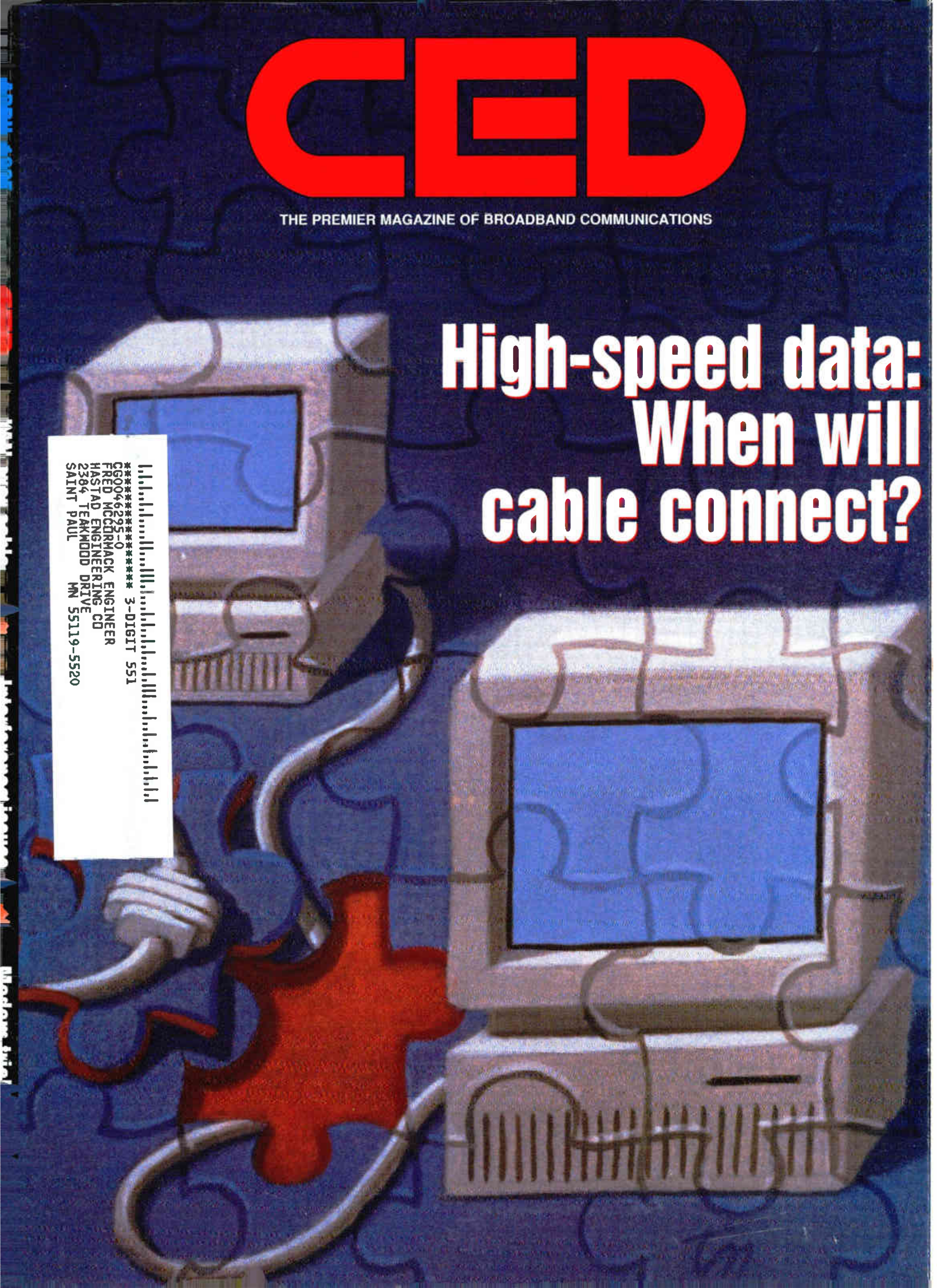
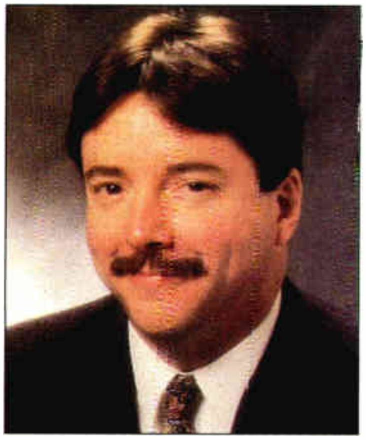


WHAT DOES THE NEXT GENERATION WANT FROM US, ANYHOW?

Every so often, I go back through my reporter's notebook to review some of the random thoughts I've written down, but didn't know what to do with. Here are a few:

✔ In case no one's noticed, competition between MSOs is creeping back into the business. During the Texas Show, where TCI briefed attendees on its new software platform, Dr. Sadie Decker was careful not to mention the vendor partners TCI has chosen for the project, for competitive reasons. "I know Time Warner was in the audience," she said afterward. Remember, Time Warner is allied with US West, which happens to be based a few miles from TCI's headquarters in Denver.



Make sure you get your two cents worth

✔ Cable operators who aren't being vocal about their future hardware needs with the manufacturers had better do so now. Increasingly, future set-top applications and functionality are being decided by standards groups–and few MSOs are active in those discussions. For example, the DAVIC group is shooting to publish its "baseline" document that addresses several standard interfaces by December, and only Time Warner Cable and CableLabs have attended meetings. Conversely, most manufacturers and a few RBOCs are quite active in that group. So you better get your two cents worth in quickly.

✔ The next time you're at a seminar or panel discussion that addresses video network architectures, take a close look. I'll bet nine out of 10 show a set-top sitting on the TV. But as Time Warner (and others) are finding out in Ohio, it isn't easy to put set-tops where they've never been before. Subscribers revolt. Newspapers write about it. The FCC demands "in the clear" signal provision. I hope someone someday makes a set-top subscribers will really want. In the meantime, don't think it's going to be easy to get subscribers to enter the interactive age with a new set-top.

✔ In order to drive down prices and jump-start service provision, the PlatCo consortium (a partnership of sorts between Nynex, Bell Atlantic and Pacific Telesis) has issued an RFP for up to four million set-tops it plans to deploy over the next five years. Faced with becoming a second-tier customer, watch for a major cable MSO (or maybe a consortium) to make an investment in a set-top manufacturer to preserve its place in the pecking order. Seems excessive, but it's the new business reality.

✔ At long last, a few more MSOs are beginning to test cablephone systems, but the manufacturers are finding that dialtone over cable systems isn't a simple process. The problem is the upstream path: It often can't be kept "clean" enough to keep the system up and running. Tellabs and ADC Telecommunications are learning some tough lessons in their field trials and making hardware modifications that should lead to better product.

✔ The cost of building a broadband network for providing cablephone services has one well-known consultant bearish about the service. Tom Gillett, a principal with Gillett-Lehman of St. Louis, told a Texas Show audience he "remains skeptical that dialtone over coax can compete with dialtone over copper." Gillett has 20 years of experience in telephony and 10 years in cable. His views shouldn't be taken lightly.

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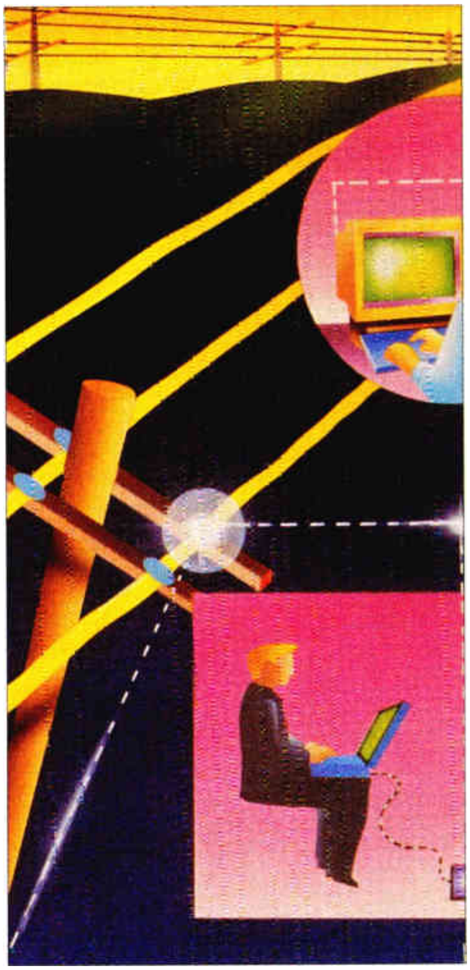

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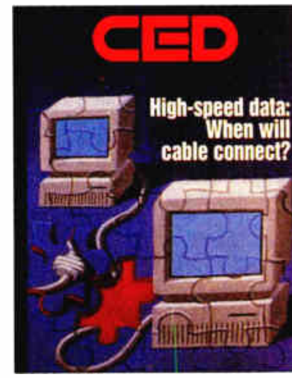
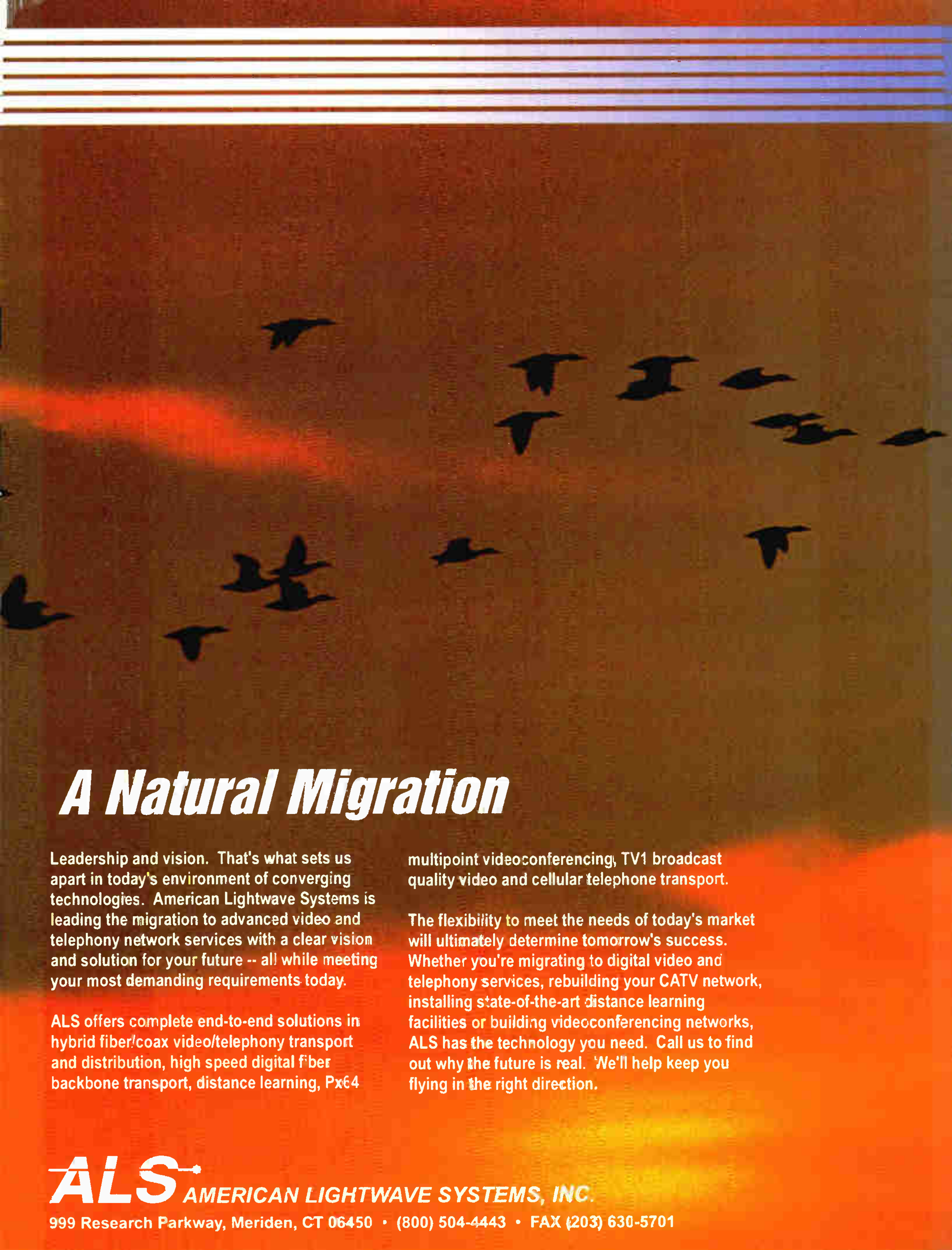


About the Cover

The cable network offers huge potential for data. Photo by The Image Bank.

Departments

CED (USPS 330-510) (ISSN 1044-2871) is published monthly except twice in May by Chilton Publications, A Capital Cities/ABC Publishing Group, 825 7th Ave., New York, NY 10019 Volume 21, Number 4 U S domestic subscriptions are $48. Outside USA, subscriptions are $69 for surface delivery or $96 for air speed delivery, prepaid in U S funds drawn on a U S branch bank Second-class postage paid at New York NY 10019 and additional mailing offices. CED is published on behalf of the cable television and broadband communications industries POSTMASTER: Please send address changes to CED Circulation, PO Box 7699, Riverton, NJ 08077-7699 MEMBERS OF THE BPA Printed in U S A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Girding for the next big interface debate

For those of you who are tired of hearing about the debate between the NCTA and the EIA over the cable decoder interface, I am pleased to be able to report that there is another interface in the works. This is the baseband digital interface, intended to interconnect digital TV sets, digital VCRs, digital cable decoders and other digital video products. It's being called an interface, but it's really a high-speed local area data network within the home, operating at 50 to 100 megabits per second (Mbps). So instead of the policy issues that have dogged the cable decoder interface negotiations, there are technical questions to be addressed.

By Jeffrey Krauss, interfacing with the digital world at jkrauss@cpcug.org and President of Telecommunications and Technology Policy

The goals

The baseband digital interface will need to operate at a data rate of around 50 Mbps or higher. While a single HDTV broadcast channel is a 19 Mbps data stream, a cable TV channel can carry two HDTV channels at a 38 Mbps data rate. But this local area network may need to carry several channels, so a data rate of up to 100 Mbps may be needed. Remember that Ethernet local area networks operate at 10 Mbps, and 100 Mbps local area data networks are being developed, so a data rate in this range for the interface should be achievable. But Ethernet networks are not yet consumer electronics products, they cost more than a few bucks per port, and they don't automatically configure themselves when you hook them together. It will be a challenge to create a foolproof, inexpensive consumer product.

Data rate, cable reach and other factors are interrelated. Other factors being equal, you can pump a higher data rate over 10 meters of cable than 100 meters. It is not yet decided whether one of these networks will cover an entire house or only a single room, and whether single room networks can be interconnected together using bridging techniques. There seems to be a consensus that twisted pair cables, not coaxial cables, should be used as the medium, but whether the cable should be shielded or unshielded is uncertain. Shielding may be needed to suppress interference radiating out of the cable, as well as to protect against ingress interference.

Contenders

There have been three specific proposals made to an EIA subcommittee established to set a standard for the baseband digital interface. One is based on the IEEE P1394 specification; one is based on the IEEE P1355 specification; and the third takes some elements from each. Both P1394 and P1355 are in the final stages of the standards process through IEEE.

The P1394 specification supports transmission rates of 100, 200 and 400 Mbps, but only 100 and 200 Mbps would be used in this consumer application. P1394 operates only within a room, with cable lengths up to 10 meters. P1355 supports data rates up to 50 Mbps, but can operate with cable lengths up to 100 meters. The third design operates at 100 Mbps with a cable reach of 15 meters.

The proponents of these networks are semiconductor manufacturers. The P1394 specification was proposed by Texas Instruments (supported also by Sony). The P1355 specification was proposed by SGS-Thomson Microelectronics (formerly INMOS). And the third design was proposed by National Semiconductor Corp. These companies will develop the chip sets that go into the TVs, VCRs and cable boxes to support these high-speed data channels. Semiconductor companies salivate at the thought of a new, high volume market for their chips. As digital processing becomes more important in the video distribution industry, companies such as these will become major players, and the industry itself will evolve to more closely resemble the personal computer industry .

Issues

The obvious technical issues that need to be decided include data rate, cable lengths, type of cable and type of connector. (What happens if a telephone RJ-45 connector is chosen, and somebody plugs a 100 Mbps network into a telephone wall jack?) Is it possible to preserve network integrity if a new device is connected or disconnected while you are watching TV? Will consumers accept a momentary glitch in the picture if a few packets of data are lost? They certainly won't accept a requirement to turn off all the devices and then do a reboot, a requirement that is common when adding a peripheral device to a PC.

Then there are timing and latency issues related to delay through a network: how to carry control packets as well as MPEG video packets, and how to minimize jitter in the video packets that can occur when several devices or types of data are contending for access to the network.

There may be policy issues. For example, the dispute between the EIA and NCTA over the cable decoder interface, a dispute over control, could come up here as well.

Finally, there is a question whether this interface should remain as a voluntary industry standard, or whether it should be adopted by the FCC as a mandatory standard. The personal computer industry has operated successfully for years without any mandatory government interface standards. Mandatory government standards in this area would stifle innovation, because the technology is likely to advance too quickly for government regulators to keep up.

The next few years will see dramatic changes in the technical structure of the video distribution industry. Hardware will become more digital, more computerized. The baseband digital interface is one example. CED

TCI unveils software platform tied to frame relay network

Executives with Tele-Communications Inc. provided the first look at its emerging advanced software platform, designed entirely by the MSO to manage mission-critical back office operations like billing, customer service, internal communications and workforce management.

The sneak peek was provided during a panel session at the Texas Show in February.

The platform is TCI's trump card against telco competition, because it lays the foundation for all current and coming services, including video-on-demand, telephony and interactive products. It calls for an elaborate web of more than 6,000 computerized nodes tied together over a common frame relay-based network that will be 90 percent complete by year's end, said Dr. Sadie Decker, vice president of TCI's Advanced Information Technology group.

The physical network will eventually migrate to ATM within two years, said Dave Brown, manager of corporate networks for the group. It will use telco carrier lines and redundant fiber rings in most metro areas, which send data packets in 53 Megabit-per-second increments, said Brown.

"This is real–it is not a trial," commented Decker, who said the software will ultimately support 600 TCI systems and 12 million subscribers.

The software is critical, Decker said, for TCI's aggressive move into packaged services —like hundreds of narrowcast programs, all of which need to be tracked and billed. Building in the flexibility to handle phone charges was also key, Decker said, noting TCI's alliance with long distance carrier Sprint.

"Sprint will be using TCI for local access, and we'll be, in essence, acting like a regional operating company for telephony," Decker said, adding that the alliance is "for all telephone services," not just personal communications services

The complete software platform includes separate modules, like customer service, automated dispatch and billing. The whole software umbrella is under rigorous testing now, and is scheduled to begin field testing later this month. The final iterations of the platform will roll out early next year, as soon as the physical network supporting it is complete.

A test of the "Summit" billing portion of the platform has already begun. The software uses the client/server structure, distributed processing, relational databases and object-oriented methodologies–or a common, commercially available engine with highly customized modules knitted into it. The specialized modules, including one that uses global positioning satellites to schedule and route trucks for service calls, were assembled by outside experts.

TCI views the enormity of the project–which has kept more than 30 full-time TCI software programmers and three times as many software consultants busy for the last two years–as a giant leg-up over telco and cable competitors. "The telco networks' back office [software] is 10 times more expensive than cable," said Decker, who estimated that each RBOC spends $1 billion/year to generate bills. TCI sends out 12 million bills per month, and when fully equipped with the new platform will be poised to handle complex billing transactions and telephone billing, Decker said.

Because of the amount of resources poured into the project, and the associated speed of deployment, TCI will not make the software available to other operators, Decker said.

Continental Cablevision of Los Angeles recently hosted a high-profile "meltdown" of about 25,000 illegal cable decoders that have been confiscated as part of an ongoing fight against cable piracy. After being dumped, the descramblers shown above were burned. It is estimated that more than $100 million in cable service is stolen per year in Los Angeles County alone. In 1992, a police "sting" netted 70,000 illegal devices with a street value of about $20 million.

RBOC group issues set-top RFP

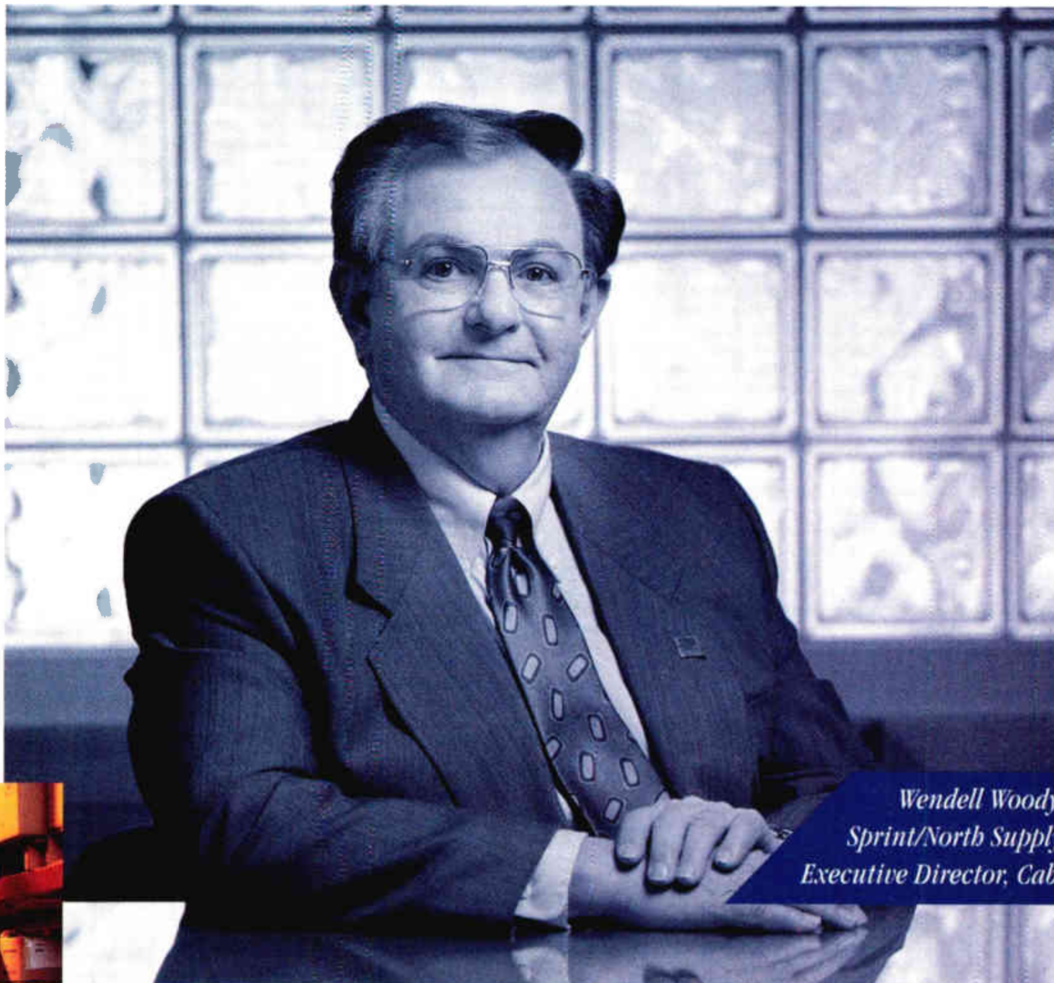
PlatCo, the consortium of Nynex, Bell Atlantic and Pacific Telesis, has issued a request for proposals for up to four million analog and digital set-tops that the group plans to purchase and deploy over the next five years as the RBOCs build their video dialtone systems.

