Atlanta Institute. Location: Atlanta. Call Bridget Lanham (800) 722-2009, press 3, to register or for info.

The issue: Status monitoring

Monitoring network performance and achieving unprecedented levels of reliability are the linchpins of telecommunications networks in a competitive environment. Yet cable TV operators have traditionally avoided use of network monitoring systems because of their cost and problems with performance. But are those old habits dying off?

WIN $50 for responding*

The questions:

1. Does your system presently utilize any network status monitoring devices?

❑ Yes ❑ No ❑ Don't know

2. If so, what type of status monitoring system is used?

❑ Power supply ❑ End-of-line ❑ Entire system ❑ Don't know

3. If not, why are such devices not used in your system?

❑ Too costly ❑ Don't work ❑ Other

4. How important will status monitoring systems become to you in the future?

❑ Very ❑ Some ❑ Not at all

5. Is your system's management more interested in status monitoring as a concept now than it was a few years ago?

❑ Yes ❑ No ❑ Don't know

6. Have the FCC technical standards sparked an interest in using status monitoring equipment in your system?

❑ Yes ❑ No ❑ Don't know

7. Would your system prefer to purchase a more expensive and complex monitoring system or a less expensive system that offers simple alarms?

❑ Complex system ❑ Simple system ❑ Don't know

8. Which features of status monitoring systems are more important: Internal hardware info (temperature, bias, etc.) or external info (carrier-to-noise, etc.)?

❑ Internal info ❑ External info ❑ Don't know

9. Do you think a standard communications protocol should be developed for all status monitoring systems?

❑ Yes ❑ No ❑ Don't know

10. Should a monitoring system just provide data, or actually be able to control and manage a system through modules for fleet management, spare parts inventory, etc.?

❑ Provide data only ❑ Help manage ❑ Don't know

Your comments:

Fax us at:

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Make a copy of this page and fax it back to us at the number above, or mail it to *CED*, 600 South Cherry Street, Suite 400, Denver, Colo. 80222.

*Every month, we'll pick one response from those we receive and award $50. See official rules below.

Names won't be published if you request your name to be withheld, but fill out the name and job information to ensure that only one response per person is tabulated.

Your name and title

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System name:

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Location:

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Your MSO:

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Your job function:

____

Daytime phone #:

Official rules: No survey response necessary. Enter by returning the completed survey via fax or mail to the locations indicated above, or print the words "CED Return Path" on a 3"x5" card and mail it along with your name, address, daytime phone number and signature. To be eligible for the drawing, entry forms must be received by 5 p.m. on October 31, 1995. CED is not responsible for lost or misdirected mail. One entry per person. Forms mutilated, illegible or not in compliance with these rules shall be considered ineligible in the sole discretion of the judges. Odds of winning depend on the number of entries received. A random drawing from eligible entries will be held on or about November 1, 1995. Winner will be required to provide his/her social security number and proof of identification and is solely responsible for all federal, state and local taxes incurred. Prize is not transferable to any other person. Sweepstakes participants agree to waive any and all claims of liability against CED magazine, Capital Cities Media Inc., Capital Cities/ABC Inc. and its affiliated and independent contractors for any injury or loss which may occur from participation in this sweepstakes or receipt of the prize. Winner consents to publication of his/her name for publicity purposes without further compensation. Participants must be 18 years of age or older. Employees of CED magazine, Capital Cities Media Inc., Capital Cities/ABC Inc. and its affiliated and subsidiary companies, and their respective employees, agents and independent contractors, and their immediate families are not eligible to participate. Void wherever prohibited, license required, restricted or taxed by law. Sweepstakes sponsors reserve the right to change or modify the sweepstakes rules while the sweepstakes is in progress. Participation in the sweepstakes constitutes acceptance of all sweepstakes rules.

RESULTS

In spite of the fact that many MSOs now offer customer contact training for their front-line personnel, basic training programs offered by cable TV network operators should be overhauled, according to 75 percent of those who responded to our training and education survey. In fact, nearly 60 percent said they lack the training they need to effectively do their jobs.

Judging from the responses, it appears most MSOs lump training duties into other job descriptions. Only 25 percent said their system had a dedicated, full-time trainer, while two out of three said they didn't. Furthermore, when it comes to training in emerging technologies, the MSOs leave it up to others to provide training: only eight percent offer in-house fiber optics training, while just 25 percent have a course in digital technology.