The intent of the consortium is to drive product prices down and accelerate competition with cable operators through high volume purchasing. The huge order may also cause delays for cable TV MSOs who now may have to wait to get set-tops as manufacturers ramp up production.

According to the RFP, the consortium has stipulated that the set-top architecture be open, flexible and modular enough to allow systems and components to be changed out. For example, the RFP calls for a network interface module that provides all video and network information to reside within the set-top. "The NIMs must be replaceable units which can be located physically within the (set-top) and allow for interfacing with the following networks: Hybrid fiber/coax, asymmetric digital subscriber line (ADSL) and fiber-to-the-curb (FTTC)," said the RFP.

Furthermore, the NIM "is required to include conformance with the General Instrument Corporation technical requirements for an HFC-compatible NIM," the RFP stipulates, signaling that the companies have chosen to use DigiCable access control technology.

After 29 Peaceful Years In The Cable Industry, Wendell Woody Helped Start A Revolution.



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The RFP also notes that NIMs may have to be acquired from Scientific-Atlanta as well.

The deadline for response to the consortium's RFP is April 3. According to the RFP, the RBOCs expect to select which companies they will buy from by May 1995. They anticipate service rollout sometime in the first quarter of 1996, although the three- and five-year forecasts for delivery of set-tops show a first delivery date of April 1996.

According to figures contained in those forecasts, the telcos expect to deploy a mix of set-top types and categories. Over five years, plans call for the companies to deploy more than 800,000 set-tops that have "limited" interactive capability; 2.7 million units that feature fast processors and have enough RAM to store a video game; more than 400,000 units with dual tuners and dual decoders that would be compatible with high-end TVs which include features like picture-in-picture; and more than 400,000 analog decoders.

3 more MSOs plan cablephone tests

Time Warner Cable, Cablevision Systems and Comcast have joined NewChannels Corp. as the latest companies to trial telephony-over-cable hardware.

Time Warner announced its Greater Rochester Cablevision system is testing Tellabs Operations Inc.'s CableSpan system in a Rochester, N.Y. apartment complex where Time Warner is the provider of shared tenant services. The MSO is providing standard telephony as well as long distance, custom calling features, fax and 911 lifeline services.

The trial has been underway since January and is expected to last several more months. Later, integrated cable and telephony will be delivered to single family homes in the same area.

Meanwhile, Comcast has chosen to test ADC Telecommunications' Homeworx access platform in late 1995. The technical test of ADC's Release 3 system will run for about 90 days, followed by a market test to about 1,000 customers. Commercial rollout is expected to occur later in 1996.

The trial equipment will include host digital terminals; integrated service units that separate telephony from video and sends them over twisted pair and coaxial cables; video transmitters and integrated service access nodes that transport both video and telephony and convert optical signals to electrical; and network management software that remotely monitors network traffic and performance.

Finally, Cablevision Lightpath, the telephone subsidiary of Cablevision Systems, announced it will use Northern Telecom's Cornerstone Voice system to provide residential telephony services during a technical trial scheduled for the second quarter this year.

The technical trial is scheduled to expand into a market trial by the end of 1995 before widescale deployment occurs in 1996.

Cablevision will use the system to provide conference calling, speed dialing, call forwarding and other CLASS services, as well as Centrex and standard telephony.

The system consists of an access bandwidth manager to provide TR -303 switch interfaces; a cable modem shelf to modulate and demodulate traffic; and a voice gate unit attached to the side of the home that terminates two line cards. Cablevision has chosen to power the side-of-home wallbox locally.

In addition, Northern Telecom's Maestro cordless phones with speakers will be used throughout the trial.

GI goes FTTC, BBT finds partner

For its part, General Instrument announced it acquired an equity interest in Next Level Communications, a developer of switched digital networks that integrate video, data and voice services over fiber-to-the-curb architectures.

The two companies have entered into a technical cooperation agreement to jointly develop network components, including set-tops, that support a range of switched-digital services.

GI has been named by several telcos as a supplier of hybrid fiber/coax products for the video dialtone systems that have been announced. However, several of those RBOCs have identified switched-digital networks as the next stage in the evolution of broadband communications technology.

Next Level's product is an ATM-based architecture that extends fiber from the central office to points close to the home, allowing for a more symmetrical information exchange. The company is located in Rohnert Park, Calif.

Meanwhile, BroadBand Technologies Inc., perhaps the best-known provider of switched digital, fiber-to-the-curb equipment, has signed an agreement with Texas Instruments whereby TI will manufacture components for the Fiber Loop Access (FLX) system in Austin.

Specifically, TI will build key parts of the optical network units, which convert digital signals from fiber to electrical cables, and broadband line cards that are part of the host digital terminal. TI was chosen because of its expertise in semiconductor production, according to BBT executives.

The FLX system has been selected by AT&T Network Systems as its switched digital product, and is being deployed by Bell Atlantic in Dover Township, N.J., as well as in Southwestern Bell's VDT trial in Richardson, Texas.

S-A allies with two new partners

Seeking a faster entry to market for both 1550 nm fiber optic equipment and a telephone-over-cable product, Scientific-Atlanta allied with two well-known companies last month.

First, S-A signed an exclusive, long-term sales, marketing and product development agreement with Optical Transmission Labs, an affiliate of Synchronous Communications, for fiber gear that operates in the 1550 nm window. Under the agreement, S-A will now sell products like externally modulated transmitters and erbium-doped fiber amplifiers under the S-A brand name. Next-generation products will be jointly developed by S-A and OTL engineers.

The two companies began discussions during the 1994 Western Cable Show, said Perry Tanner, VP and GM of transmission systems at S-A.

MSOs have expressed renewed interest in 1550 nm gear as they begin to cluster systems, collapse headends into hubs and install rings of fiber for reliability. At 1550 nm, video signals suffer from less attenuation than at 1310 nm, making it a better choice for long distances.

Two days after that announcement, S-A entered into a joint venture with Siemens Public Communications Network Group to develop and market a telephony-over-cable family of products. Siemens has agreed to provide capital, technical and human resources, while S-A will offer engineering and technical resources, as well as the intellectual property of its CoAxiom system, which was first demonstrated in 1993.

The JV is the latest step toward bringing IMMXpress, an interactive multimedia network architecture, to market. The IMMXpress initiative was announced as a collaboration between Siemens, S-A and Sun Microsystems last November . . . . CED

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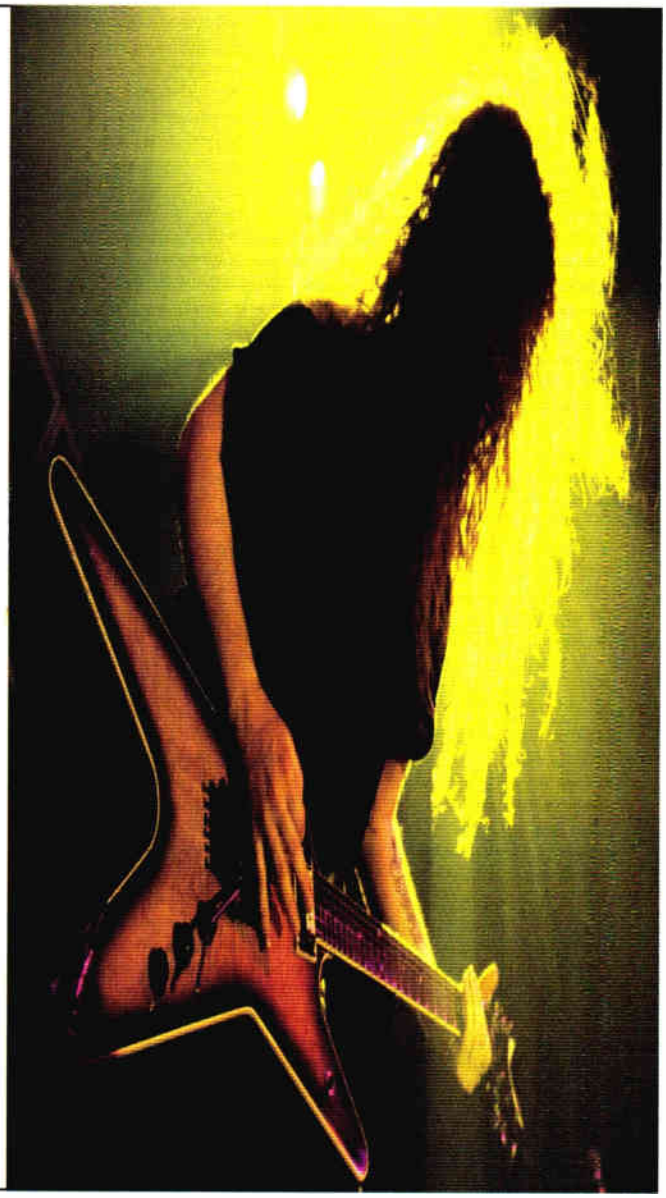

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For a few pennies more

By Dana Cervenka

When he initially approached his employer about building a full service network, Michael Nelson said he needed "just a few pennies" to make it happen. As it turned out, that would be about 30 billion pennies. If his request seems rather ambitious, it's simply because he wants to continue to care for his subscribers in the manner to which they have become accustomed: Media General Cable of Fairfax, Nelson's employer, is well-known throughout the industry for the level of service it offers. In keeping with that tradition, Nelson plans to provide his customers with everything from video-on-demand to telephony to Personal Communications Services.

That's everything, and then some. As the newly-christened Vice President of Technical Projects for Media General Cable, Nelson has already conceived of a dizzying number of projects. Under his guidance, the company is currently conducting a quiet trial to provide interconnectivity to the Internet via its cable system–thus far, having hooked up three schools, and borrowing access security ideas from the Secret Service in the process.

He is also ahead of the curve in dealing with the utility industry. As early as 1992, Nelson initiated a status monitoring project involving 2,000 of the company's 2,300 power supplies, with the goal of determining when and where commercial power is lost in the cable system. The project will eventually tie the status monitoring system into Media General's billing platform, allowing the company to provide very specific outage information to the local power company. In turn, the power company would be able to troubleshoot its own system more efficiently and get its customers back on-line faster, ultimately increasing revenues. "For that monitoring service," says Nelson, "we'll charge them just a few pennies" (they'd better start saving now).

As indicated by the wide range of projects he's involved in, Nelson's responsibilities are diverse, encompassing construction, engineering, design, headends, RF equipment, the institutional business network and system maintenance personnel. (You remember the TV commercial featuring the gentleman with a phone up to each ear, more phones ringing on the desk, and a secretary who is waving 15 pink message slips at him? That's Nelson.) In his previous position as vice president, construction and technical services, he also dealt with safety, security, purchasing and transportation, but his new position will free Nelson up to play with the technological "toys" he loves. In one example, since 1985, Media General has had its own, internal telephone network running on its cable system. Another of Nelson's gems is a fiber optic hookup which connects five metropolitan cable systems, making possible local, regional and national ad insertion on extremely short notice.

One of his current toys is called the "Virginia Gateway," a means for the MSO's subscribers to access stock portfolio information, as well as other services offered by a sister company, via line items on home PCs. Another portion of the gateway that Nelson is working on involves souped-up, onscreen TV guide listings, consisting of channel logos that a subscriber could access to obtain updated listings for the day, the week and the month.

But before his system can offer many of the newer, more advanced services Nelson envisions, the technological underpinning for all of these must be in place. To that end, Media General will be deploying fiber optics down to nodes of no more than 500 homes, in effect, creating 2,500 local area networks. "This makes it very robust, protects us, and gives us a lot of reliability," says Nelson. "It really sets the stage for all of the new services we will provide."

Nelson's fascination with toys developed early, at of all places, the telephone company. His first job in the communications industry, at New York Telephone Co., teamed him with 18 other people in evaluating new technologies and services. Moving into the cable industry in 1972, Nelson would eventually do benchtech work for Suffolk Cablevision (which became Viacom), and then join Cablevision as a service tech. After constructing the company's Yonkers, N.Y. system from scratch, he signed on as operations manager at Storer Broadcasting in Florida. And in 1983, he joined Media General as headend technician, eventually becoming vice president of operations.

Reflections on becoming green...

Outside of the telecom world, Nelson's self-professed "second love" is investing in the stock market. Once he finds a stock he likes, he doesn't think twice about investing in it. "You just do it," he declares. "In the process of thinking, blood rushes from your feet to your head, and you get cold feet." He has even recruited his co-workers for an investment club; has mulled over medical and technology stocks with his wife, Nushka; and has introduced his 14-year-old daughter, Krystina, to the wonderful world of Wall Street, with promising results. His nine-year-old daughter, Jeanine, may be too young for stocks now, but just wait–Nelson is already priming her to be a financial wiz so that she and her sister can send Mom and Dad away on cruises when they get older.

Given his fascination with the world of finance, it's not too surprising that Nelson homes in on the importance of capital in cable's future.

"The industry has to get stronger financially; we have to regionalize; and we have to tie our systems together," concludes Nelson. "The process may take the next five to 10 years, but it has to happen." CED

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Application of standards a delicate balance

By Wendell Bailey, VP of Science and Technology, NCTA

I have spoken many times about standards-setting, the hundreds of standards-setting bodies that exist in the world, and the cable industry's current level of involvement in the whole process. Recently, I had an interesting conversation with a person who represents a major advisor to the U.S. government. Once again, the question came up about how we feel about standards, and what it's going to take to get us to adopt them.

I replied that of the myriad things that seem to be important to us, one of the biggest and most misunderstood is the issue of interoperability and interconnectivity. I say that the issue is misunderstood because there is a great deal of "understanding" in various circles about which standards are needed in order for the information infrastructure to be built and to survive. In my opinion, most of that information is incorrect.

Standards overkill

The problem is that people seem to think all of the elements of an entire system need to be standardized so that any signals, services, products or features can flow seamlessly through them to the consumer. I admit that this is one definition for interoperability, and it may even meet the test of what needs to be standardized. I would, however, point out that we deliver signals to 60 million-plus homes, and while the end product may be a standard NTSC picture, there is nothing standard about how the product is handled along the way.

Take, for example, the fact that we have a TV camera that produces a signal. The output of that camera is not in any form that can be conveniently transmitted to customers (it's baseband). The baseband signal form is used as the input to a modulator which converts it into a signal for uplink (by driving modulators to make an FM signal that drives a satellite transponder). Then the FM signal is ultimately received at a cable headend where it is converted from an FM signal to a VSB/AM signal, and changed into a new RF frequency before it is placed in a "channel" slot. This much-handled and converted signal is delivered to customers in a form that makes their television sets respond correctly.

Nowhere in this chain of events is the entire system using the same standard from end-to-end. Instead, each segment of the system uses a standard that fits within its segment. Indeed, that segment has been optimized for the efficient handling of the product in that form. The protocol issue between one form and another is dealt with at the point of interconnection between two subsets of this system.

One example of this interconnection point is between the satellite signal being delivered as an FM signal to the headend, and the cable operator converting it to an AM signal for use on the cable system. The fact that there is a conversion price caused by the use of more than one standard is not necessarily the determining factor in deciding whether this is a good idea or a bad idea.

For instance, it might be argued that the satellite company could carry the signal from uplink to headend as an AM signal, leaving us only to heterodyne the signal to the correct channel slot. But there are reasons why AM isn't used on the satellite links. That link and apparatus are optimized for efficiency, and the optimization includes a decision to use FM as the primary transmission modulation. The price paid at the conversion point between an FM system and an AM system, in the case of a cable headend, is a price that is easy to tolerate when shared among numerous customers. Secondly, it more than offsets the problems we would have if the satellite link used an inappropriate standard to deliver signals to us in the first place.

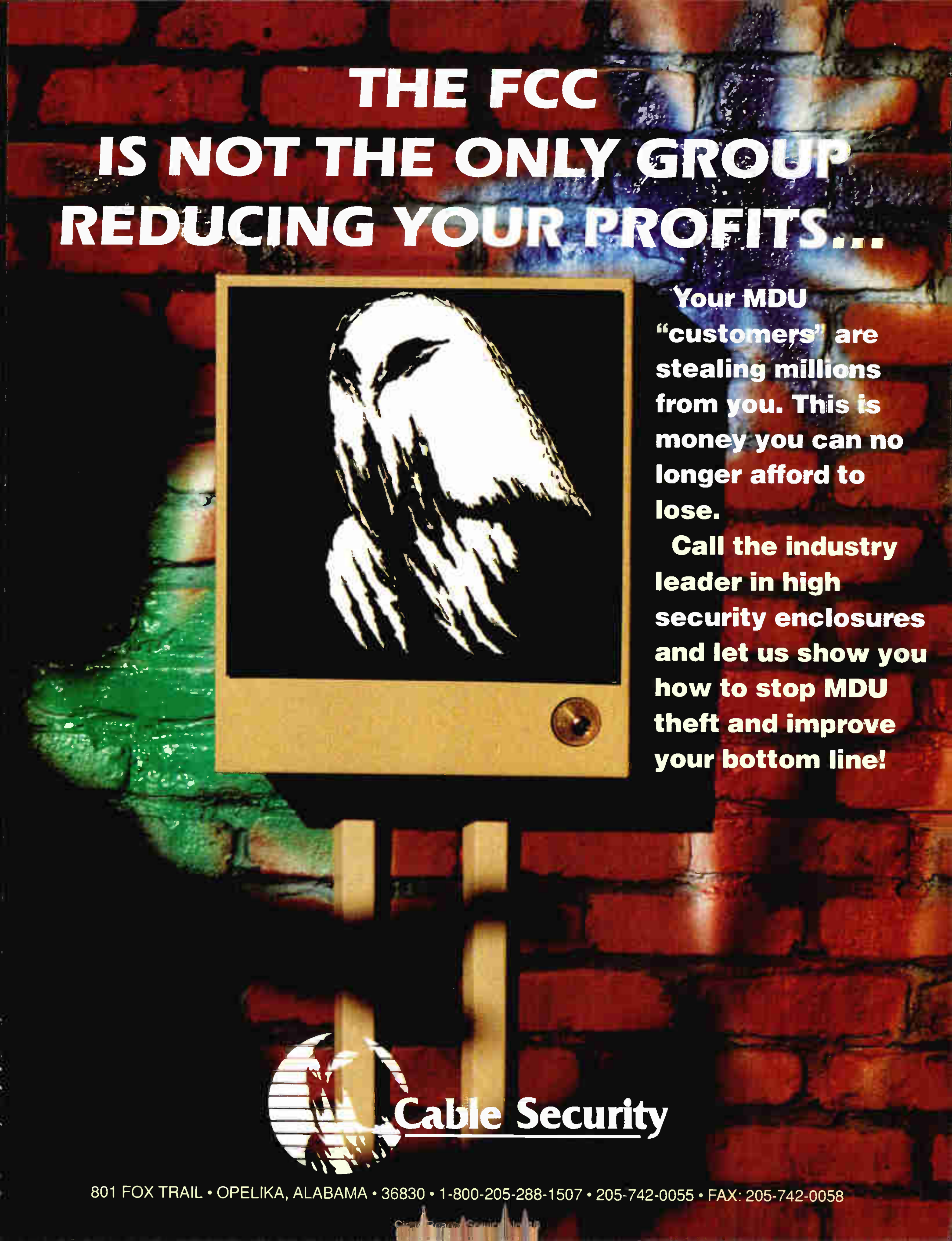
Therefore, it's safe to say that the optimization of each of these links must be done in such a way that efficiencies and the operational ruggedness of the system are perfected. A small price for a protocol conversion is not necessarily a need to cause one segment to use exactly the same standard as the next segment in a chain. To do so would give up the efficiencies gained in each segment. And that would not necessarily be good.

In the end, we must work to convince all of the standards-setting bodies that are talking about interconnectivity and interoperability that we must all agree on where interoperability standards must apply and under what circumstances, before we can decide what has to be standardized. And we also must be careful not to go around telling other people how to change their networks, if it impacts optimization and achievement of efficiencies, just as we object strongly when groups of people get together to make decisions that would force us to change our networks.

A careful balance

Ultimately, if the infrastructure of the future is to survive, we must understand that there are prices to pay for each and every segment. There are prices to pay for everything we do. The price is either exacted as degradation in the products we deliver (e.g., as noise and distortion), or as costs of capital equipment needed to convert from one standard to another. In the first case, anything that happens to a signal will be apparent to every customer. In the second case, if we can make the conversion inexpensively and maintain the optimization that our networks have achieved, then the cost of that can be spread among many customers.

A balancing of these two issues is difficult, but it's not impossible. Indeed, it is the way most businesses and industries delivering products to customers have learned to work. CED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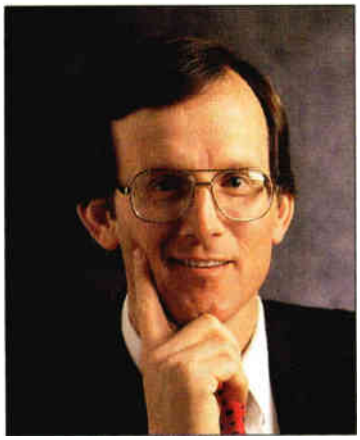
The drop cable dilemma continues



By Chris Bowick, Group Vice President/Technology, Jones Intercable

Thus far in this series on drop cable, we've moved from accusing the vendor community of breeding brand-loyal rodents who have an affinity for drop to a more serious look at actual drop cable deployment patterns, and how they have shifted tremendously in recent years. We've found that most drop cable shipped today is for in-home wiring, rather than for replacement drop.

In fact, it has become commonplace to run tremendous amounts of drop throughout the home to multiple additional outlets as part of our "whole-house" strategy. The result is that we are extending the reach of the plant, rather than replacing all of the drop that we already have out there, and that's not all bad.

But as I wrote last month, I don't want to leave the impression that all is perfect in the land of drop. Yes, we are deploying more, and for good reason, but based on the results of the study[1] (liberally quoted below), we could be wasting quite a bit of drop cable, too.

The study actually found that there are many different potential sources of drop cable waste, with each source being only a small contributor to the overall total–which was estimated to be as high as 20 percent. The net effect is that simply attacking a single source of the problem will have hardly any effect on reducing overall waste. In many cases, the amount of waste can be boiled down to a simple issue of awareness.

Drop cable is often perceived by the installer or service technician as a cheap commodity, and is dealt with as such, without thought for the amount of waste being generated. But the study determined the three primary contributors to drop cable waste were: non-recovery and non-use of spool ends; non-recovery of temporary drops; and general installation or service waste from installation or service practices. The study also cautioned that any action taken to curb waste be carefully evaluated against cable system economic considerations. In other words, don't put a program in place that will ultimately cost more than the cable being wasted!