Thankfully, most MSOs have policies in place that reimburse self-starters who have enrolled in either local colleges or home study courses, provided they pass the course. Oddly, however, the MSOs are split when it comes to providing time away from work for employees to attend local SCTE meetings, with 33 percent saying that policy was in place, 33 percent saying it wasn't, and 33 percent didn't know. And only one-quarter of those who responded said their MSO would pay the cost of becoming SCTE certified.

The issue: Training and education

As the Society of Cable Telecommunications Engineers gathered in Las Vegas last June for its annual Cable-Tec Expo and Engineering Conference, the spotlight was once again thrust upon the value of certification, standards and training. Many say education will become increasingly important as the industry moves forward and begins to deploy new, complex network systems. This survey shows what you think.

The results:

1. Does your system offer formal, in-house training in customer contact skills for installers and technicians?

Yes	No	Don't know
58%	**42%**	**0%**

2. Does your system offer formal, in-house training for installers and technicians to actually sell cable services to customers?

Yes	No	Don't know
58%	**42%**	**0%**

3. If you chose to enroll in an outside course teaching these subjects, would your company reimburse you for the tuition cost?

Yes	No	Don't know
58%	**0%**	**42%**

4. Does your system offer formal, in-house training for (check all that apply):

Installers	Service techs
67%	**58%**
Headend techs	Line techs
25%	**50%**

5. Does your system offer in-house training in fiber optics?

Yes	No	Don't know
8%	**83%**	**8%**

6. Does your system offer in-house training in digital technology?

Yes	No	Don't know
25%	**75%**	**0%**

7. If you enrolled in an outside course in cable TV technology, would your company reimburse you for the tuition cost?

Yes	No	Don't know
75%	**0%**	**25%**

8. If you chose to pursue college or vocational training in electronics, would your company pay at least a portion of the tuition?

Yes	No	Don't know
67%	**0%**	**33%**

9. Does your system allow you time away from your job to attend SCTE meetings?

Yes	No	Don't know
33%	**33%**	**33%**

10. Does your system pay the cost of SCTE BCT/E certification exams?

Yes	No	Don't know
25%	**33%**	**42%**

11. Do you believe you've received adequate formal training to do your job effectively?

Yes	No	Don't know
33%	**58%**	**8%**

12. Is there a dedicated, full-time trainer at your system?

Yes	No	Don't know
25%	**67%**	**8%**

13. Do you think there's a need to overhaul your system's training program?

Yes	No	Don't know
75%	**8%**	**25%**

Comments:

"I rely on trade magazines like *CED* for all my education on up and coming technologies, such as fiber, telephony and [the] return path."
– David Iacovelli, Time Warner Cable, Foxboro, Mass.

"Many MSOs have training, many don't. My company is committed to giving each installer the best basic training, and we're a contractor."
– Earl Bennett, RTK Corp., New Providence, N.J.

"Training and definite goals have always been a concern and problem area within this company. Very poor communication!"
– Gregg Brazee, Auburn Cablevision, Auburn, N.Y.

catel invests $50 mill more in fiber

CLAREMONT, N.C.—Less than two years ter completing its $100 million investment in a w optical fiber plant and fiber cable plant pansion in Claremont, Alcatel :lecommunications Cable is investing more oney in the Claremont complex to help it meet —e increasing market demand for fiber optic ble products.

The company is investing a further $50 mil- ɔn that will increase the capacity of the laremont complex to manufacture optical fiber ıd fiber optic cable by 35 percent by the begin- ng of 1997. The $50 million will be used to :pand the operation's capacity for both existing ıd new fiber cable products. Alcatel will also stall, in the fiber plant, new proprietary tech- ɔlogy which has recently completed develop- .ent at the company's optical fiber manufactur- ıg facility in Douvrin, France.

=orta Systems facility awarded ISO 9002

SYOSSET, N.Y.—Porta Systems Corp.'s .opkinton manufacturing facility has been reg- tered to ISO 9002 by its registrar, ·nderwriters Laboratories.

The Hopkinton plant, which manufactures .ster fiber optic couplers, joins the company's ther facilities in Limerick, Ireland; Coventry, ngland; Matamoros, Mexico; and Kingsville, 'exas in having received ISO certification.

I wins two major contracts

HATBORO, Pa.—Cox Communications will pgrade its 3,300 mile operations in the .ouisiana parishes of Jefferson, Orleans and St. :harles with distribution electronics from ;eneral Instrument.