It is interesting to note, however, that our training materials for installers and service technicians properly emphasize sound engineering practices, quality of installation, and customer satisfaction, but they make no mention of the "cost-effective use of materials."

The study also found that the drop material tracking, purchasing and subscriber management information systems currently employed are inadequate for the task of tracking and accounting for drop cable and related materials that make up the majority of our networks. In fact, one of our biggest assets, which is our "inactive" drop inventory, and which includes disconnected drops, pre-wires and builder activity, is rarely tracked at all. In spite of the limited management tools available to them, however, system and warehouse staff have implemented reasonable manual and computerized systems, along with sound management practices and oversight, to negate the possibility that drop cable waste can be attributed to theft or lack of accountability.

Limited field diagnostic capabilities used by installers and service technicians were also found to contribute to an inaccurate assessment of problems, resulting in more drop material being replaced than is absolutely necessary.

Better management of the drop

As a result of these findings, there were many suggested recommendations, some of which are:

✔ Implement a basic waste-reduction program in every system. This would include: ensuring that the amount of cable remaining on a spool is truly too short to use before discarding the spool; requiring depleted reels to be returned; removing cable from a reel/box when less than 200 feet remains to make more room in the truck; installing toward the reel; sealing cable ends in unused drops; installing temporary drops with sufficient cable for later burial; locating the buried drop so as to reduce the chance of damage; installing connectors properly to reduce water migration; and making sure the drop is bad before replacing it via a drop-verification program.

✔ Introduce figures-of-merit and tracking concepts for drop cable consumption, such as the number of feet per sub per year to create a benchmark and an awareness of the amount of cable being used.

✔ Introduce or revise ongoing installation and service training and communications programs to emphasize engineering efficiency, to dispel the notion that drop cable is "cheap," and to focus on waste reduction.

✔ Streamline the material ordering, warehousing, tracking and information management system through eliminating obsolete drop cable types; reducing the number of cable types; optimizing ordered increments for shipping efficiencies; and using actual reel quantity for usage tracking. Inactive drop inventory is a huge asset that should be tracked and managed accordingly.

✔ Initiate a study to assess the feasibility of increasing reel content. If the amount of cable on a reel is increased (but still manageable) the amount of spool-end waste should be reduced accordingly (fewer reel ends to waste).

✔ Explore ways in which technology can be applied to field activities for diagnostic equipment to aid in the identification and verification of drop before it's replaced.

There is no doubt that there are sound business and engineering explanations for most of the cable that is being installed in the drop portion of the network, with the major reason being the shift in deployment from outside to inside wiring. Note, however, that none of our practices is perfect, and as such, we should always be seeking ways in which we can improve operating efficiency. CED

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1. Media Management Services Inc., "An Analysis of Drop Cable Deployment Patterns and Recommendations for More Efficient Use of Drop Cable," Internally Published, February 1995.

A few lessons about entering the information superhighway

"Don't be left in the 20th century," they said. "Multimedia, convergence–ya gotta get on the information superhighway."

So I got on. I went out and ordered all these neat services from my cable company and got the latest fancy box on my TV. Uh, then I discovered that the picture gets snowy every time it rains. And we can't record one thing while watching another, but that's okay, because we can't remember how to program the VCR, anyway. And the rabbit ears in the bedroom still kind of work, if you stand by the door but don't touch the clock radio.

Undaunted, I went out and bought an answering machine with a neat toll-saver feature that would pay for itself in a year or two. And I got a home fax machine, and a switch so that it would use the same line as my phone. Uh, then I discovered that, well, the toll-saver feature won't work with the fax switch, and it's really tricky to answer call-waiting with the switch in line. And sometimes the switch doesn't work, because someone designed it to telco specs, and this is the real world. And my brother in Indonesia can't remember to turn his fax on at night.

Still undaunted, I went out and bought a home computer with lots of neat software and signed up with a bunch of on-line services. Uh, then I learned that some software packages crash when they're used at the same time that I'm running another one, and I started learning which on-line services crash when I try to download certain kinds of information. But they said, "Don't worry, that's normal." And I learned that if one service hangs up, I'd better go back to the C:> prompt and reboot my computer before calling the Internet; otherwise, my Internet provider misreads my password and kicks me off. But that's not all bad: I can't get through to the Internet after 4 p.m. anyway.

One on-line service has a reputation for slow download, so I thought I'd compare it with the others. Uh, remember the old truck races, when they saw which truck could go the slowest? This is the information superhighway version of that race.

What I've learned is that the information highway is really the information super tollway, but we don't know what it costs, and we don't know who's going to pay for it. We don't even know where to put the toll booth. Further, we don't know where the information tollway goes, and we don't know what we'll find when we get there.

But it's wonderful: in the old days, I was bombarded with twice the information I could handle. Now, I can be bombarded with 20 times more! And talk about computers and a paperless society–a good computer can go through more paper in a minute that I can in a week.

(Then I said to my wife, "There's this little cabin on the mountain, and I may be able to get running water in, and, and . . . .")

Jim Farmer
Antec

Little goes a long way

I would like to comment on your February editorial ("Industry's future depends on its people," p. 5). I am a technical supervisor for Time Warner Cable in Champaign/Urbana, Ill. I am currently in the position you made mention of, in that we are presently one-quarter of the way through an upgrade with 118 to 120 (fiber) nodes.

My technical staff is now required to understand all new transmission tactics. We now have fiber optics, laser transmitters, 750 MHz actives, two-way transmissions, impulse PPV buying and new microcomputer controlled set-top terminals.

They also have to learn new types of hookups, and the customer education [requirement] has doubled!

I'd like to mention something I believe should be added to your article. I agree we need to increase our training efforts. As a supervisor of a six-tech service department, I realize you're only as good as the people who work for you. If they aren't trained well, you'll have to do the job yourself. I can't wait for the new technology–I look forward to playing a Sega game with one of my fellow employees through the cable box. However, I feel we overlook one thing that's important to everyone–morale.

We ask our employees to learn new troubleshooting skills, complete more paperwork, and deal with negative customers who don't want change. But how often do we sit back with our staff and say "thanks" for the hard work they do everyday?

Every system I have worked in has had its fast and slow periods of the year. These days, it seems like it's constantly fast paced, as we try to keep lead times down, repair problems within 24 hours and overcome installation pushes. Hiring more people to do the work is a thing of the past. Every manager, supervisor and team leader needs to stop and think, "When was the last time I showed my staff some appreciation for the hard work they do?" Saying "thank you" is a great start. Maybe a weekend together for a cookout or softball game would help break the tension.

I understand times are tight and regulation has caused budget constraints. But think about the overall morale of your departments. After non-stop work, we tend to get burned out. Then tempers flare and attitudes get poor. This may affect customer service. Remember, the customer's image of the company is based on contacts with the employees, from CSRs to installers. A break in the action could do wonders for morale and possibly build camaraderie between the supervisors and the staff.

Remember, all employees are human. They all have feelings and need a vote of confidence now and then. This industry starts with CSRs and installers, so let's support them, or this big "race to the top" will have a hard time getting out of the starting gate.

Charlie Heflin
Time Warner Champaign/Urbana

Here comes wireless

Digital compression technology will enable wireless cable stations (MMDS) to carry up to 10 different video programs in each licensed 6 MHz bandwidth, according to participants in the first annual technical symposium of the Wireless Cable Association International (WCAI), which I attended in Tampa, February 4-6. Martin Frankel, president of Decathlon Communications of Denver, announced at the symposium that production of its MPEG-based system for wireless cable, using 64 QAM chips with adaptive equalization, would commence in July 1995.

Joe Waltrich said General Instrument's 64 QAM compression system for wireless cable would be available in the first quarter of 1996. Digital compression equipment would comply with FCC regulations and would be generally compatible with most existing MMDS transmitters.

Archer Taylor
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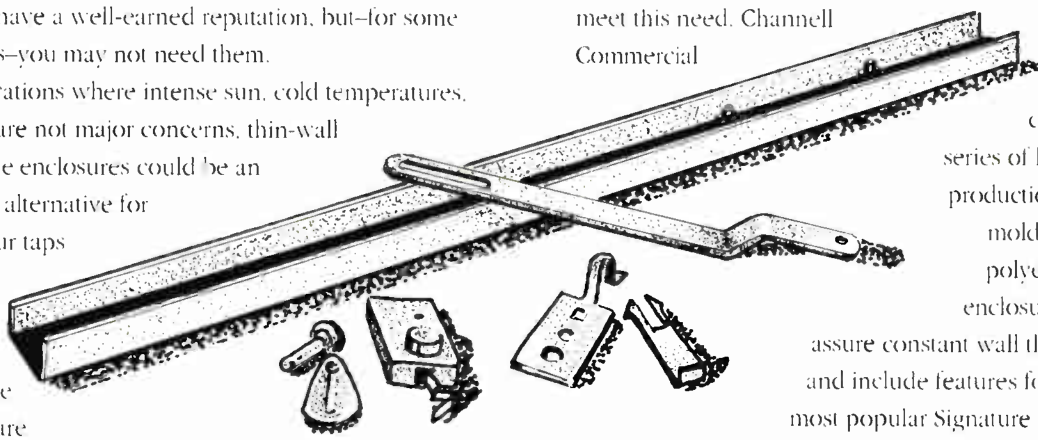
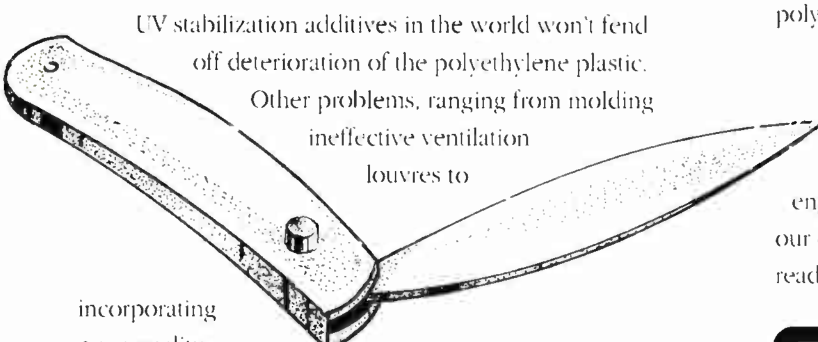


Most polyethylene enclosures are either vacuum or blow-molded, but these manufacturing methods leave a lot to be desired. A constant wall thickness cannot be assured and all the UV stabilization additives in the world won't fend off deterioration of the polyethylene plastic. Other problems, ranging from molding ineffective ventilation louvres to incorporating poor quality locking features, are associated with these techniques. And, as many system operators have found out, a simple pocketknife in the hands of the local street bully can be a polyethylene enclosure's worst nightmare.



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Unleashing the power of the PC

Cable networks are the key to high-speed computing

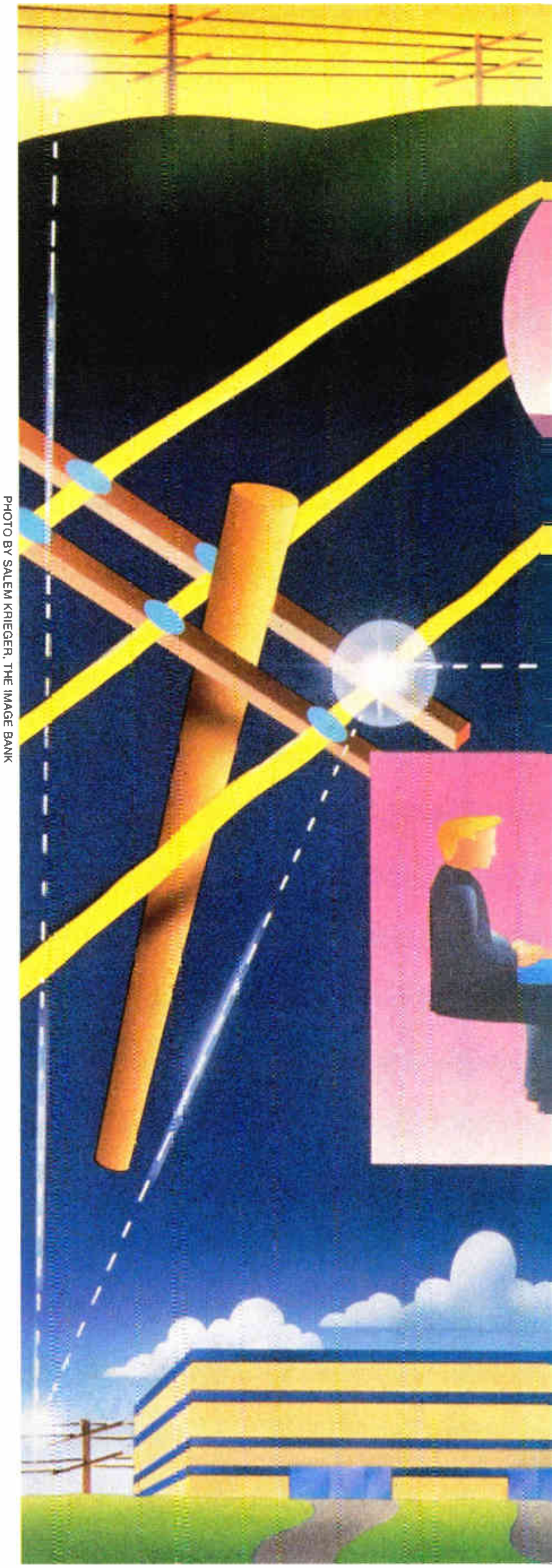


PHOTO BY SALEM KRIEGER, THE IMAGE BANK

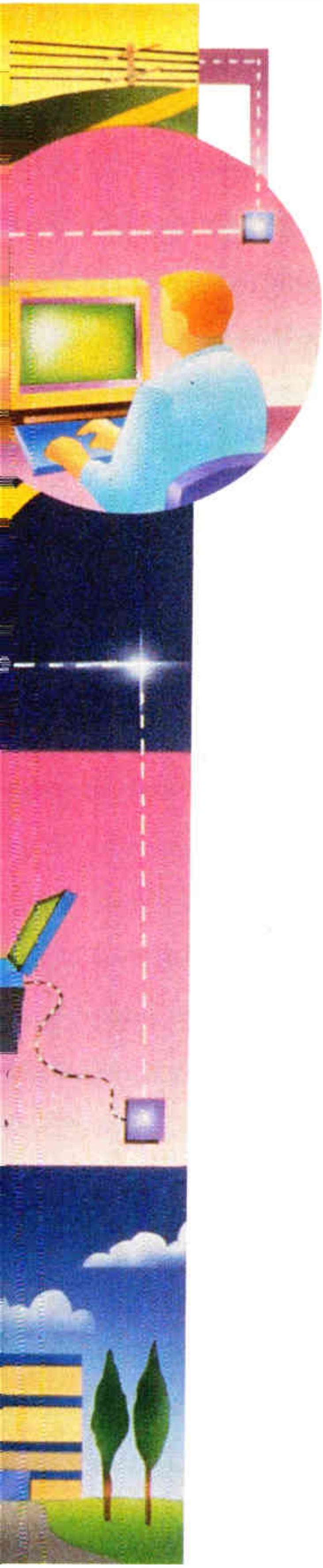
By LANcity staff

Editor's note:
This article is part one of a two-part series.

Data communication over cable television allows computing resources to be interconnected citywide, providing a common link between homes and businesses (see Figure 1). The computer model of today consists of client/server computers intercommunicating at high data rates, sharing files, programs, databases, and applications and using a networking infrastructure to accomplish this. Products and technology exist today that allow this interconnection to be accomplished over the cable TV infrastructure.

The cable TV operator is in a unique position to provide high-speed data services over the existing cable TV topology. The types of applications that can be provided over HFC are as varied as the homes it passes, providing the services that a community of users require to run their business, teach their students, occupy their leisure time and improve their productivity and quality of life. Typical services desired by large user populations who have access to cable TV are:

✔ Internet access services. Computer networks that interconnect the world have been around for a long time, but only recently has there been an explosion of usage outside of academia and into the commercial and home communities. New Internet applications such as Mosaic are becoming too bandwidth intensive for the service model provided by the telephone modem. Internet access over cable TV is attractive because of



the simplicity of the network architecture, as well as the high data bandwidths provided.

✔ Local area network interconnectivity citywide. Many buildings use local area networks to interconnect their PCs and workstations. Municipalities, governments, school systems and corporations desire to interconnect these networks to provide a homogeneous networking environment at high data rates.

✔ Work at home. As the year 2000 approaches, the government is mandating a reduction in commuting. This, coupled with the fact that more than 50 percent of homes contain PCs, forces a demand for a data communication service similar to that provided by local area networks, but on a citywide scale. A derivative of this application is the study at home concept that allows disabled students to be able to stay current with their studies remotely.

✔ Multimedia database services. Schools and corporations desire to maintain central file servers that contain multimedia applications and load them into localized personal computers when the application is run. Applications include distance learning, multimedia library referencing, real estate information, and others that require high levels of data, voice and video information to be transferred.

✔ Multimedia conferencing. Personal computers, especially in the commercial sector, are being outfitted with multimedia conferencing capabilities, allowing multiple people to communicate in real time with voice, video and data. This allows meetings and design reviews with team members, vendors and manufacturers to be held remotely, but with the same level of information transferred as if the group was in the same room.

To satisfy the demand for these applications, the hybrid fiber coax infrastructure must not only meet the objectives of reasonable cost, high performance, ease of use and low operating expense, but must also accommodate a multimillion user base. To meet this goal, the following objectives must be considered:

✔ Use the cable TV infrastructure as the physical media for telecommunications

✔ Develop a media access control (MAC) protocol for the cable TV infrastructure

✔ Design a scalable internetworking model for multiple community networks

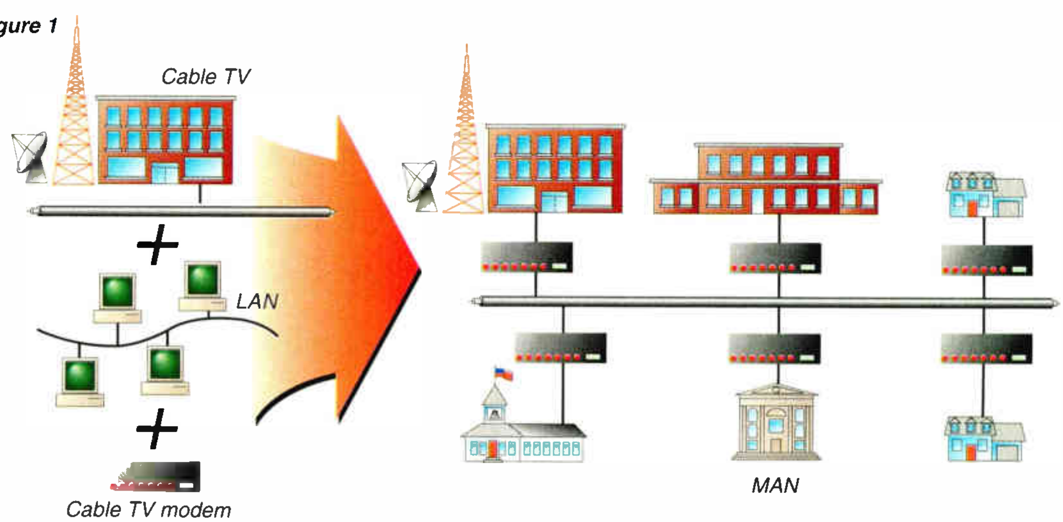
✔ Manage the HFC-based network using standard industry tools.

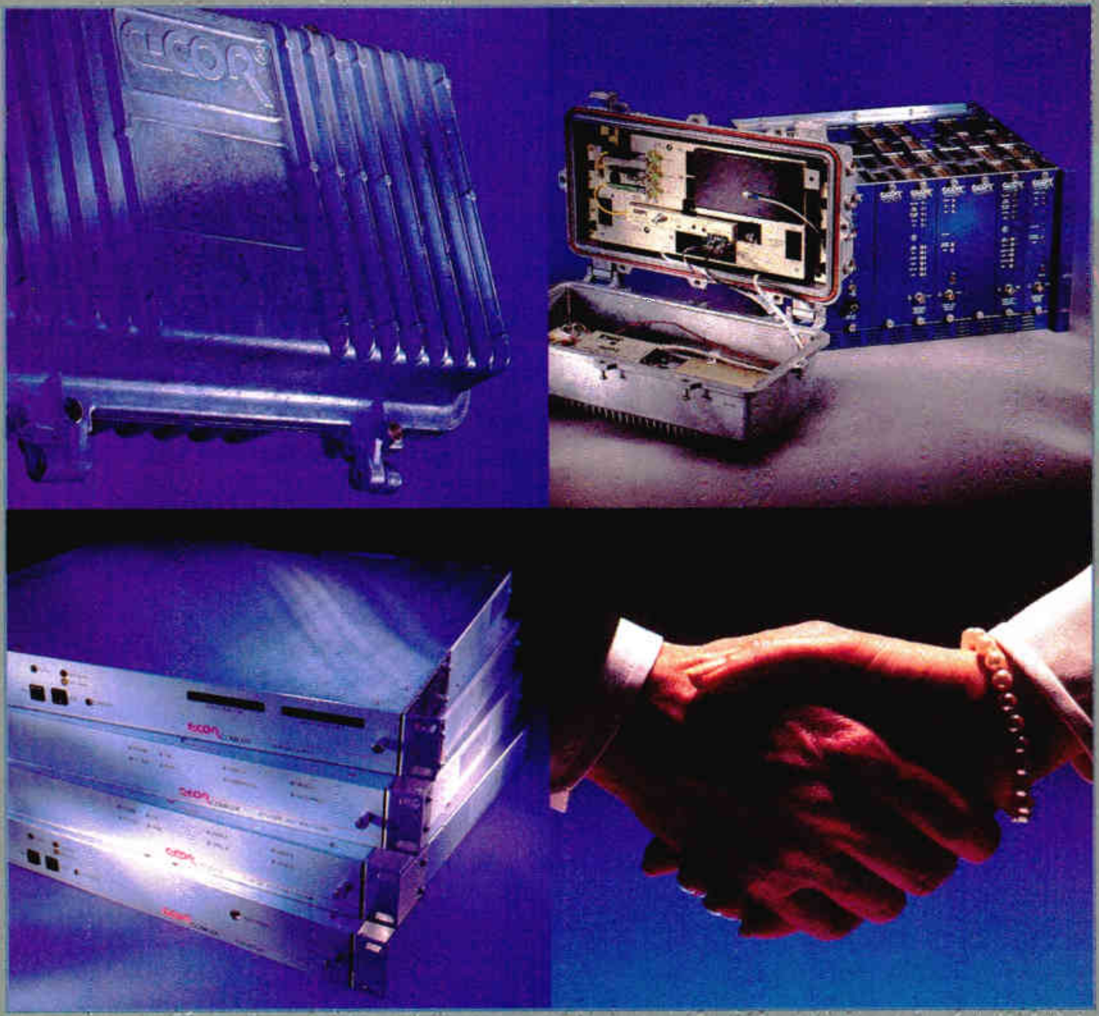
The cable TV operator is in a unique position to provide high-speed data services

The HFC network as physical media

The purpose of a data communications network is to move information between users. To achieve this, a communication channel between users and the means to control the delivery of information must be provided. In the data communications world, a model has been developed to describe the structure of data communication systems. Known as the Open Systems Interconnection (OSI) Reference Model, it is an internationally accepted framework of stan-

Figure 1

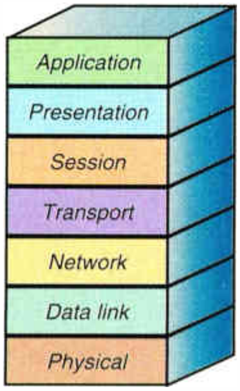




dards for communications between systems made by different vendors. See Figure 2.