In upgrading its system to 750 MHz, Cox /ill use GI's RF electronics, including the com- any's latest-generation broadband telecom dis- :ibution amplifiers, mini-bridgers, line exten- ers and assorted taps and passives.

General Instrument Corp. has also announced .1at China Central Television has chosen the ompany's digital technology to bring advanced ɜlevision services to the country. The initial -ontract, for 1,500 decoders, will permit CCTV o launch three pay TV channels to more than ·00 network operators in China.

By installing GI's compression on ChinaSat ;, CCTV will immediately launch three pay -hannels. CCTV will also lease capacity on \siaSat 2, due to be launched this summer. The ıplink will employ compression to provide ncreased domestic capacity, as well as capacity 'or export distribution.

Both satellites will use DigiCipher compres- .ion technology, increasing channel capacity for :CTV.

TV/COM, Tectelcom sign pact

SAN DIEGO, Calif.—TV/COM International has signed an agreement with Tectelcom of Sao Paulo, Brazil to manufacture and distribute TV/COM's Sigma product in South American markets. Tectelcom is currently under license to manufacture and distribute ProGuard, TV/COM's analog satellite product, in Brazil.

The Sigma inband analog cable and MMDS systems are targeted to markets such as South America, where the demand for low-cost imple- mentation of addressable technology is growing at a rapid rate.

S-A to facilitate 750 MHz upgrade

ATLANTA—Southern Multimedia Communications Inc., a subsidiary of US West, has named Scientific-Atlanta as a key supplier for upgrading a 12,000-mile cable network in the metropolitan Atlanta area.

The project will make the entire Southern Multimedia cable network capable of providing integrated video, voice, data and other enhanced services over an advanced, two-way system. Southern Multimedia's cable systems, GCTV and Wometco, pass approximately one million homes and serve nearly 500,000 subscribers.

S-A will supply receivers, stereo encoders and modulators for the headends, as well as ampli- fiers for the distribution network. The new equip- ment will upgrade the system to 750 MHz. The 750 MHz system will provide about 90 channels of traditional analog cable programs, and eventu- ally, hundreds of digitally compressed services.

C-COR supplies digital fiber to Singapore

STATE COLLEGE, Pa.–C-COR Electronics Inc. will supply video transmission equipment for five hubs in a redundant, self-healing, digital ring cable television network to be built in Singapore in 1995. The value of the equipment is approxi- mately $1.2 million.

The Singapore system, which will be turned on in phases from mid-1995 to the end of 1998, is designed to carry up to 64 PAL video channels, plus audio. Presently, 41 channels are being offered. A number of audio channels will be enhanced by using a new digital baseband codec being developed by C-COR. The device allows for delivery of NICAM stereo audio channels free from the degradation that is common in ana- log signals. The method can also be used to deliver dual-language programming.

Laser Precision wins Swedish order

UTICA, N.Y.–GN Nettest's Laser Precision Division has been awarded a contract from the Swedish Telcom, Telia AB, for a nationwide remote fiber optic administration system called Orion.

The initial value of the contract is $700,000, with a planned extension of more than $4 mil- lion. Deliveries begin in the third quarter of '95, and the final phase is scheduled for completion in 1997. GN Nettest won the Swedish order after a four-month field trial, competing with other manufacturers.

The Orion system will detect, measure and report the status of a cable fault; detect and report instances of increased attenuation that may turn into faults causing service disruption; regularly store and correlate results from a com- mon database; and correlate optical and physical location of events in the cable.

3M opens fiber training center

AUSTIN, Texas–3M Telecom Systems Division has opened a new center for training students in optical fiber installation and mainte- nance.

The 2,300 square-foot classroom is specially designed to accommodate up to 16 students per class for mostly hands-on training in fiber optic splicing, terminating, connecting and intercon- necting products and test and measurement sys- tems and instruments.

Suspended from the classroom's ceiling are 4,000 meters of fiber optic cable routed between fiber distribution units in nine different equip- ment racks. Black, Plexiglas-topped work tables make it possible to see tiny glass fibers that stu- dents work with. The classroom is also equipped with a 60-inch television and a VCR.

Augat supplies Korean network

MANSFIELD, Mass.–Augat Inc. has announced that its Communications Products Division has completed initial deliveries of RF amplifiers, optical nodes and coaxial connectors to be used in the construction of Korea's new cable TV network.