The Physical Layer provides the lowest level (physical) connectivity between users. The means to control the delivery of information is provided by the data link and network layers.

Figure 2: OSI model, seven layers



In the case of an HFC network, the Physical Layer includes the headend equipment and the distribution components. It also includes the equipment at the user site, commonly called a "cable TV modem," which converts the digital information into a modulated RF signal and demodulates it back to digital information.

To insure the success of the HFC network as a data communications physical layer, the disadvantages of the system must be overcome. This is achieved through cooperation between datacom and HFC equipment manufacturers and service providers and through careful design and maintenance of HFC plants.

The first questions to be addressed are the requirements placed upon the HFC network by high-speed data communications and the problems associated with the use of the sub-split return band.

In order to install a data network, two-way communications must be provided on the cable system.

Four important parameters must be met to insure proper operation of a data network over cable TV, including:

✔ Balanced RF levels
✔ Flat frequency response
✔ Acceptable carrier-to-noise ratio
✔ Reduced interference.

Balancing RF levels

In most cases, the forward receive levels are fairly well balanced from outlet to outlet because of the requirements of FCC proof of performance and the customer demands for consistent picture quality. Therefore, a cable modem with a dynamic range of 20 dB or more should operate on a cable plant's forward system with no special balancing. It is a good practice, however, to adjust outlet receive signal levels to fall within the middle of the dynamic range. Doing so will allow for variations of levels resulting from aging active components and temperature.

To set up this level, a signal is generated at the outlet location on the assigned reverse frequency. Level is "balanced" at the input to the translator at the headend and then the forward (receive) assigned frequency is measured back at the outlet location. This is also known as a round-trip or total loop measurement. At worst case, this level should be +0 dBmV on a commercial HFC system. As mandated by the FCC standards, a video signal should be no less than +3 dBmV at the end of a 100-foot drop cable.

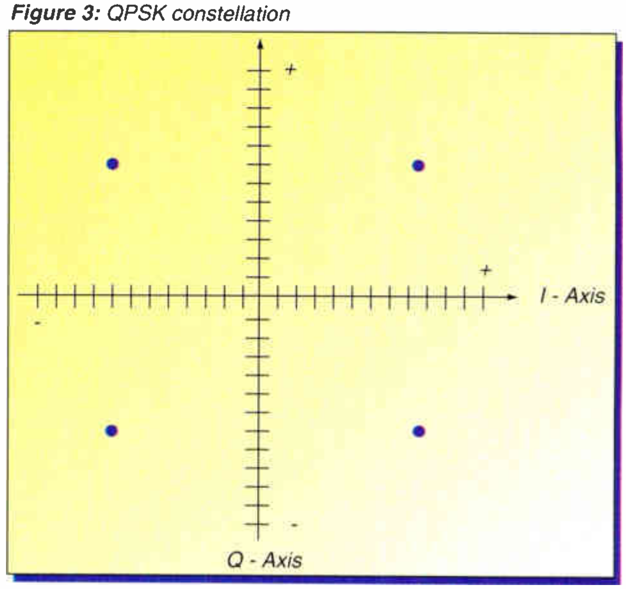
The RF levels that are presented to the input of the headend translator from all the installed locations should be balanced. The nominal level and allowed deviation are determined by the specifications for the headend equipment and the nominal transmit level of the modem.

In order to install a data network, two-way communications must be provided

Flat frequency response

While the balancing is being performed, the amplitude response should be measured across the assigned 6 MHz channels. Ideally, all frequencies across the 6 MHz bandwidth would be flat. To insure proper signal detection and demodulation, the frequency response, or amplitude variation, across the assigned channel should be ±1 dB (2 dB peak-to-valley). This requirement is specific to the digital data transmission. The FCC has specified the in-channel response to be ±2 dB from 0.75 MHz to 5 MHz with a 6 MHz channel. The ±1 dB response imposed by digital transmission is usually attainable on systems with long amplifier cascades. If needed, minor adjustments to the slope or equalizers (if adjustable) will usually bring the response into this 2 dB window. Although expected slope at an installed location can be calculated by using the equation below, an actual measurement is recommended.

Figure 3: QPSK constellation



Acceptable peak-to-valley deviation (in dB) = (N ÷ 10) + 1

Where N is the Nth amp in cascade

Example: Acceptable peak-to-valley response at the 32nd amplifier in cascade would be:

(32 ÷ 10) = 3.2 + 1 = 4.2 dB

To accomplish this measurement, a CW carrier is injected in the allocated reverse channel from the installed location in 500 kHz increments from one side of the channel to the other. The amplitude is measured and recorded.

Carrier-to-noise

This is a ratio expressed in dB of the peak RF signal to the noise power density measured within a specified bandwidth. With video channels, this bandwidth is 4 MHz. The current standard mandated by the FCC is 40 dB (after July 1, 1995 it will be 43 dB). That is to say that the average noise contained within a 4 MHz bandwidth is 40 dB down from the video carrier peak. If this ratio is decreased, the picture quality as viewed from a video monitor starts to degrade. The requirements of the QPSK modulation technique used for data transmission is >30 dB carrier-to-noise measured over 6 MHz. This is not an issue because noise tends to be broadband in nature, and if the carrier-to-noise ratio is being met and kept for video transmission, then data is able to run in this same environment without problems.

Reduced interference

Another cable TV system parameter that needs to be reviewed and inspected prior to the installation of data channels is interference. Ingress is a signal on the cable TV system that originates from a signal which is generated and propagated over the air. An issue may arise when installing sub-split systems where the reverse channels are limited to the 5 MHz to 30 (42) MHz range. Running on parallel frequencies outside the cable TV system are short-wave and Citizen Band radio frequencies. Corroded cable connections, distribution hardware breakdowns (leaky RF gaskets), and open shields on distribution cables are some of the common examples of invitations to ingress.

The next area to be addressed is the limited bandwidth available for data communications use. The high demand for expanded television programming, combined with the narrow allotment of return channels, requires that datacom modems provide the maximum reliable data rate in the minimum occupied bandwidth. One method of doing this is to use a spectrally efficient modulation technique when converting between baseband data signals and broadband HFC signals.

> **Datacom modems must provide the maximum reliable data rate in the minimum occupied bandwidth**

Quadrature Phase Shift Keying (QPSK) is one such technique which offers a reliable compromise between spectral efficiency, robustness in the presence of interference and noise, and ease of implementation.

Although QPSK modulation has been used primarily in satellite communications, it has also been utilized as a modulation scheme for telephone data modems. From an RF viewpoint, the QPSK modulated data is unlike a typical 6 MHz video channel. Whereas the video channel has three distinct carriers within (video, chroma and audio), the QPSK modulated data appears as random "carriers" throughout the assigned 6 MHz channel when viewed with a spectrum analyzer. QPSK modulation utilizes approximately 5 MHz of RF bandwidth to transmit 10 Mbps of data. When used within a standard 6 MHz RF channel, adjacent channel operation is insured. This equates to a spectral efficiency of 1.67 bits/hertz, ($10*10^6$ bits divided by $6*10^6$ hertz).

QPSK involves varying the phase of the carrier signal (sinusoid) depending on the digital data to be sent. For example, a digital "1" might be transmitted by a 180-degree phase shift in the carrier, and a "0" might correspond to a 0-degree phase shift. The "quadrature" aspect of

Ethernet broadband solutions of the past were restricted to limited channel pairs

the modulation scheme means the carrier is being shifted to one of four possible phases (0 degrees, 90 degrees, 180 degrees or 270 degrees) depending on the data to be transmitted. In this case, each phase can correspond to two bits of data: "11" can be transmitted by a 90-degree shift, "10" by 180 degrees, "01" by 270 degrees and "00" by a 0-degree phase shift. See Figure 3 for more detail.

The last disadvantage of the HFC network is the availability of compatible datacom equipment.

Ethernet broadband solutions of the past were not frequency agile and were restricted to limited reverse/forward channel pairs. Although this may not be an issue on less-populated cable systems such as institutional or private systems, this can definitely be an issue on a residential HFC system where a limited number of channels, if any, are available. The ability to configure a cable TV modem to transmit on any contiguous 6 MHz channel not only provides flexibility during installation, but also has the added benefit of being able to "move away" from unwanted signals that may be present and unavoidable within the low frequency reverse channels. A cable ready data communications modem should:

✔ Adhere to existing standards for both the datacom and HFC environment.
✔ Provide flexibility through wide frequency range, manageability and ease of configuration.
✔ Offer enough robustness to operate under a variety of cable plant conditions.

An additional piece of equipment is required in the headend between the reverse and forward systems. The function of this equipment varies from simple frequency translation to complex remodulation and retiming. Like the modems, the headend equipment is usually supplied by the datacom manufacturer to meet the specific requirements of its system.

MAC layer protocol

Communications protocols provide the means of access to a physical media. For data to be communicated between end devices, mechanisms must be provided for predictable and efficient utilization of the connecting media. Stable data bandwidth performance, robustness against problems, recovery from problems when they do happen, fairness of access between nodes, and operational information are all items that must be addressed in order to provide reliable data communication channels.

A media access control (MAC) protocol provides the mechanism that controls access to a shared communication media when there is more than two connected

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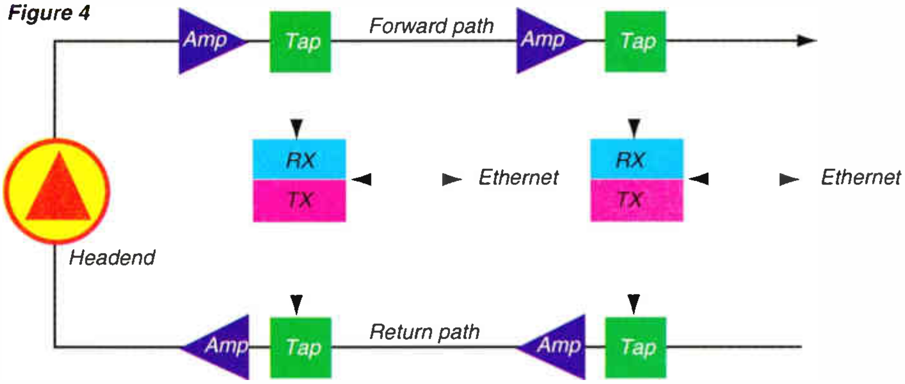
users. It acts as the traffic cop, assuring fair and orderly admittance to the data highway and directing drivers to the best route that meets their needs.

Multiple MAC protocols exist, each one developed to best meet the needs of the connected users and provide them the levels of service necessary to run their specific applications. Protocols that are popular and in wide distribution include:



✔ Ethernet. Originally developed by Xerox, it has since been defined and standardized by the IEEE as an industry standard 802.3. It uses the Carrier Sense Multiple Access with Collision Detection protocol (CSMA/CD), allowing multiple connections (multiple access) to listen until no signals are detected (carrier sense), transmitting and verifying that no more than one signal is present on the cable (collision detection).

If a collision occurs, the connected device that attempted transmission will retransmit the same data after a random length of time. Ethernet provides almost instantaneous access under light loads but tends to bog down with heavier loads, especially on longer networks.

✔ Token Ring. Originally developed by IBM, it has also been standardized by the IEEE under the 802.5 designation. A token is passed from connected device to connected device with the device holding the token only being allowed to put data on the network. In this way, access to the network is deterministic under heavy data loads but has high latency access under light loads.

Standardized protocols are not acceptable for cable TV because of distance and performance limitations

Cable TV for data communications

Currently available standardized protocols are not acceptable for cable TV because of distance and performance limitations. The recently formed IEEE 802.14 committee is chartered to address this issue and provide a protocol that is suited for this application.

A cable TV MAC protocol must be provided that allows the peer-to-peer communication of many multimedia devices in a multidrop environment. This protocol must efficiently use the existing tree-and-branch infrastructure and account for operation in a citywide environment.

The following is a list of important operating characteristics in a metropolitan area environment. Many of these characteristics are being discussed within the IEEE 802.14 CATV committee as requirements for a standardized MAC protocol for the cable TV environment.

✔ The MAC and physical layer protocol must operate in existing bi-directional infrastructures. This implies support for everything from pure coax tree-and-branch cable systems to the evolving HFC systems. Because of the citywide deployment of these networks, distances of up to 160 miles roundtrip through the headend must be supported. It is essential that operation be within the standard frequency allocations set up by the cable operators and that the scarce reverse channel frequencies be used efficiently.

✔ The origination point for data, video conferences, applications and information can be distributed throughout the network based on the client/server model and studies of Internet utilization patterns. Assumptions that all information can originate at the headend and propagate down the forward channel are just not valid. Data bandwidth rates on the forward and reverse channels must support symmetrical data transfers and account for the distributed computer and multimedia models that have become standard in the industry. Data rates of 10 Mbps on the forward and reverse channels are equal to Ethernet data rates.

✔ The cable TV network supports a large user community and therefore requires fair and stable access to a large number of end nodes that remains robust under varying data conditions. Because the applications being run at any time, and the number of applications is indeterminate, the access protocol must dynamically adjust to optimize operating conditions under varying operating conditions. Different applications require different levels of performance, and therefore, the network protocol should allow multiple levels of performance and prioritization.

✔ Many thousands of man-years of application software development exist, and the cable TV MAC must take advantage of this. Many applications are written to the 10 Mbps data rates provided by Ethernet, and therefore, the protocol must provide equal or better performance levels to avoid disappointment and frustration on the part of the end user.

✔ The MAC protocol developed for cable TV must not limit the types of applications possible, otherwise, large market segments will be excluded, forcing a reduction in revenue potential. Bulk, interactive and multimedia traffic must be supported efficiently, regardless of the mix or number of current users.

✔ The coax cable used by cable television is a shared media among many connected devices, with each having varying expectation of performance and ability to access. Efficient resolution of contention for the media and minimization of the latency to accomplish this must be provided, regardless of the traffic mix and levels. CED

Next month, an access protocol for cable will be discussed, as well as internetworking and networking management issues.

Data transmission interference in CATV systems

Squeezing data close to video

By William Sward, Sr. RF Engineer, XEL Communications Inc.

Modern CATV systems will carry data as well as video information over the same cable plant. The addition of data transmission to an existing CATV system, however, requires an understanding of the potential for interference between the data and the video.

The downstream path is expected to carry data and video from the headend to the subscriber. The data will typically be transmitted in spectral "openings" within the 50 MHz to 750 MHz downstream bandwidth. It is advantageous to transmit as much data as possible without degrading the video signals. To maximize the data throughput and spectrum utilization, it's desirable to squeeze the data channel(s) very close to the television channel(s). On the other hand, interference issues suggest that the data and video channels be separated by a reasonable amount. Various trade-offs must be made to achieve desirable performance.

The upstream path may also carry both video and data (e.g., video conferencing), or may simply carry data. In any event, interference issues must be considered when planning the addition of data transmission to a system.

Baseband data spectrum

Most data transmission is characterized as a random bit stream where each bit is identified as a 1 or a 0 by its corresponding voltage level. Data represented in this manner is referred to as non-return to zero (NRZ) data. The bandwidth of a baseband NRZ signal is a function of the data rate and is illustrated in Figure 1. The shape of the power spectrum is the classic $[\sin(\pi x)/(\pi x)]^2$ [also referred to as sinc (x)] for a random NRZ bit stream (The composite filtering is the combination of transmit filtering in the RF modem and receive filtering in the television channel of interest).

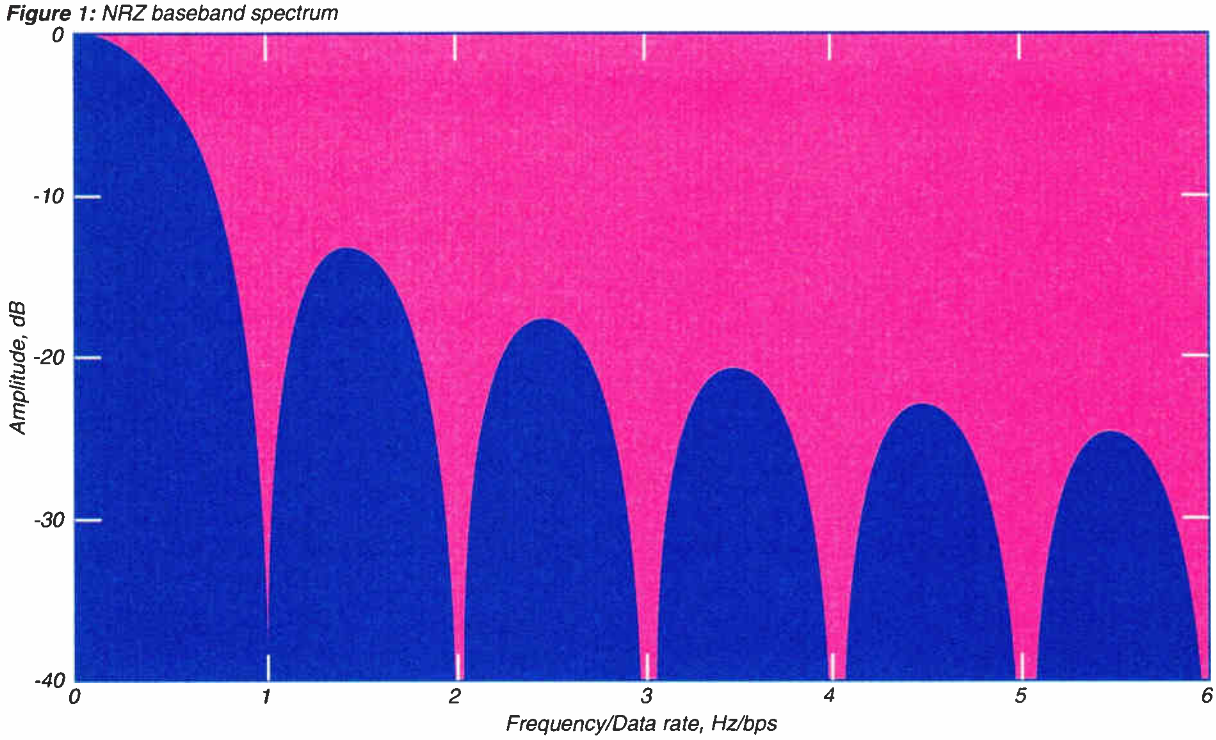
The nulls of the sinc (x) function occur at integer multiples of the bit rate. Notice that the spectrum theoretically extends indefinitely with the sidelobes of the sinc (x) function. The sidelobes represent potential interference to adjacent channels, if not adequately filtered.

Nyquist minimum bandwidth

The Nyquist theorem states that a system bandwidth (at baseband) of at least one-half the symbol rate is required to properly recover the data. Recalling that the first null of the sinc (x) function is located at a frequency equal to the data rate, only one-half of the mainlobe is theoretically required to recover the original data. Non-ideal filtering requires practical systems to transmit more than one-half of the mainlobe of the data spectrum. Typical system bandwidths are 30 percent to 100 percent greater than the Nyquist bandwidth (in other words, 65 percent to 100 percent of the mainlobe bandwidth). The remainder of the sinc (x) mainlobe and sidelobes are ideally filtered out. However, non-ideal filtering allows residual energy to be transmitted and possibly interfere with closely spaced adjacent channels.

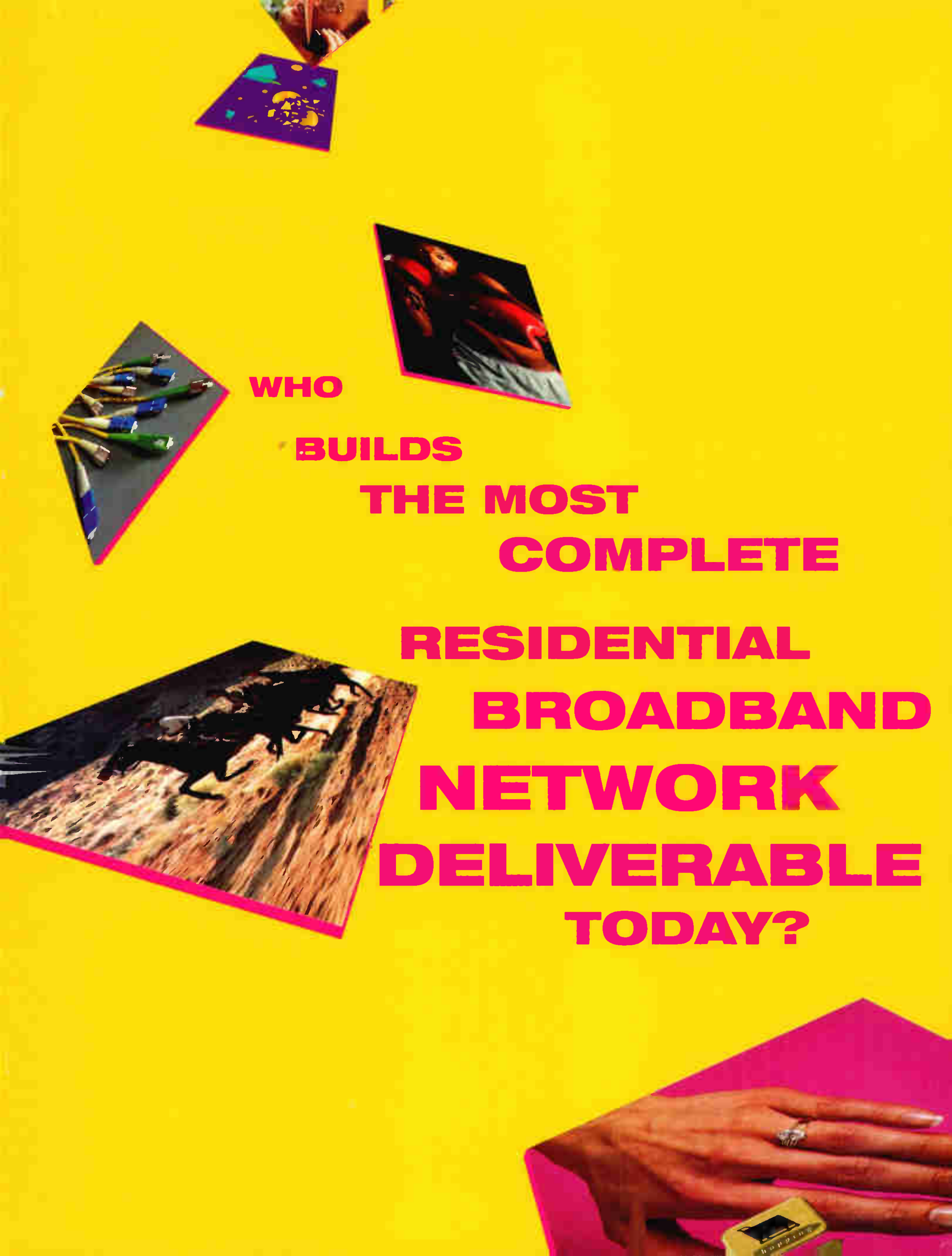
Interference issues must be considered when planning the addition of data

Figure 1: NRZ baseband spectrum



RF modulation

For more efficient transmission, data is typically modulated onto an RF carrier prior to transmission. Typical RF modulation schemes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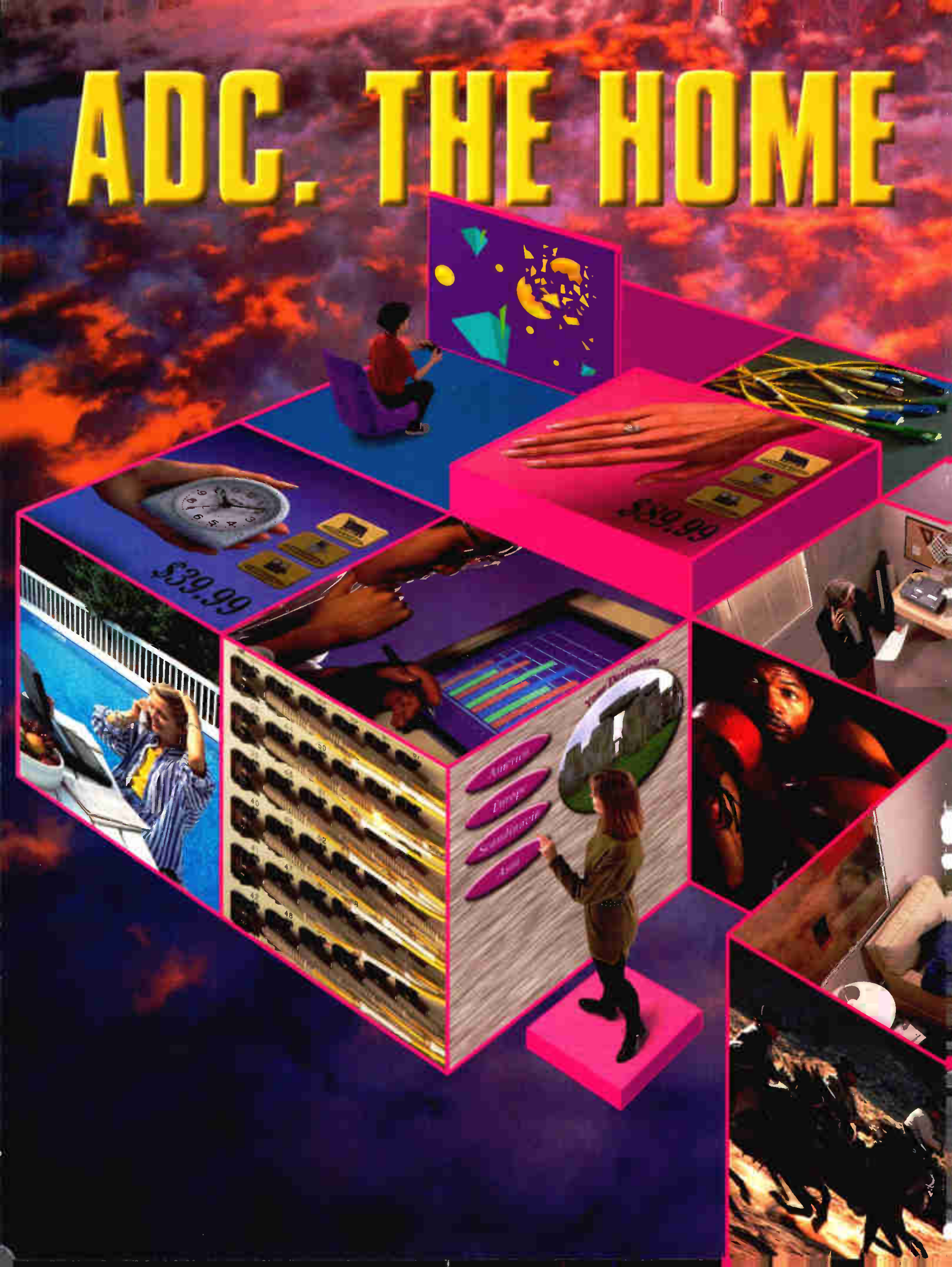
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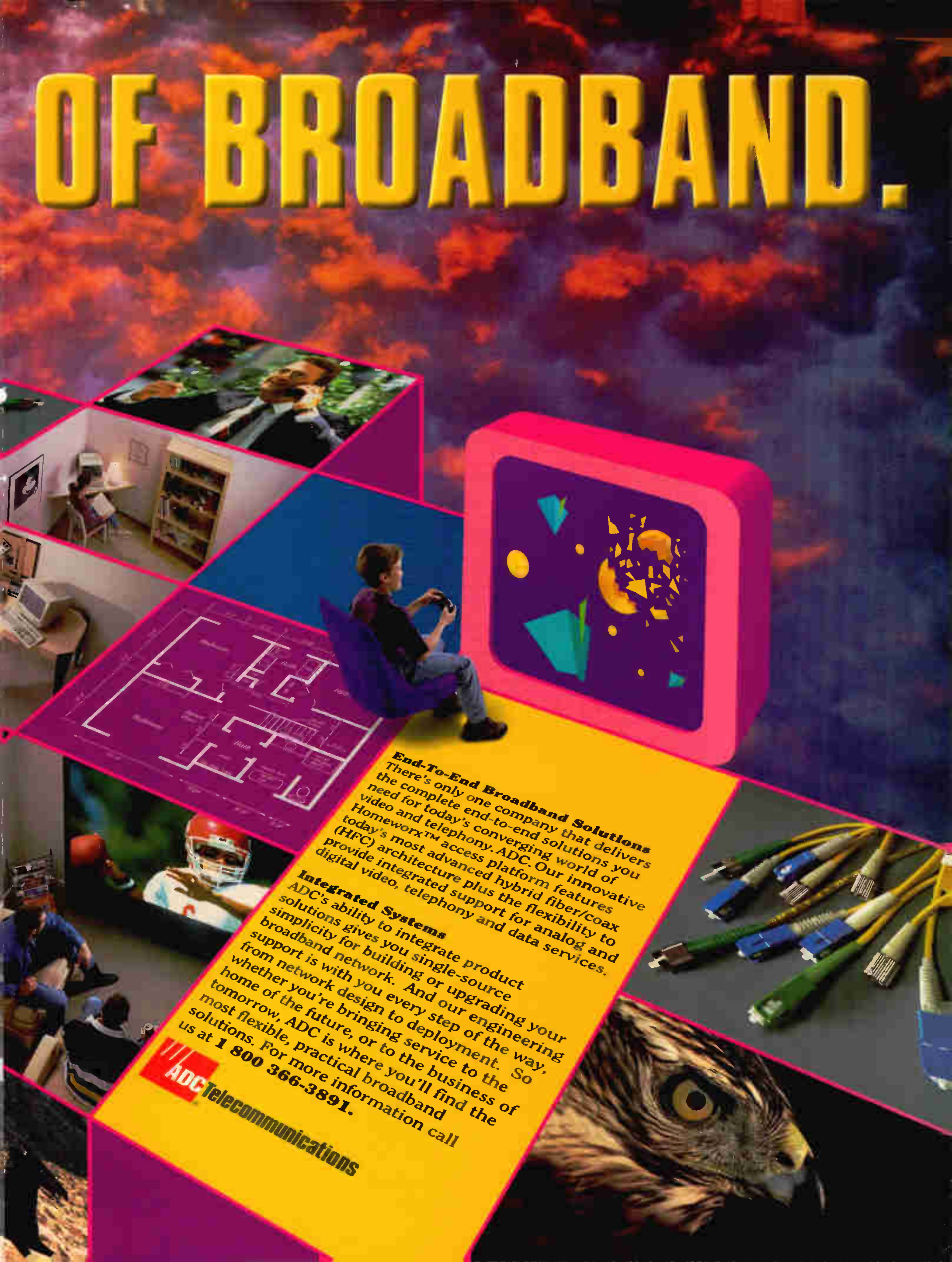
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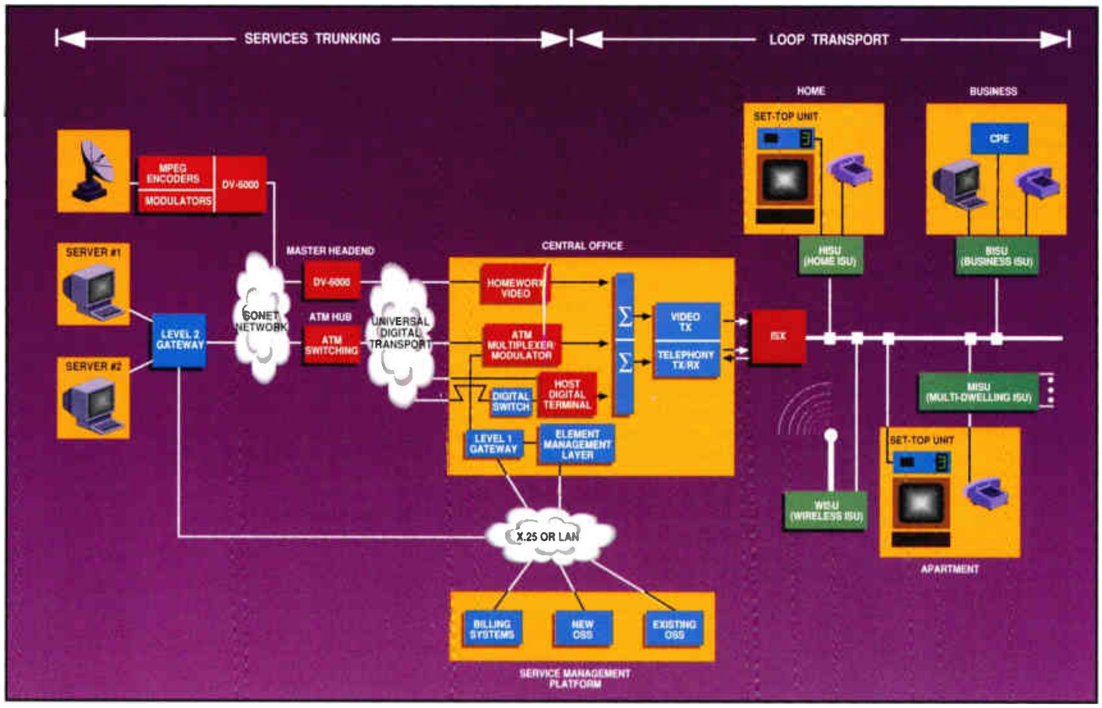

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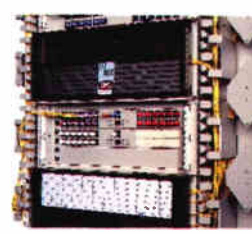

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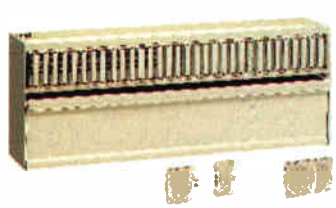

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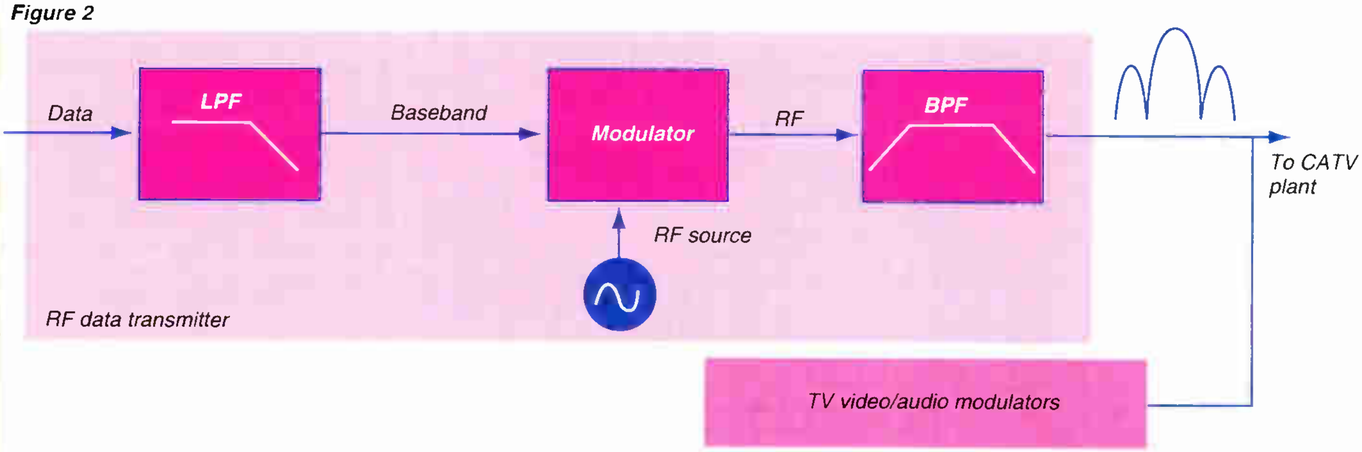
Figure 2



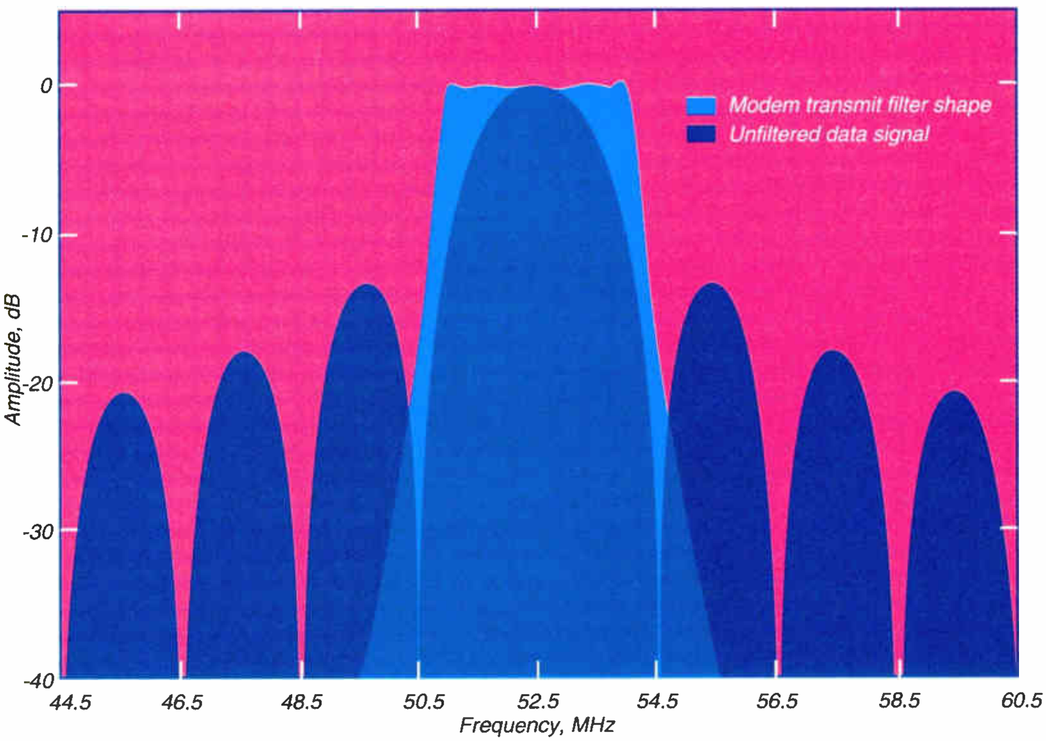
include BPSK, QPSK and QAM. Each modulation scheme has an associated RF bandwidth efficiency which is typically described in terms of bps/Hz, where the system bandwidth is assumed to be the Nyquist RF bandwidth. Note that the Nyquist RF bandwidth is twice as wide as the Nyquist baseband bandwidth for double-sided modulation schemes. For example, BPSK modulation can support 1 bps of NRZ data for each 1 Hz of transmitted RF spectrum.

QPSK is popular, because it has twice the bandwidth efficiency (2 bps/Hz) of BPSK for the same bit error rate (BER) performance. On the other hand, 16 QAM has an RF bandwidth efficiency of 4 bps/Hz, but requires more signal-to-noise ratio (SNR) than QPSK to achieve the same bit error rate. And 64 and 256 QAM yield higher bandwidth efficiencies (6 bps/Hz and 8 bps/Hz, respectively), but at the expense of worse BER for a given SNR. This becomes an increasingly important factor as interference power degrades the system SNR (e.g., in the upstream path).

Filtering

The data stream is usually filtered prior to transmission to limit the bandwidth of the transmitted spectrum. This prevents out-of-band energy from interfering with signals in

Figure 3: *RF data and transmit filtering*



adjacent spectrum. Nonetheless, out-of-band energy may spill over into adjacent channels due to non-ideal filtering. This energy may introduce an interfering signal to adjacent television and/or data channels, and may degrade the carrier-to-noise ratio of the adjacent television and/or data channel by increasing the overall noise level.

Additional filtering is usually present in the receiver, but once the energy has spilled within the bandwidth of the adjacent channel, it will be passed to that channel's demodulator without further attenuation.

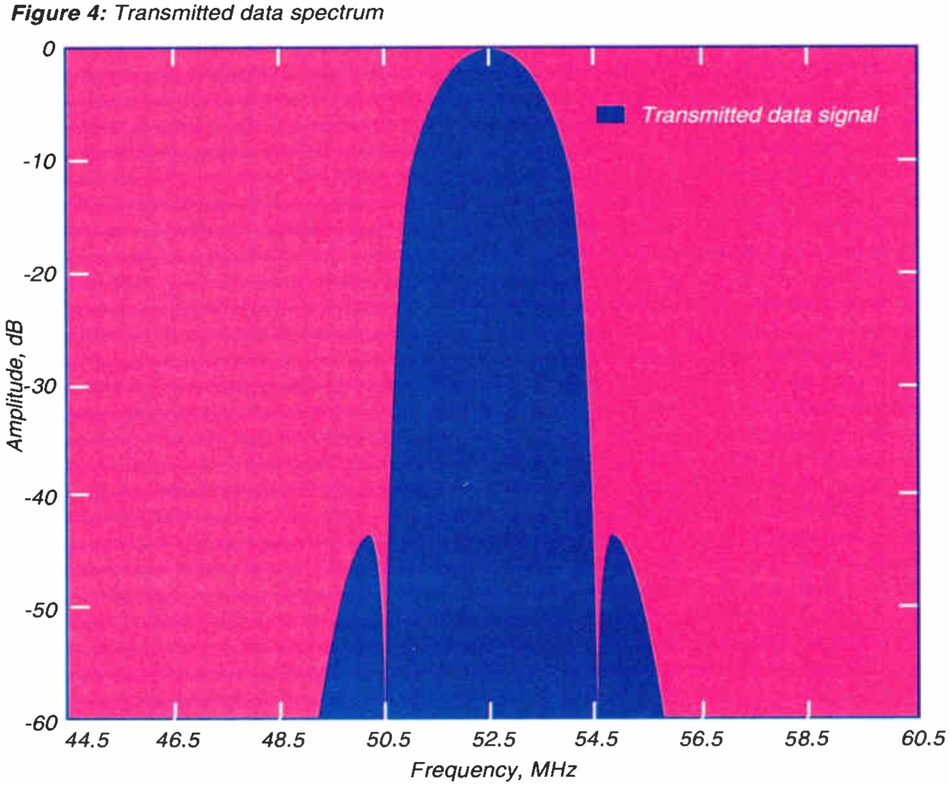
Filtering at the transmitter may be increased to reduce the interference to adjacent channels. The transmit filtering may be done directly on the data before it is modulated onto the carrier, after modulation, or both, as shown in Figure 2. In any case, care must be taken to avoid distortion through "over filtering."

Realizable LC filters present a fundamental trade-off between amplitude roll-off (selectivity) and phase linearity. From an interference point of view, it's desirable to have maximum selectivity and approach the amplitude response of the ideal brick-wall filter. However, a poorly designed LC filter may exhibit significant phase distortion which results in intersymbol interference (ISI) during demodulation. ISI exists when signal distortion causes the received pulses to overlap one another. The "tail" of one pulse overlaps the adjacent symbol interval and interferes with the detection process. Excessive ISI will degrade the bit error rate of a data communications system.

Transversal filters such as surface acoustic wave (SAW) filters enable the simultaneous optimization of the amplitude and phase response. Thus, SAW filters enable high selectivity and linear phase. The trade-off is that SAW filters are generally more expensive and lossy than LC filters. Digital filters may also be used on the data stream prior to modulation. The filter of choice is dependent upon the unique requirements of each application.