Augat's products were supplied to KEPCO, the Korea Electric Power Corp., via several part- ners based both in the United States and Korea. Initial deliveries totaled approximately $3 mil- lion.

Power & Telephone Supply adds line

DANBURY, Conn.–Power & Telephone Supply Company has signed an agreement with Amphenol RF/Microwave Operations–CATV Connector Group to distribute and stock Amphenol's complete line of CATV connector products, including hardline and drop connec- tors, adapters, terminators and cable preparation tools.

Power & Telephone Supply Company is headquartered in Memphis, Tenn. and has distri- bution and sales offices located throughout the United States and Canada. CED

Hybrid cable management

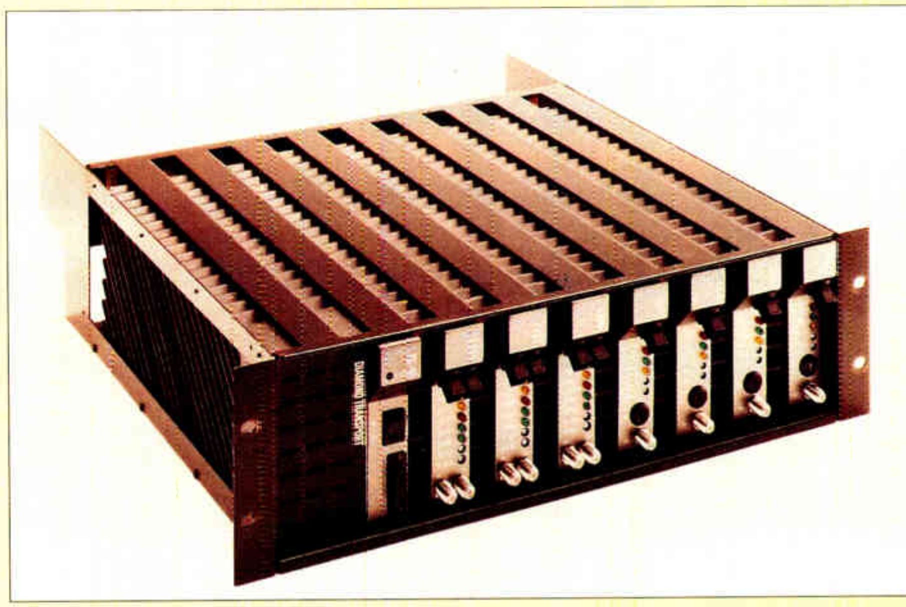
AUSTIN, Texas–3M Telecom Systems Division has announced the availability of an integrated broadband cable management system for the cable television and telephony industries. The company's broadband cable management system enables cable and telephony network engineers to reduce copper and fiber installation time, while increasing system performance and reliability, according to 3M.

The system's modular design allows operators to customize the system to fit the size requirements of individual, controlled environmental vaults or huts. The system accommodates all cable TV and telephony applications using any combination of copper, fiber, or hybrid fiber/coax cabling.

The Category 5-listed management system consists of the 3M brand 4500 high density protection system (HDPS), the brand 8425 fiber distribution system, the 3M brand 2700 fiber distribution system (FDS), and the brand 4200 video information system. Each system is customized and fully equipped with fiber optic and copper connectors, splicing units and cross connect panels upon arrival at the installation site.

In brief, the system works like this: optical fiber cables enter the CEV/hut and are fed into the 3M 8425 fiber distribution system, or the 3M 2700 fiber distribution system, which provides complete termination, splitting and optical attenuation in a single unit. The output signal is de-multiplexed to twisted pair and connected to the HDPS. 3M offers a demultiplexer of the customer's choice. Copper cable exits the vault or hut into distribution.

Circle Reader Service number 61



Universal shelf system

MANLIUS, N.Y.—Philips Broadband Networks Inc. has introduced its Diamond Transport universal shelf system for 750 MHz transmission and reception of analog fiber signals. Diamond Transport accommodates up to 91 transmitters per rack, in various configurations, and accepts up to nine modules in its three units of rack space, so users completely control rack architecture.

Remote and phone in one

WILLOW GROVE, Pa.—Cable Technologies International Inc. has introduced the Remote 'N Phone, which combines the features of a cordless telephone with those of remote controls.

Features of the product include: 10-channel autoscan; audio companding noise reduction circuitry; RF range 500-1,000 feet, out-of-range indicator; lighted keypad between recharge; mode indicator; find (remote locator); nine-number speed dialing; last-number redial; mute; hold; flash; battery status indicator; three-day battery life; automatic security access; touchtone/pulse dialing; ringer on/off control; modular jack; desk mount and wall mount.