The filter of choice is dependent upon the unique requirements of each application

Figure 4: *Transmitted data spectrum*



Carrier-to-noise ratio

The interference power that spills over from an adjacent data channel can be considered as an additional noise source to the channel of interest. This will degrade the carrier-to-noise ratio in that channel. The amount of degradation is dependent upon several factors. These include: (a) the relative power of the desired signal to the adjacent channel signal; (b) the

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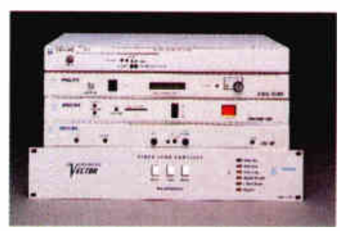

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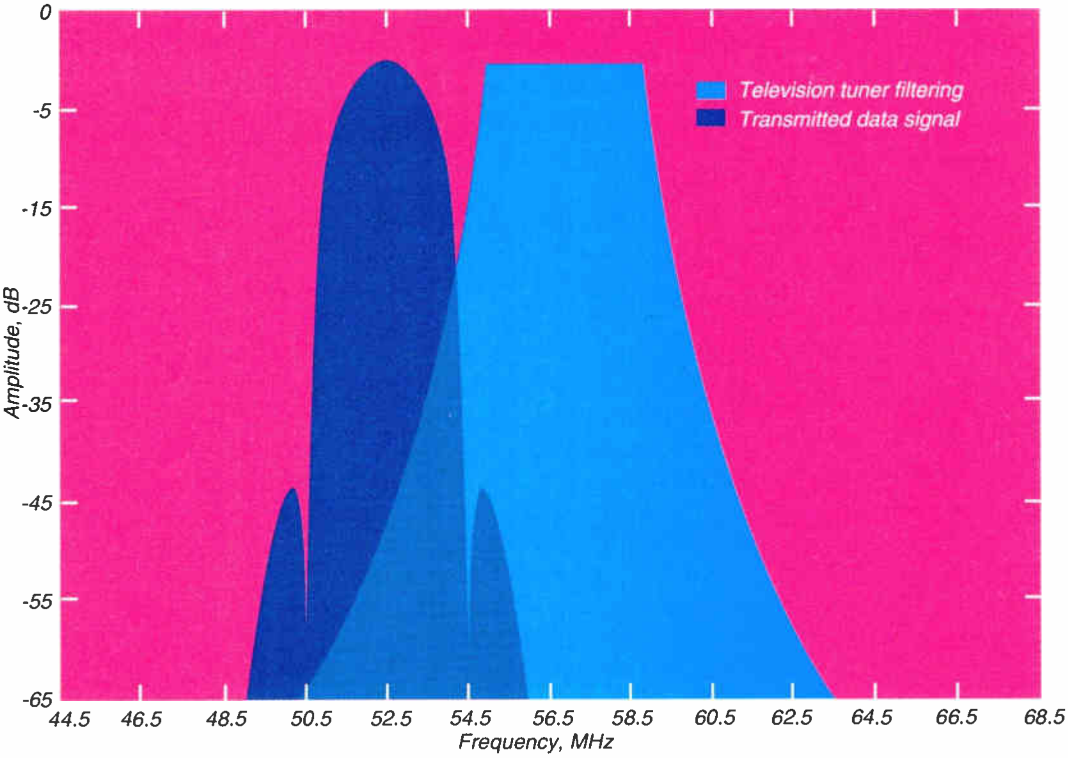
Figure 5: Data adjacent to TV channel

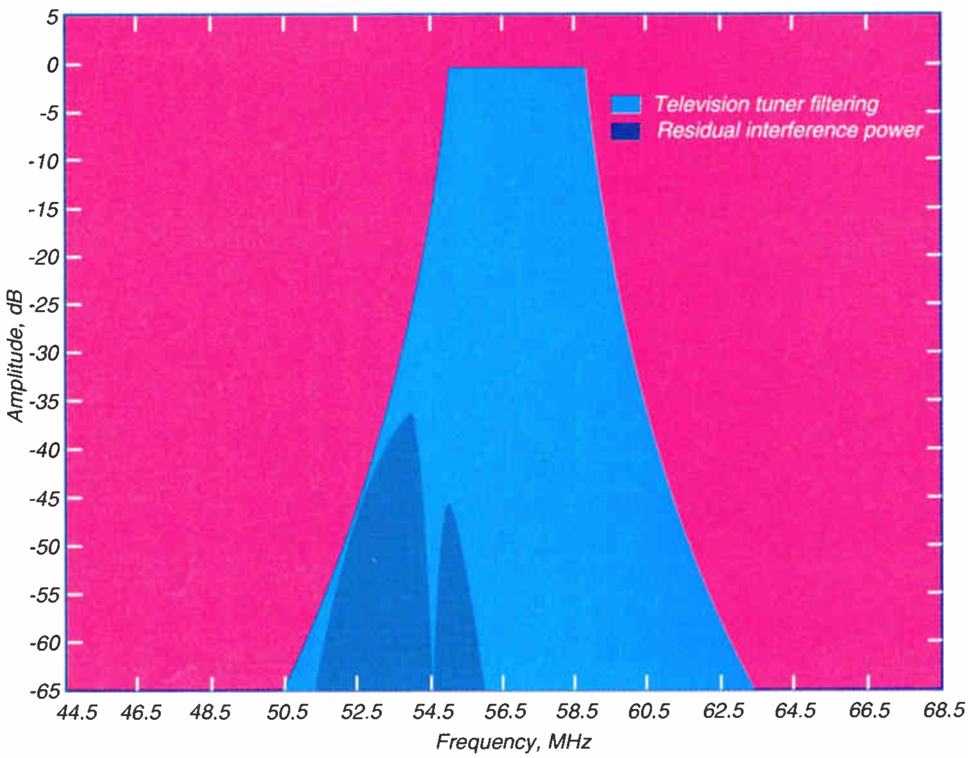


channel spacing; (c) the data rate; (d) the modulation scheme; and (e) the composite filtering on the interfering signal.

In most instances, the cable operator will have control over the relative power levels and data channel spacing. The selected RF data modem will generally determine the modulation scheme, data rate and transmit filtering characteristics.

As an example, consider the following:

Figure 6: Interference to TV channel



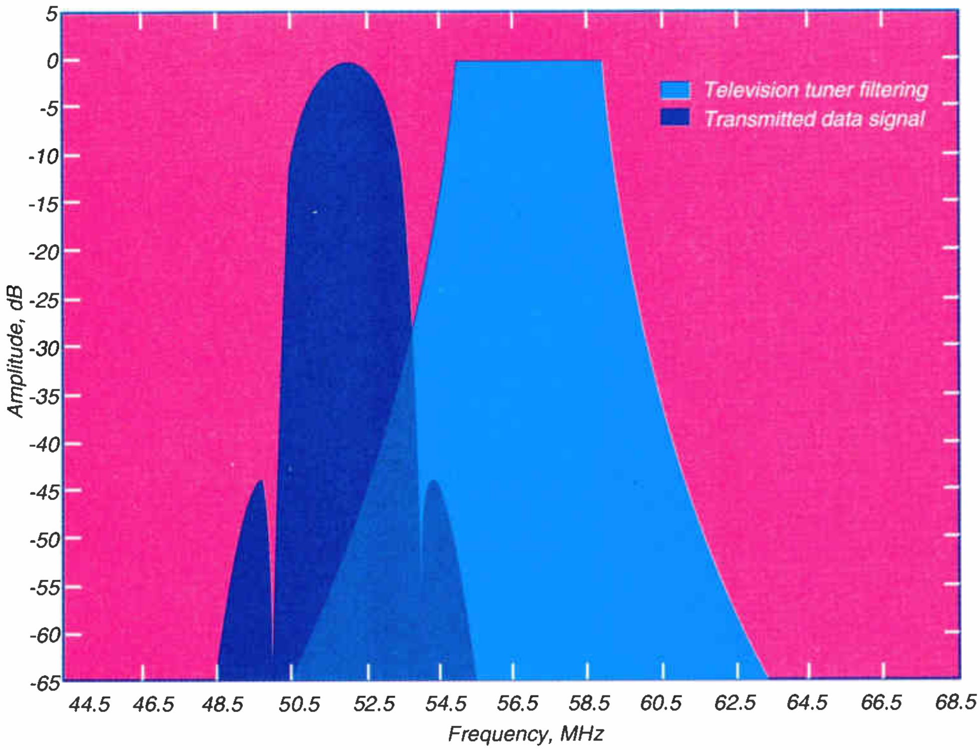
A cable operator wants to add a downstream data path to the system. The power of the data signal is initially set equal to the power of the picture carrier. A data rate of 4 Mbps is required, and the selected center frequency for the data channel is 52.5 MHz. Assume a television channel is at a directly adjacent, higher frequency, with the picture carrier at 55.25 MHz (no guardbands are present between data and television signal). The data modem operates with NRZ bit representation, QPSK modulation and no forward error correction (FEC).

The RF (double-sided) Nyquist bandwidth for QPSK at 4 Mbps is 2 MHz. The null-to-null RF data bandwidth for this scenario is 4 MHz. For the example, the data transmitter is assumed to be bandlimited to 3 MHz. Assume the transmitted data is filtered with a composite of -3 dB to -40 dB filter shape factor of 2:1. The amplitude response of this filter (an ideal 5th order Chebychev with 0.3 dB ripple) and the data spectrum are illustrated in Figure 3. The resulting transmitter output spectrum after filtering is shown in Figure 4 (the scale has been expanded for clarity). Note that the mainlobe of the spectrum is passed without attenuation, while the sidelobes are significantly reduced, but not completely eliminated.

The attenuated sidelobe power will appear as interference or as an additional noise source to the adjacent television channel. The television channel is assumed to have receive filtering with a -3 dB to -40 dB shape factor of 2:1 (again, modeled as an ideal 5th order Chebychev with 0.3 dB ripple). Figure 5 shows the transmitted data spectrum overlapping the television tuner/IF filtering. Note that although the peak amplitudes are clearly separated in frequency, the spectrums overlap at lower amplitudes.

The interference power that passes through both the data transmit filtering and television tuner filtering is shown in Figure 6. It is clearly not CW (continuous wave) nor white Gaussian noise, but rather, it's modulated interference. This interference may be quantified by peak carrier-to-peak interference ratio, or by average carrier-to-noise ratio where the interference power is treated as an additional noise source. The total noise-plus-interference power is cal-

Figure 7: Wider channel separation



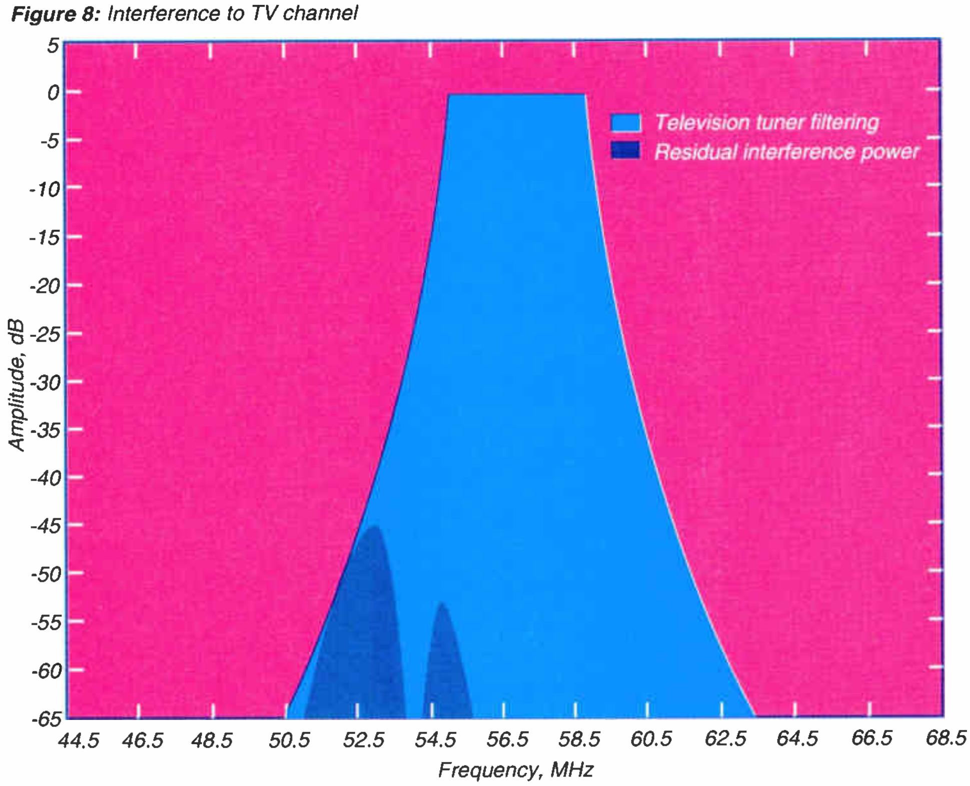
culated by integrating the residual sidelobe power over the bandwidth of the television channel. This average interference power is then added to the noise floor to determine the resulting carrier-to-noise ratio.

For this example, the resulting peak carrier-to-peak interference ratio is 36.4 dB. The average carrier to average interference power ratio is 41.2 dB.

Performance can be improved by reducing the power of the data signal with respect to the power of the television signal. If the relative power of the data signal can be reduced by 10 dB while maintaining an adequate BER, both carrier to interference ratios will increase by 10 dB.

The cable operator can also improve performance by increasing the channel spacing (i.e., adding a guardband). Modems are typically designed with a built-in guardband so the operator isn't required to add one. Figure 7 shows an increased channel spacing where the data signal is moved lower in frequency by 500 kHz to a center frequency of 52.0 MHz. The residual interference power is shown in Figure 8. The resulting peak carrier-to-peak interference power ratio is 44.9 dB, an improvement of 8.5 dB. The average carrier to average interference ratio is 46.6 dB, an improvement of 5.4 dB.

Figure 8: Interference to TV channel



Conclusions

This example has made several assumptions to simplify the analysis. In real life, the transmit and receive filter's ultimate rejection will be finite, temperature effects will cause filter responses and local oscillators to drift, filter characteristics may be different, and so on.

Guardbands are typically included in modem designs to minimize the possibility of adjacent channel interference under all operating conditions. This allows the cable operator freedom to place the data channel adjacent to television channels without inserting additional frequency spacing.

A similar issue exists for television signals interfering with the data channel. The treatment of that topic is similar to the development presented here.

A well-designed RF data modem will minimize adjacent channel interference to ensure its peaceful coexistence with television channels. If necessary, the cable operator also has the ability to improve performance by increasing channel spacing and/or adjusting the relative amplitudes of the data and television signals. CED

Acknowledgment

The author wishes to express his gratitude to Mr. Gaylord Hart, director CATV Product Development at XEL Communications Inc., for the insightful discussions on this topic.

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Circle Reader Service No. 22

High-speed data for the consumer market

An ongoing test in Castro Valley

By Ed Moura, Vice President of Marketing, Hybrid Networks Inc.

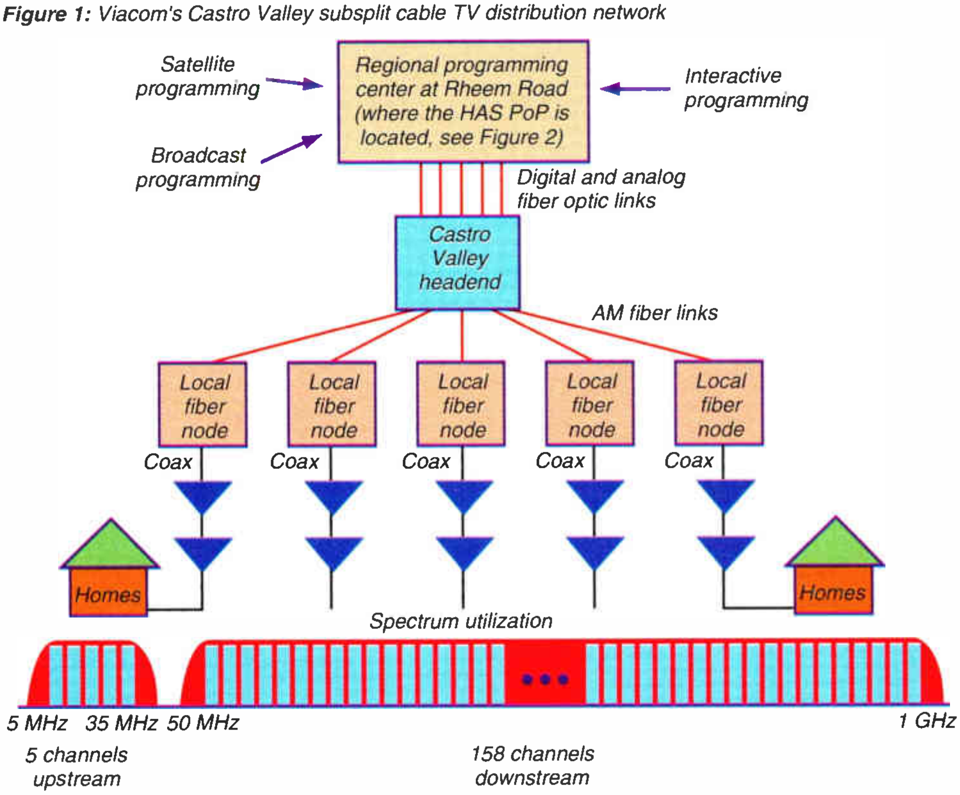
There are currently several high-speed "cable modem" trials underway in the United States. One of these is a new system network architecture, dubbed "Hybrid Access System," or HAS, that was specifically designed for services to homes, schools and small offices. The system is currently undergoing a field trial in Viacom's Castro Valley, Calif. system, in conjunction with Intel Corp. and General Instrument.

The architecture provides an asymmetric bandwidth connection for the user: a high-speed network-to-user (downstream) connection coupled with a lower speed user-to-network (upstream) connection. This configuration is engineered to take full advantage of a modern, two-way, hybrid fiber/coax (HFC) cable TV network, such as the Castro Valley system. Other configurations using the public switched telephone network (PSTN) for upstream communications are available for use in more typical cable TV systems that have not yet been upgraded to support two-way communications.

The system uses the standard TCP/IP (Transport Control Protocol/Internet Protocol) networking software to enable home PC users to connect to the Internet and popular on-line services such as Prodigy and America Online. Furthermore, the high-speed distribution network paves the way for delivering multimedia services to mass markets.

Current multimedia industry efforts, with switched digital baseband video, dual-coax, and other full service networks, generally require some form of equipment upgrade to the cable distribution plant. This involves significant capital investment, strategic alliances between many parties, and digging to put fiber in the ground. Prior experience indicates that digging and equipment upgrades are costly and time-consuming. The HAS capitalizes on current, in-ground distribution networks so that services can be deployed today. The architecture is fully compatible with HFC networks and will evolve with these distribution nets as they begin to provide telephony, cable television and data services over a full service network architecture.

Figure 1: Viacom's Castro Valley subsplit cable TV distribution network



Technology alternatives

The notion of an information superhighway and the convergence of the telephone, television, data communications, computer and consumer electronics industries into one information industry has created a flurry of technical and marketing activities. As a result, it has become increasingly difficult to judge the potential of a given new technology, or to determine whether it will grow. There are a number of potential technologies that are capable of providing high-bandwidth distribution for on-line services, including:

✔ Symmetric LAN over cable TV technologies, including Ethernet, isochronous Ethernet, and FDDI to provide wideband remote access;

✔ Fiber-to-the-curb (FTTC) Sonet/ATM end-to-end architectures providing digital voice, video and data services over one distribution network;

✔ Other digital fiber-in-the-loop (FITL) architectures providing digital voice, video and data services over one distribution network; and

✔ Hybrid fiber/coax (HFC) networks providing both analog and digital services over one distribution network.

Key parameters for a strategic analysis of these proposed technologies must include the availability of high-bandwidth two-way capability, ubiquity for service deployment, low cost, near-term availability of the distribution network and changes in federal regulation rates that might affect a return on the investment. The HFC architecture meets these criteria, given its ability to support a mix and match of various independent downstream and upstream channels.

Early deployment of interactivity

From a technology and end user equipment perspective, broadband services can be categorized as TV-centric or PC-centric services. The differences in the PC-centric services and the TV-centric services are subtle and distinct.

Interactive TV-centric services such as video-on-demand, near-video-on-demand, enhanced pay-per-view and home shopping

referred to as a subsplit system, employs 5 MHz to 30 MHz (or more recently, 5 MHz to 42 MHz) for upstream signaling, and upwards of 500 MHz for downstream video distribution (see Figure 1). A typical midsplit system uses 5 MHz to 200 MHz in the upstream and 250 MHz and up for the downstream distribution. Midsplit systems are much less common than subsplit systems.

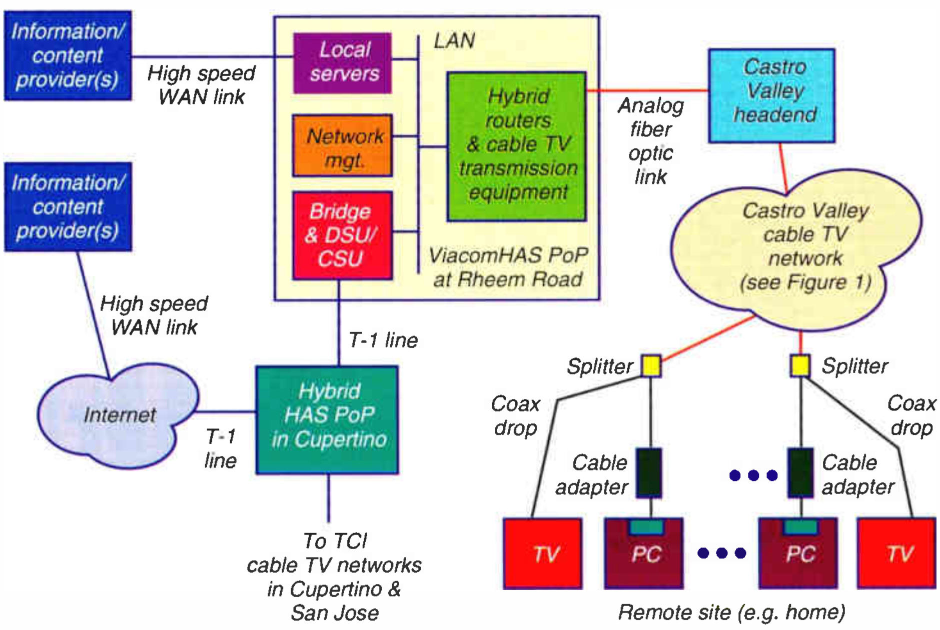
The cable TV industry has not yet reached a consensus regarding what constitutes a two-way cable plant. Some HFC systems assume use of various modulation techniques to improve the efficiency of upstream transmission. The Orlando Full Service Network built by Time Warner assumes use of 695 MHz to 735 MHz in a 1 GHz spectrum for upstream traffic. The US West Omaha trial is a dual coax system with cable A carrying subsplit 5 MHz to 30 MHz upstream, and cable B providing 5 MHz to 112 MHz for upstream. The Castro Valley trial assumes the use of the more conventional 5 MHz to 30 MHz subsplit frequencies for upstream traffic.

Symmetric bandwidth LAN on cable

Broadband data services can be delivered over current cable television networks by modulating data onto one or more 6 MHz TV channels. The cable spectrum is divided into increments of 6 MHz each, carrying the equivalent of one analog television channel. When a client PC transmits data, the signal is sent out in a 6 MHz upstream channel to the cable headend. At the headend, the signal is repeated, usually with a heterodyne processor, and inserted into a separate 6 MHz downstream channel which is broadcast over the cable distribution network. In this arrangement, data transmission over cable does require two (one up, one down) 6-MHz cable channels, one for transmitting and the other for receiving. Data transmitted by the client PC is sent over a 6 MHz channel in the 5 MHz to 30 (or 42) MHz area.

In order for a symmetric network to operate, the upstream and downstream rates must be equal. For its part, 64 QAM allows data rates of 30 Mbps to be transmitted in a 6 MHz downstream channel (5 bits per hertz). For a symmetric network to supply 30 Mbps of data in the downstream direction, the upstream must also be 30 Mbps. However, due to noise and ingress, the upstream modulation scheme cannot be 64 QAM. It must be limited to FSK, QPSK, or possibly 16 QAM. To transmit at 30 Mbps in the upstream direction will require at least 15 MHz of bandwidth using QPSK. This is more than 50 percent of the useable space in the 5 MHz to 30 MHz upstream spectrum.

Figure 2: The HAS configuration at Viacom in Castro Valley



In addition, this symmetric system would require a much more complex headend repeater, since it would have to translate between QPSK in the upstream direction and 64 QAM in the downstream direction. This excessive bandwidth and complex headend requirement is expected to prevent symmetric systems from achieving rates greater than about 10 Mbps.

As full service networks capable of delivering telephony, television and data applications emerge, the HAS architecture will evolve toward more symmetric network configurations. However, it will continue to support asymmetric bandwidth services over the network. So far, studies indicate that symmetric LANs over cable architectures are an expensive solution in the near-term.

The upstream spectrum in the subsplit region may be allocated for telephony and data applications as well as interactive television applications. For client-server applications and in networks with limited upstream capacity, an asymmetric bandwidth architecture over cable may prove to be a more practical choice.