Circle Reader Service number 62

Line monitor

SARASOTA, Fla.–Superior Electronics Group Inc. has announced the introduction of its new LC-1000 line monitor. The LC-1000 is a 1 GHz, cost-effective RF level monitor that is used primarily for status monitoring.

Superior Electronics Group's LC-1000 line monitor

While transponders typically provide information on whether active devices are functioning properly, only a line monitor will provide RF levels which are necessary to evaluate the quality of the signal the customer is receiving. By placing the LC-1000 beyond nodes, at splits or termination points, the operator may "See what the subscriber is seeing," according to the company.

Since ingress on the return path may disrupt status monitoring systems, the LC-1000 includes a frequency agile RF data modem that allows the operator to remotely re-program the return frequency within a 3 to 4 MHz range.

Also designed to limit field replacements, the LC-1000 includes remotely re-programmable firmware that allows the operator to upgrade thousands of devices remotely. If field service is required, the LC-1000 includes an RS-232 port for local access. The LC-1000 is part of the Cheetah Status Monitoring System.

Circle Reader Service number 63

Sonet OC-12 capacity

RICHARDSON, Texas–Alcatel Network Systems has announced a Sonet transport solution to meet the needs of carriers seeking to accommodate new customers and meet the demands of network expansion.

Alcatel's 1603/12 SM Sonet multiplexer now has OC-12 (622 Mbps) transport capability, which quadruples the capacity of the base OC-3 model (155 Mbps).

Philips Broadband Networks Inc.'s Diamond Transport

Diamond Transport's cool operation is achieved by Philips' patented fanless heat transfer. The cooling-fin thermal design eliminates fan failure and the subsequent system shutdown or destruction that mechanical fan malfunctions can cause.

The system's optical performance derives from Philips' linearization technique, yielding distances from 20 to 35 kilometers. Offered in a variety of models ranging from 7 dBm to 12.5 dBm, Diamond Transport increases power in 2 dBm increments. A 1 dBm output for narrowcast application is also available.

The universal system is compatible with virtually all existing equipment and offers front-panel access to facilitate module installation or substitution. AC or DC power redundancy adds reliability, as does the advantage that each individual rack can be powered separately, or the entire six-foot rack can be powered as a single unit.

Diamond Transport integrates with Philips' Net Prophet AM-based system software for space-efficient local and remote status monitoring through the shelf's backplane.

Circle Reader Service number 60

Alcatel accomplishes a four-fold capacity expansion in the 1603/12 SM through an in-service, "in-shelf" upgrade which requires only two new card types and the loading of new software–no additional racks or shelves are required. The product offers carriers the option of OC-3 or OC-12 configuration in a single, compact shelf. The 1603/12 SM can operate as an OC-3 and OC-12 system at the same time, interfacing an OC-12 line rate through one high-speed direction, and OC-3 through the other high-speed direction of the same shelf.

This capability allows route tapering using only the high-speed section of shelf, leaving the low-speed interface positions 100 percent available for local access of up to 12 DS-3s, 84 DS-1s, or for additional optical extensions.

Circle Reader Service number 64

Access and security

KANATA, Canada–West End Systems Corp. has announced the debut of its Janua product family.

The Janua product line includes West End's WestBound 9600 line–a platform of products enabling access and security of communications over hybrid fiber/coax networks; its range of FRADS (Frame Relay Access Devices); as well as its ISDN Terminal Adapters–enablers of LAN access and interconnection over both leased and ISDN access lines.

West End has also launched two of the Janua products: the Burgundy FRAD and the Shureino Terminal Adapter.

Circle Reader Service number 65

Fiber software

SYOSSET, N.Y.–Porta Systems Corp. has introduced its Fiber Frame Administration Software (FFAS). The program automates both the fiber optic jumper cable assignment and the recordkeeping portion of the company's distribution frame system.

FFAS allows the user to select a range of housings to create a fiber distribution frame system that may consist of up to 40 frames in a lineup. By selecting a source and a destination, FFAS provides the ideal jumper length and routing of the cable based on the user's available patchcord inventory. An override feature permits the rerouting of the alternate jumper cable lengths up to 25 meters.

FFAS automatically prepares reports that may be printed or viewed on the screen. Standard reports provide details on patchcord assignments, frame or cable identification connections, patchcord inventory and a database summary of the system components. If necessary, a work order may be printed which contains information about the connection circuit, as well as an image of the recommended cable routing.

Circle Reader Service number 66

Fiber management

AURORA, Colo.–FiberTronix Inc. has introduced the FOX (Fiber Optic Crossconnect) fiber management system, which provides an efficient solution for fiber optic cable management and cross-connection.

The modular system is comprised of universal mounting shelves that can be equipped with a variety of apparatuses for terminating, splicing and coupling applications. The FOX system can be either fully equipped initially, or incrementally equipped, as required.

FiberTronix Inc.'s FOX fiber management system

Features include: a FOX fiber distribution frame, a FOX electronic distribution frame, an OTV (optical transition vault), pretermination shelves, splicing shelves, a customer premises unit, splitter modules, and cables and connectors.

Circle Reader Service number 67

Decoder board

ST. PETERSBURG, Fla.–The Vela Research Model 2000-0203 SCSI-2 Decoder Board is a single-board, audio/video decoder designed for environments where high-quality decoding is needed on computer platforms that offer the SCSI-2 Fast Mode Interface.

The SCSI-2 decoder acts as an SCSI target. As a result, multiple decoders can be "stacked" on the same SCSI cable, thus allowing multiple playbacks from a single SCSI-2 bus.

Although the decoder is especially suited for broadcast quality ITU-R 601 (704 x 480 pixel), it is also capable of decoding at SIF (320 x 240 pixel) resolutions. The decoder board also has a genlock video input feature which allows the decoder board's video output to be timed and phased to a video source such as a blackburst reference timing signal or a video signal source. Timing adjustments are made via software commands sent over the SCSI bus.

Circle Reader Service number 68

Voltage testers

MEMPHIS, Tenn.–Thomas & Betts has added two new voltage testers to its line of T&B Electricians' Supplies. These new testers offer sturdy construction and accurate measuring abilities to handle a range of metering needs.

The 19-806 Voltage Tester-Solenoid Type features dual voltage indication–both solenoid vibration sensing and electronic neon visual identification. It is capable of positive AC/DC voltage identification in a wide range of voltages: 120, 240, 480 and 600 VAC at 60 or 50 hertz, and 120, 240 and 600 VDC.

Circle Reader Service number 69

Fiber optic cable puller

MANKATO, Minn.–Condux International's new fiber optic cable puller is now 30 percent lighter and offers bi-directional pulling capabilities. This improves its transportability and eliminates time-consuming setup changes, according to the company.

Standard features include a 30-inch capstand, hydraulic motor, variable-speed foot control, manual flow control valve and footage counter. An optional electronic tension control system and chart recorder provide a permanent pull history.

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SYSTEM TECHNICIAN- Set levels, set-up and change out system electronics, including fiber. Calculate signal level losses; conduct system tests and semi-annual proof of performance testing; responsible for troubleshooting and repair of the entire distribution system. The requirements of the position are: the ability to lift and carry 70lbs. drive company vehicles and use bucket trucks when necessary; 3 years cable TV experience; valid drivers license and a good driving record; ability to be on call as needed. Completion of NCTI System Technician and Fiber course; previous System Technician experience.

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The irksome interface impediment

By Archer S. Taylor, Director and Senior Engineering Consultant, Malarkey-Taylor Associates

I just bought a new TV set. Twenty-seven-inch. Universal remote control. PIP (picture-in-picture). Not that my 10-year-old, 20-inch set was defective or deteriorating. Actually, it was working just fine. But my favorite easy chair is about 15 feet from the screen, about 15 times picture height. Moving furniture is not a viable option, considering the geography of the windows, doors, fireplace and an opening to the kitchen. Yet, even with the 27-inch screen, viewing distance is about 11 times the 16.2-inch picture height, well above the recommended six times. There is no way I could manage an HDTV screen large enough to be viewed at three to four times picture height.

I found out how difficult it would be for a typical, non-technically oriented consumer to install a modern television receiver, especially on a cable TV network, dual cable at that. I knew that PIP would not work. I knew about the VCR problems. Dave Large did a splendid job of outlining the almost unlimited number of ways to connect the set-top convertor box, the VCR and the TV set. Complicating the process were (a) the matter of programming the universal remote control to operate the cable box, TV and VCR; and (b) the offer of 30 days free use of a special program navigation guide and control service.