Networking protocols

The Internet provides users with access to global information, including Wide Area Information Servers (WAIS), World Wide Web (WWW) hypertext-based servers, e-mail, USENET newsgroups (bulletin boards for numerous specialty topics from around the world), File Transfer Protocol (which allows for transfer of information between locations), Telnet (which allows a remote login to another Internet-connected computer), and Internet Relay Chat (which provides live dialogue among Internet users.) With an estimated 30 million Internet subscribers worldwide, the global network has reached a critical mass in generating support (commercial) services such as NetMarket, CommerceNet and LibertyNet. Delphi, CompuServe, America Online, Prodigy and many other service providers are beginning to provide gateways to and from the Internet to maximize business opportunities.

From a networking and architectural perspective, access to the Internet resulted in the selection of TCP/IP as the networking protocol. On the consumer PC side, as well as on the network platform side, modifications to TCP/IP networking software are used to manage asymmetric bandwidth connections.

Architectural overview

Figure 2 shows an overview of the HAS asymmetric bandwidth architecture. The end user residence uses a conventional splitter for the television cable so that the residence has access to entertainment services along with the data services delivered to the PC. The cable drop is connected to a cable adapter, which provides either an Ethernet or a direct bus connection to the user PC. Information received from the cable data channel is extracted by the adapter and is sent to the PC for further processing. The user response, consisting of key strokes and mouse clicks, is captured and sent over the upstream cable TV connection using narrowband, robust modulation techniques.

In cable TV systems without upstream capabilities, this traffic would be processed

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Comparing the different approaches

One of the primary limitations of the LAN-over-cable symmetric architecture is that it does not include the concept of a PoP. It is a peer-to-peer system, and any remote home user can dominate the data communications channel without giving the cable TV operator control over the situation. For example, separate home users can start continuous file transfers between their home PCs using the entire capacity of the channel. Without a PoP-centric architecture, it's significantly more difficult to manage such a situation. The cable TV operator must monitor the packet transmissions on the channel and set up a billing service that charges per packet. This might not be received well by customers and would not necessarily stop users from abusing the system and flooding the channels. Routers at a PoP, conversely, can be programmed to prevent traffic flood situations.

Another key limitation with LAN on cable is scalability. In order to scale this type of system, the cable TV operator needs to provide at least two or three subsplit 6-MHz channels for the service. Since cable TV operators will want to reserve subsplit bandwidth for other applications such as telephony and interactive TV services, it will be difficult for them to allocate bandwidth to scale a symmetric LAN on cable architecture.

On the other hand, the HAS does not have this limitation. Downstream channels can be added without consuming additional upstream subsplit channels. The asymmetric architecture, although technically more complex to design, has unlimited growth potential by decoupling the upstream data rates from the downstream data rates. Most importantly, it can be configured to only use a number of 100 kHz-wide sub-channels in the upstream direction, while the rest of the upstream subsplit bandwidth can be reserved for both telephony and interactive TV services.

Finally, a LAN on cable system is wasteful of upstream and downstream bandwidth. Upstream traffic that is destined to go off-network travels through the downstream channel. This prevents other subscribers from using the downstream bandwidth for their own applications. In addition, collision detection, no matter how efficient, reduces available bandwidth. Conversely, the HAS operates its downstream channels up to saturation without causing any traffic congestion or other related problems.

Requiring the use of 6 MHz in the upstream direction is also wasteful. It gives home users the additional speed required for video conferencing applications, but requires the cable TV operator to find additional upstream bandwidth.

Cable TV operators will want to reserve subsplit bandwidth for other applications

The asymmetric approach does not automatically give the home user excess upstream bandwidth. Rather, it allows the cable TV operator to provide it upon request for an additional premium fee. Symmetric connections are therefore possible with the HAS, but are available without compromising the rest of the system.

Field trial objectives

The HAS system trial in Castro Valley features typical cable customers using the system to gain access to a number of interactive services via their PCs.

An important first step in realizing the strategic, financial and business goals is to understand the value chain for on-line services. In the multimedia and on-line services industry, independent software developers and content owners bring the information to packagers or content integrators (enhanced service providers) such as Prodigy and America Online. The enhanced service providers package the information and present a uniform easy-to-access interface to the end user. Some of the major on-line service providers attract advertisement revenue as the content is regularly viewed by a large number of consumers in the mass media. Service ubiquity is an important parameter to successfully reaping the benefits of advertising revenues.

The enhanced service providers use a nationwide network such as the Internet to provide information to different regions. A local access provider such as a telephone company, cable company, or a combination of both may be used to deliver services to the last mile. For the emerging interactive multimedia services industry, the enhanced service provider–network service provider–access provider chain forms the distribution network between content owners and the end user. All partners are examining these concepts with real subscribers in order to determine the most effective business scenarios for their broadband multimedia service offerings. The user feedback will also be useful in determining the best user interface and will help the proponents understand the necessary customer service requirements.

What operators should look for

Cable TV operators thinking about offering their own PC-over-cable services should keep in mind the following issues when selecting a system:

✔ Scalability. Operators should select system architectures that scale the service to tens and hundreds of thousands of PC users.

✔ Configuration flexibility. Operators should select a system that utilizes their cable TV coax plant "as is" to offer PC services. As user demand increases, the system should offer several growth alternatives. These include supporting more downstream channels, HFC fiber-to-the-node architectures and two-way cable TV plants.

✔ Traffic control. Operators should select a system architecture that allows them to exercise traffic control on the network. Consequently, one or two PC users should not be allowed to dominate the entire bandwidth of the network in either the upstream or downstream directions.

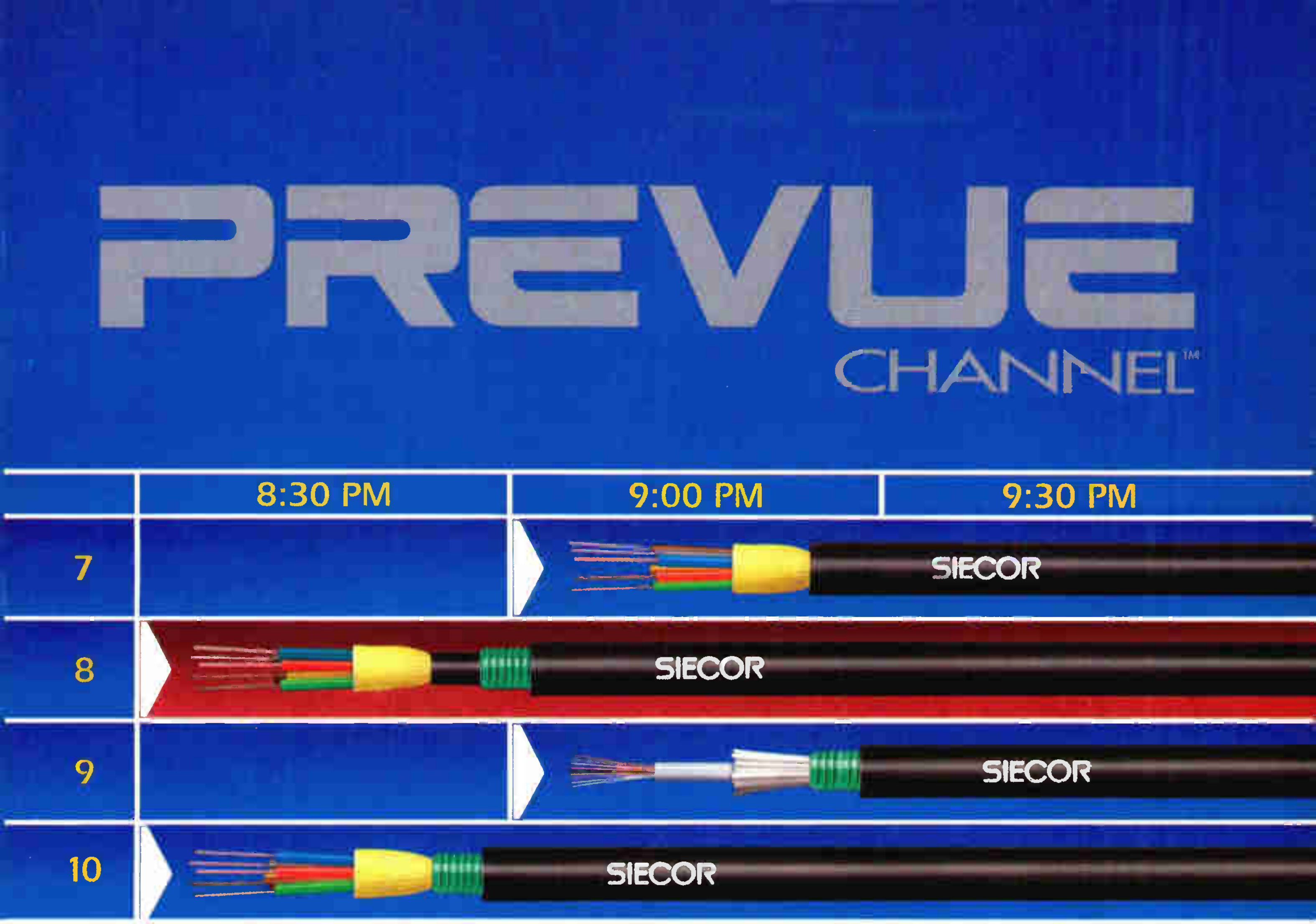
✔ Service management. Operators need controls over home PC users who take advantage of their high-speed connection to offer their own high-speed services while only paying for the lowest monthly rate.

✔ Bandwidth utilization. Operators need to make sure that the system that they select is not wasteful of bandwidth, especially in the upstream direction.

✔ Overall system management and security. The system selected requires tracking and billing of individual services and general troubleshooting. Built-in security and encryption capabilities are also very important. CED

Acknowledgments

The author is grateful to Craig Strachman of Hybrid Networks Inc.; Doug Semon, director of engineering at Viacom; and John Tate and Lew Adams of Intel for their contributions and careful review of this paper.



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The high-speed CATV data revolution

Prospects for near-term revenues

By Ken Pyle, Product Manager, E/O Networks

A revolution is impending that will transform today's primarily entertainment-driven cable television networks into citywide, local area networks. These networks, built from the foundation of today's CATV infrastructure, will provide residential customers with high-speed data connections to various remote service providers, such as America Online and Prodigy. The throughput speeds promise to be in excess of 100 times an ISDN line, while priced similarly to what a second telephone line would cost from today's telephone service provider.

Further, the technology will allow complete bypass of the local exchange carrier (LEC). This will have a significant impact on the LECs, as it is estimated that up to 50 percent of the traffic carried on the public switched network is data.[1] This article provides an overview of the business motivations,the technology implementation, and the advantages and issues surrounding this exciting new service. Finally, it briefly touches upon the application of this type of service in rural areas.

Business motivations

The Cable Television Act of 1992 and the resulting FCC regulation of the cable industry provided a framework for what a cable operator could charge for certain services. In turn, this has caused the operators to look for unregulated revenue sources, such as pay-per-view (PPV), local advertising, interactive games and digital music. Thus, the major MSOs (multiple system operators) have all proposed residential, high-speed data services, as these services offer the prospects of near term, unregulated revenues.

In fact, the revenue potential is enormous. Rogers Cablesystems, a Canadian MSO with more than 2 million subscribers, expects half of its revenues to be derived from PC services by the turn of the century.[2] Of the 36 million PCs in the United States, only 5.5 million are connected to on-line services, leaving an immense untapped market.[3] Additionally, the prospect of connecting residences to the Internet is very enticing, as the Internet is experiencing explosive growth that is estimated at 50 percent to 100 percent per year.[4] This growth rate is attractive to the MSOs, given basic cable's relatively slow growth of approximately four percent.

Another benefit of these on-line services is that they will not directly cannibalize the cable operators' existing service base. For instance, PPV generates additional revenues, but some of those revenues are potentially taken from existing cable programming, such as pay services like HBO. High-speed data services, however, are more likely to be substitutes for services offered by competitors, such as the LEC, or are more likely to create new markets, such as interactive home shopping. The implication of these new markets is that the cable operator may not face effective competition in some service niches and will be able to dominate those areas. Lastly, market studies from several research firms confirm that the high-speed data service is more viable and more likely to provide significant near term revenues than other advanced services, such as video-on-demand.

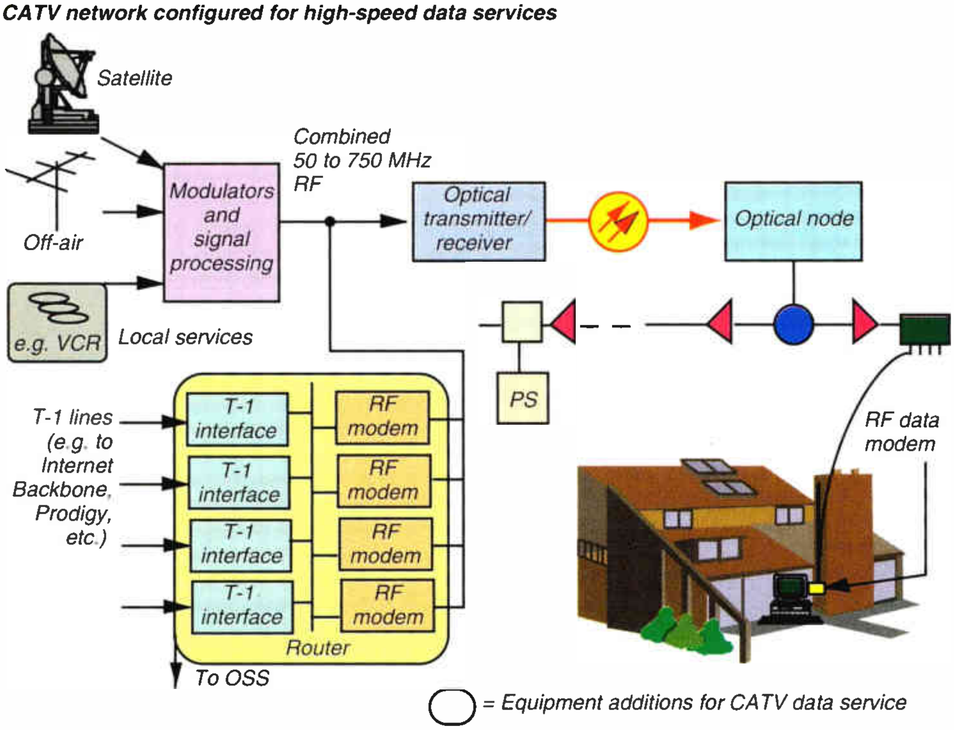
Momentum is building for implementing high-speed data services, as service providers, cable operators and equipment manufacturers are all readying product. Both America Online and Prodigy have made commitments to provide this service, while Comcast is going to provide high-speed Internet access to all of its 3.3 million subscribers by 1999. Other cable operators which are trialing or are planning wide-scale deployment of these services include TCI, Continental, Cablevision Systems, Viacom, Cox and Jones Intercable.

Well established consumer and industrial manufacturers are supplying or gearing up to supply this technology. They include: Digital Equipment Corp., Hewlett Packard, Intel, General Instrument, Scientific-Atlanta and Zenith. Today, the price for an RF modem ranges from $500 to $5,000, but, as with telephony modems, it is anticipated that these prices will decrease significantly with volume and will approach $100 within a few years.

Technology implementation

The technology used for this service is an adaptation of Radio Frequency (RF), coaxial

CATV network configured for high-speed data services



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based wide area networks (WAN) which were widely installed in the 1980s for intra-business and campus data connectivity. Typically, in those configurations, a coaxial cable television network was used to connect LANs (local area networks) located in various buildings into a larger WAN. Essentially, the RF coaxial system became a shared data bus with all users or LANs contending for its bandwidth. A bridge provided the interface to connect the various LANs with the RF, coaxial system.

Today's systems are similar, in that they also treat the cable system as a shared bus and require a bridging function to go between the baseband data and the RF format. Some schemes provide symmetrical data rate transmission for the upstream and downstream signals, while others provide asymmetrical upstream and downstream transmission, where the upstream is slower than the downstream. Commercially available products offer downstream transmission from 500 Kbps to 10 Mbps with upstream data rates of 128 Kbps to 10 Mbps. Products under development from the partnership of General Instrument, Hybrid Networks and Intel promise to yield downstream rates to 30 Mbps.

As with any bus type system, the per-user throughput of this type of system is traffic dependent. The traffic is dependent upon customer usage, service penetration level and node size. In the downstream direction, each 500 Kbps to 10 Mbps data channel will occupy 1.5 to 6 MHz (one NTSC modulated television channel) of bandwidth. The upstream signals occupy between 100 kHz to 6 MHz of bandwidth. Multiple data channels can be put onto a coaxial system, thus multiplying the effective data rate of the system.

One of the enabling technologies is the extensive use of fiber optics in the cable TV network. What this technology has done is to divide the cable system into multiple cells of typically 500 homes, about the size of the intra-business and campus WANs described previously. This provides greater bandwidth per subscriber and limits sources of ingress, making the upstream path more robust and useful for high-speed data traffic. Interconnection of high-speed data services onto today's modern cable network is depicted in the figure on page 52.

In that scenario, T-1 circuits terminate at a router in the cable headend. These T-1 circuits might be coming directly from the inter-exchange carrier (IXC), completely bypassing the LEC. The router, which is adapted from LAN and WAN technology, uses address data contained within the data packet to route messages and payloads to the appropriate output T-1 or RF port. The router thus acts as a traffic flow control point. On the subscriber side, the consumer's PC is connected, typically via an Ethernet interface, to the RF data modem, which attaches to the RF drop cable from the coaxial cable network.

Advantages to this approach

This approach offers advantages over alternative delivery schemes for the end users, the network operator and the service providers. From an end user perspective, the following are a few of the advantages:

✔ Cost-effective, higher speed data throughputs
✔ Does not tie up their existing telephone line
✔ No dial up modem access limitations.

This service promises to be more cost-effective than alternatives such as ISDN and price

competitive with a second phone line. For instance, Comcast suggests a fee of $5 to $9 per month with unlimited access time to this service. This is significantly less than the typical $30 per month plus usage charges for ISDN service provided by a LEC. Additionally, by not using the telephone line, the consumer may be on-line and have simultaneous access to voice communications. Lastly, because a dial up line is not required, the interconnection at the service provider side is via a LAN interface, ensuring that the subscriber always has service access. This prevents the busy dial tone that subscribers now sometimes experience with dial up modems during peak traffic loads.

This technique offers the following advantages to the network providers:

✔ Addition of this technology represents only incremental additions to the existing network.

✔ A bus network is more efficient for bursty and occasional data requirements.

As the outside plant infrastructure is already in place, the addition of this type of service consists of adding components at the headend and subscriber side, with minimal network modifications to cable plant that is two-way capable.

A bus network is inherently more efficient than a point-to-point switched network for bursty and occasional data use, which will be the predominant use in a residential environment. This is because access to the switching mechanism (i.e., the router) is available to all subscribers at all times. Additional switching capacity or bridges need to be added only as dictated by traffic demands. A switched point-to-point network, on the other hand, requires a switch port for every on-line subscriber. This switch port is occupied as long as a customer is on-line, even though data is not being sent or received.

On-line service providers must offer this service to stay competitive as it enhances current offerings with the addition of video clips, high-speed file transfer and improved graphics. Additionally, it provides the service operator with a new source of income, as it will be able to offer services that heretofore have not been economically feasible.

Issues

The application of the technology to this market is relatively new, and thus, there are several technology and service issues that must be resolved before this service will gain widespread deployment. These can be categorized into system and service issues.

Regarding the system issues, signal ingress in the upstream path must be resolved because it impairs the reliability of upstream communications. Nationwide, only five percent or so of the upstream plant has been activated, so some network upgrades will be required in the majority of systems.[5] The system reliability, in general, must also be addressed as the service demands of providing data services may be different than television services. For instance, battery backup may be required, as more and more customers will have battery backed-up portable computers that will continue to operate even during a power outage. Lastly, the fiber optic node sizes will have to be small enough to ensure adequate traffic capacity. Cable operators and equipment manufacturers are currently working to resolve these issues through a combination of network and equipment design.

The delivery of data services to residential customers is a new business for cable operators. The personal computer user will have different service requirements and expectations than a television viewer. The technical support people for this service will need to have some knowledge of both the TV network, as well as data transmission and personal computers. This will require training for existing service personnel or additional personnel dedicated to just this service. It might even mean new organizations within the cable system to specifically address this service. Another issue is that there is currently no explicit standardization of the technology, which could mean that a person who purchases a modem in California may find it unusable when he or she moves to New York. Additionally, other issues, such as graceful upgrades to more system capacity, will have to be addressed.

The momentum generated from the service providers, the equipment manufacturers and the desire of the network operators to garner new revenue streams virtually guarantees that these obstacles will be overcome, and that these data services will be successfully implemented. As with telephony modems, the RF modem technology will probably converge around a de facto standard set by the manufacturer with the most market influence.

Rural opportunities

The technology required for cable networks goes a long way toward satisfying the needs of residential customers for high-speed data services, effectively putting them in the fast lane of the information superhighway. This works as long as the potential subscribers have access to a coaxial-based, cable TV network. What happens to the approximately 4 million homes not served by a coaxial system?

E/O Networks is investigating ways to service this market through the use of a local loop, fiber optic transport product utilizing copper and bandwidth extension technology. This product, which features a counter-rotating ring architecture, can be configured as a wide area network with shared, high-speed data services carried in the same data stream as the lifeline telephony signals. This allows delivery of high-speed services to areas lacking a coaxial infrastructure, but which already have embedded twisted pair, copper plant systems.

Summary

The promise of new markets and new revenue sources is motivating MSOs to provide high-speed data services via their networks. The technology to implement such services represents incremental additions to the existing networks. This approach provides advantages to the customers, cable operators and on-line service providers. Many issues must be resolved before these services are successfully implemented, but the number of manufacturers, networks and service providers that are committed to this technology suggest that it will eventually be successful. CED

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Key attributes of modern OSSs

What to look for from vendors

PHOTO BY G.K. AND VIKKI HART, THE IMAGE BANK

By Steven Wright, consultant

Editor's note: This is the second part of a three-part article.

The competitive telecommunications ball is ready to start. The orchestra is warming up, and you have to decide what to look for in your operational support system (OSS) dance partners.

Advances in both hardware and software technology have made possible new services and enhancements to existing services. In a competitive environment such as telephony, you can't afford to assume that your competitor will ignore technology which could make him better. If new technology is available, you must use it, as well. Market forces, therefore, give the network operator no option but to excel at operations through the use of every available modern technology.

Market forces

If there is anything that can be said with certainty, it is that the pace of change in the telecommunications market is accelerating. Everything about the consumer market changes at an ever-increasing rate.

Network operations that succeed in this environment must be flexible enough to add new services and modify existing ones. The time to market and the time required to make changes must be continuously shortened.

Since service mix cannot be determined from the outset, and service buy rates cannot be accurately forecast, operational support systems must be able to grow rapidly. Scalability of systems will be critical. No network operator will have time to implement a new system in order to grow an already successful service offering beyond a certain point.