It was not too hard to follow the diagrams for connecting the cable box and the VCR. There remained the daunting task of physically connecting all the ports together. The proper tools, which any responsible installer would have had, were not available to me, nor to most consumers. I was reduced to using crimp rings and whatever 59 cable, F-fittings and splitters could be obtained from the nearest Home Depot. Since I already had a motley collection of preassembled 59 jumpers of various lengths and descriptions, some with push-on fittings, I did not need to make up new ones.

The new TV set is much too heavy to wrestle with. It sits on a cabinet containing the VCR on a sliding shelf and a bunch of video cassettes behind a pair of doors. The cable set-top box is on another sliding shelf above the cabinet doors. Access to the back of the TV set is obstructed by furniture on one side and by a wall on the other. The cable drop is size 6, siamese and very stiff. Feeding one of the dual drops through cutouts in the back of the cabinet to the proper cable box ports, while the other is led to the back of the TV set, requires considerable acrobatic skill, and–I might add–patience.

After getting it all together, the pictures went snowy when I rotated the TV on its turntable. With much difficulty, I was able to trace the noisy connection to the three cables connected to the splitter. Bedeviled with cross-threaded F fittings, I changed out first one cable, then another. I even tried a different "Made in China" splitter I happened to have on hand. Still snowy. So, I drove to an electronic parts shop five miles away to purchase a somewhat larger, more durable looking splitter, also made in China. Success! It wasn't the F-connectors after all.

The programming instructions for the universal remote were clear enough. But when I tried to explain to others how to use it, I began to see problems for the typical consumer. Turn the TV set on by pressing the **TV** mode key, then the **Power** key. Turn on the cable box by pressing the **Cable** mode and **Power** keys. Then, go back to the **TV** mode and use the **10-key pad** to select channel 3. OK so far. Now, go back to the **Cable** mode key in order to use the same 10-key pad to select any one of the 120 channels available on the dual cable system. The **Volume** up/down and **Mute** keys will work in either **Cable** or **TV** mode. However, if you have muted in **TV** mode, you cannot restore the sound by pressing **Mute** while in **Cable** mode, and vice versa. Moreover, if **Volume** is reduced in **TV** mode, it cannot be restored while selecting channels in **Cable** mode. The temptation to select channels while in **TV** mode is great, but results in losing everything. Now, is it perfectly clear? If so, try the **VCR** mode and the **Guide** mode; then try to get back to **TV** and **Cable** modes. Good luck.

Time is running out

Actually, the best way to understand the universal remote control is to recognize that it is nothing more than two separate remotes, physically packaged in one case. In fact, it is actually four separate remotes, since it also includes the VCR controls and the program guide and navigation controls, as well as TV and Cable. But, for those who are not particularly good at technical and mechanical things, it is "a pain in the butt!"

An immediate, but only partial solution would seem to be set-top boxes (without volume control), used only to convert premium programs to channel 3, and to descramble. All non-premium channels would be bypassed directly through to the TV set. However, even the by-pass convertor requires two remotes. This concept has not been promoted in the U.S., apparently because of the imminence of a set-back Decoder Interface to deal with a host of other functions, described so well by Walt Ciciora at the recent NCTA Convention. The by-pass convertor, even with dual facilities to accommodate simultaneous viewing and recording, is not enough. The truly compatible interface should not restrict the services cable can offer to the capability built in to the TV sets and VCRs. It should be able to accommodate demand for services beyond the built-in bandwidth and capability of commercial TV sets. It could accommodate satellite DBS and ADSL, as well as conventional CATV signals. Time is running out. If the parties do not soon agree, the matter may well be resolved or obfuscated by the FCC, most likely to everyone's disadvantage. CED

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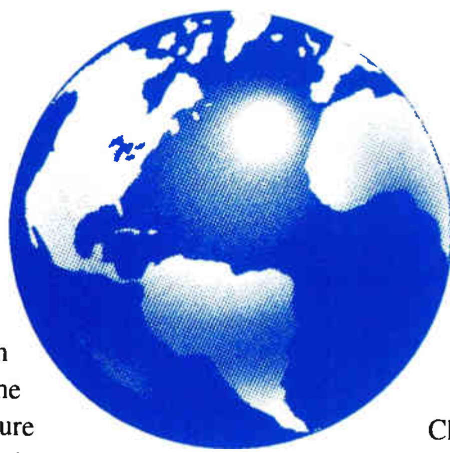

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