In such a competitive environment, employee empowerment is key. The employees who get the job done must have the authority and capability to change the process they perform as they proceed. Waiting for management to approve changes, and for MIS to assign programmers, etc., will not work. This is a fundamental tenet of continuous improvement processes. Software tools now exist to enable this concept in the telecommunications services industry. Expert systems can be controlled by interfaces which do not require computer programming experts.

What do visionary companies expect in terms of improvements? Pacific Bell, in documents filed with the FCC, states that it expects to realize an approximately 75 percent cost reduction in operations expenses with a com-

pletely new broadband-capable network and OSS set delivering standard telephone service. It is widely recognized that the telcos must replace their OSSs to control spiraling OSS-related expenses. In comparison to most other OSS-intensive industries, telcos spend about twice as much relative to revenues (about 10 percent total, compared with less than five percent for most other industries).

To help the telcos get control of OSS expenses, some experts have recommended two important shifts in strategy: Outsourcing of common, non-industry specific functions such as payroll, accounts payable, human resources, some inventory management and fixed assets and certain types of financial and business modeling; and a shift to distributed computing solutions, or client/server technologies with an open systems approach.

One of the primary design strategies of extensive modern computing systems is the client/server architecture. Users have computers with specific capabilities according to their functional needs. Engineers, for example, have workstations, and CSRs have basic microcomputers with good displays. These computers are the "clients." The client systems in a workgroup of people with similar responsibilities are then all tied together on a network.

Also on the network is a central computer with large data storage and processing capability (powerful, but not like a mainframe). This computer is the server, which does things like administrate the network, run the e-mail system, store central databases, store copies of applications not frequently used by the clients, and many other tasks as well. The common standard cited for this architecture is the Distributed Computing Environment (DCE).

This architecture is the predominant one for modern computing systems, which is indicative of the desire of employees to have solutions tailored to their specific needs. The client server architecture allows this tailoring and individuality. Customization also extends to the software applications used.

Another major benefit of the client server system is how computing system costs are kept under control as they are shifted to local budgets. Each workgroup must cost justify its computing costs within its own budget constraints. Thus, greater accountability results in better cost/benefit decisions.

Open systems concepts are another major hardware selection criteria. Open systems are those in which the interfaces between various parts of the system are "open" to the public, enabling hardware and software to be made by more than one vendor. This sets up a competitive environment, resulting in lower costs and more innovation.

Software technology

Graphical user interfaces. In this day of Windows and Macintosh operating system interfaces, it hardly seems necessary to point

Ad Index

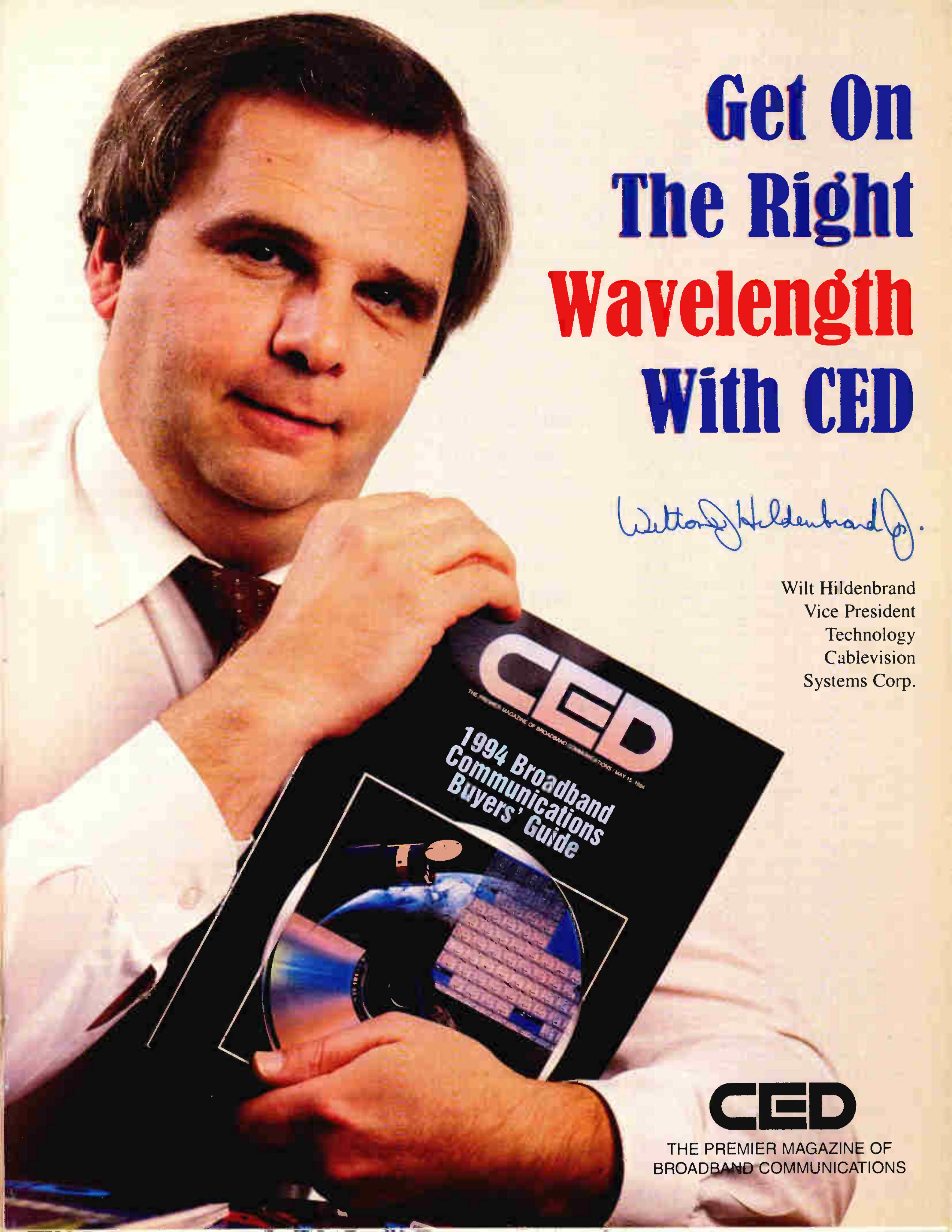
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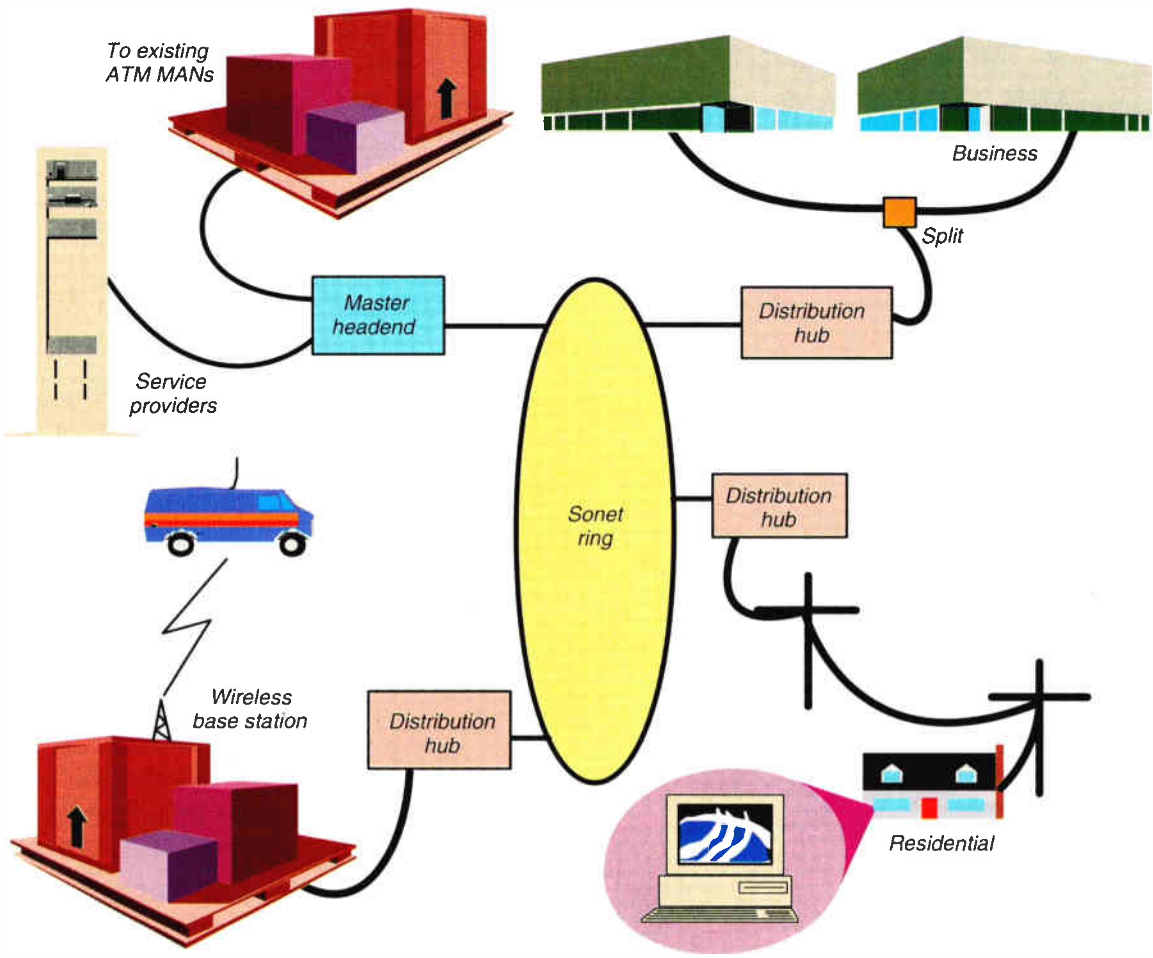
Figure 2: Communications topography



enced. Ethernet's contention mode works well for data, but not for multimedia services. Other approaches, such as switched Ethernet, are interim and bandwidth-intensive solutions between Ethernet and connection-oriented protocols. They can't increase efficiency beyond the 40-50 percent level due to the lack of quality of service parameters typical of Ethernet architectures.

First generation

Several cable modems have been introduced in the marketplace. Most are Ethernet bridges, sending Ethernet inputs to a network that transports the signals symmetrically in an Ethernet fashion. As such, these solutions are simply extensions of traditional LANs.

To date, the primary customers of early cable modems are business users with symmetrical networks. These networks have up to 10 Mbps in a dedicated downstream channel and an equivalent amount in a dedicated upstream channel. Symmetrical networks are an inefficient use of bandwidth, because most applications use much more bandwidth on the forward channel.

With Ethernet, every signal has the same priority. Bandwidth, however, is a precious commodity that needs to be managed. This requires prioritizing via quality of service parameters, depending on whether the signal is voice, data or video.

Costs for the first-generation equipment are high: $500 is the minimum list price for a modem; a router may cost $5,000 or more. And the reliability of first-generation cable modems is limited due to the wide carrier and noisy environment in the upstream channel.

A new generation of cable modems

A new generation of cable modems is on the horizon. While different manufacturers have varying viewpoints, the author believes the shortcomings of existing cable modems can be rectified.

The following is a list of requirements

businesses can obtain LAN-like performance for telecommuters and employees in satellite offices. Employees, suppliers, customers and prospects can participate in videoconferencing. Universities can reach out to more students. Hospitals can monitor patients at their homes.

Organizations and families alike are avid users of on-line services. The "Big Three" on-line services recognize the value of having greater bandwidth. They know that cable modems will encourage not only faster delivery, but also the addition of real-time video content. Cable operators, then, are extremely well positioned to generate revenue from the booming on-line services market, which is expected to triple by the year 2000.

Other potential applications of the cable modem abound for both homes and businesses. Figure 1 lists a sampling of enhanced traditional services and new services that could flourish over cable.

With the increased emphasis on easy-to-use, graphical applications, document and image files are expanding geometrically in size. Consequently, applications often require more bandwidth than LANs or the public telephony network can provide.

The big bottleneck in both home and office computing is the network, not the computer. Delivering data through a hybrid fiber/coax system, however, offers significant advantages over existing information delivery mediums. A hybrid fiber/coax (HFC) network has the bandwidth to support a single information pipeline shared by multiple services: analog video, digital video, telephony, data and voice.

For the home and home office user, the HFC solution provides the speed for faster access to current applications and the introduction of new services. For businesses, HFC increases speed, reduces investment in LAN equipment and leased lines, and expands application opportunities.

Is end-to-end Ethernet a solution? Not for multimedia applications, because Ethernet does not provide an efficient use of bandwidth. True, a "fast Ethernet" is capable of 100 Mbps throughput. But Ethernet-type networks can only support multimedia applications at light loads before a degradation in service is experiexpressed by forward-looking operators:

1. Support TCP/IP and connectionless services.
2. Provide the ability to charge based on differing service levels.
3. Provide office-level performance and connectivity for telecommuters.
4. Support voice circuits for use with interactive games.
5. Support videoconferencing.
6. Provide compatibility with a variety of computer platforms and operating systems.
7. Be economical enough for residential applications.
8. Prevent a single user from monopolizing a link by using huge amounts of bandwidth.
9. Connect into the wide area environment.
10. Provide the frequency agility to be able to work with other upstream devices and circumvent noise.
11. Provide security in the upstream and downstream directions.
12. Ensure scalability.
13. Allow remote diagnostics.

ATM (asynchronous transfer mode) is well suited to cable modem applications and has all the capabilities to meet these requirements. A connection-oriented protocol, ATM provides a methodology for mixing voice, video and data in a single real-time transmission. It accommodates a wide variety of media speeds from 25 Mbps to 2.4 Gbps. It also provides quality of service parameters and automatically allocates bandwidth to each active user.

Implementing cable modems

Figure 2 shows a communications topography for implementing cable modems in a wide area network. The master headend provides access to the public network and local servers, which, along with network management computers, are connected to an ATM switch. Economies are realized by sharing expensive headend components among users at multiple distribution hubs. Signals travel to and from the master headend via a Sonet loop or point-to-point fibers. Distribution hubs enhance the signals for transmission over the cable plant.

The modem in the home is tuned to specific upstream and downstream frequencies allocated for PC subscribers. It can be reassigned to another channel by the network, depending on current loading. Downstream signals are demodulated and sent to the PC. Upstream signals are modulated onto the cable modem based on a standards-based access mechanism.

Conclusion

The time is ripe for cable operators to participate in the computer revolution. The critical mass of personal computers has arrived. The market demand for interactive applications has arrived and is growing rapidly. The broadband and telecommunications technologies are here, too, with second-generation cable modem products soon to be available.

With the addition of cable modems and reverse-path cards in existing amplifiers, MSOs can open a wide door to new revenue opportunities. Remember, many personal computer users are already paying $15 a month or more to get a dedicated modem line. Business users pay much more for ISDN solutions, which cost about $30 per month for each termination point, not counting equipment and installation costs. That revenue–along with fees paid by on-line services and other content providers–can be yours. CED

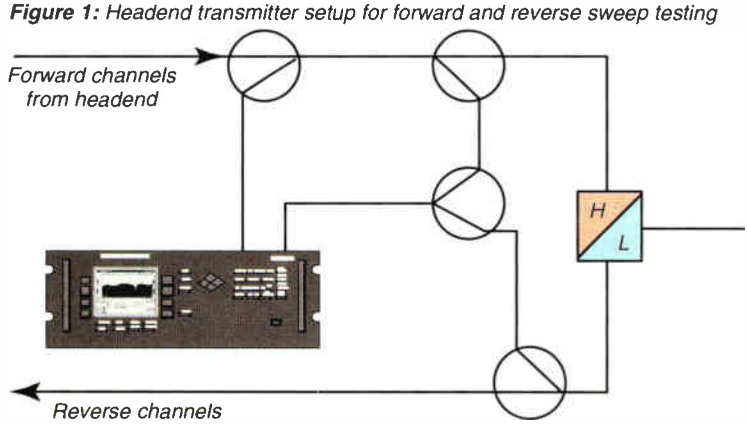
Reverse testing and alignment for cable TV

Fast, accurate measurements

By Steve Windle, Product Marketing Manager, CATV and Communications Division, Wavetek Corp.

Cable TV systems have long flirted with the possibility of two-way communications on their networks, but actual implementation of these systems has been relatively limited. However, changes in system architecture which shorten amplifier cascade lengths have limited some of the more common technical problems related to reverse path activation. In a shorter cascade, which may be considered a smaller subsystem, ingress is limited due to the lower number of possible sources. With fewer amplifiers between any subscriber and the headend, the carrier-to-noise summing effect is also limited. New services such as PPV, interactive multimedia, telephony and data offer new sources of revenue that justify activation of reverse bandwidth in the cable network.

Figure 1: Headend transmitter setup for forward and reverse sweep testing



Previous test methods–cumbersome at best

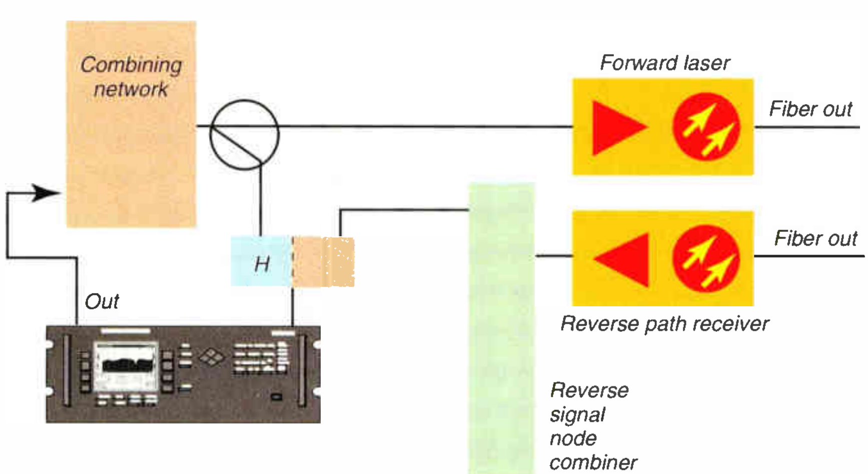
Along with activation of the reverse bandwidth comes the baggage of network alignment and testing. Previous test methods have not offered the optimal solution for comprehensive alignment of these networks. One method called for the use of existing test equipment for sweeping the forward path to sweep the reverse path. The test equipment had to be factory modified with a special data pilot that would pass through the reverse bandwidth, and the sweep transmitter and the sweep receiver would trade places–one technician would remain in the headend with the receiver, and another would take the transmitter out into the field.

The field technician would inject the sweep at the amplifier test point, and the headend technician would tell him, via radio, what kind of alignment needed to be done. This is obviously a time-consuming method, and it doesn't lend itself to excellent results, in that the field technician can't actually see the results of his alignment. The results are subject to interpretational error, depending on the clarity of the communication between the two technicians.

Another alternative is to use a TV camera to view the headend sweep receiver. This eliminates the need for the headend technician, thereby shortening the time consumption. This process requires expensive equipment (TV camera, modulator and TV), uses up a 6 MHz channel worth of precious bandwidth in the forward spectrum and requires the use of a TV set in addition to the sweep transmitter out in the field.

Two carrier alignment systems have been available for the reverse path for many years. These systems also have some drawbacks, such as the requirement for rack space for an additional instrument, the need to carry two boxes out in the field, and a measurement limited to two carrier frequencies. The latter can be a problem if there are sharp changes in response, which may not be detected by looking at only two carriers. This can indicate a hardware problem and have a detrimental effect on services carried, especially data carriers which are subject to group delay problems.

Figure 2: Headend transmitter setup with reverse node combiner (multiple node returns)



A solution

The reverse sweep option solves reverse alignment and test problems by incorporating a comprehensive reverse sweep test capability into the same equipment that performs the forward sweep. This means that no extra rack space is required, as it uses the forward sweep transmitter to receive the reverse

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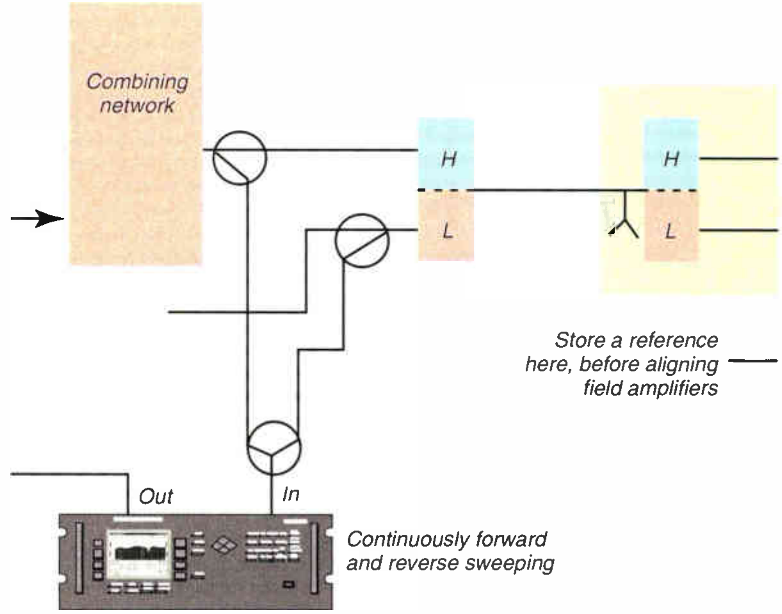
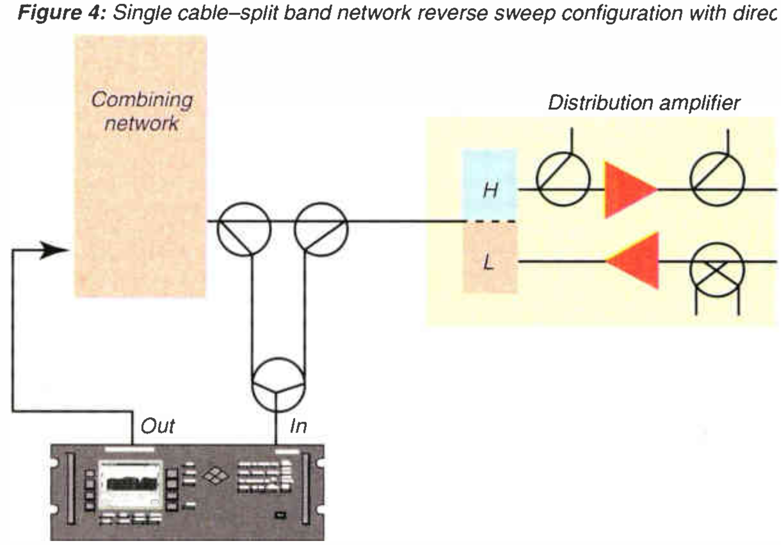
Figure 3: Single cable–split band network reverse sweep configuration with bi-dir

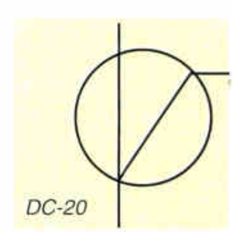


sweep. One handheld instrument in the field does both the forward and reverse sweep tasks, eliminating the need to carry multiple boxes. The reverse option has the capability to sweep return with up to 250 kHz resolution, ensuring that no response problems are overlooked.

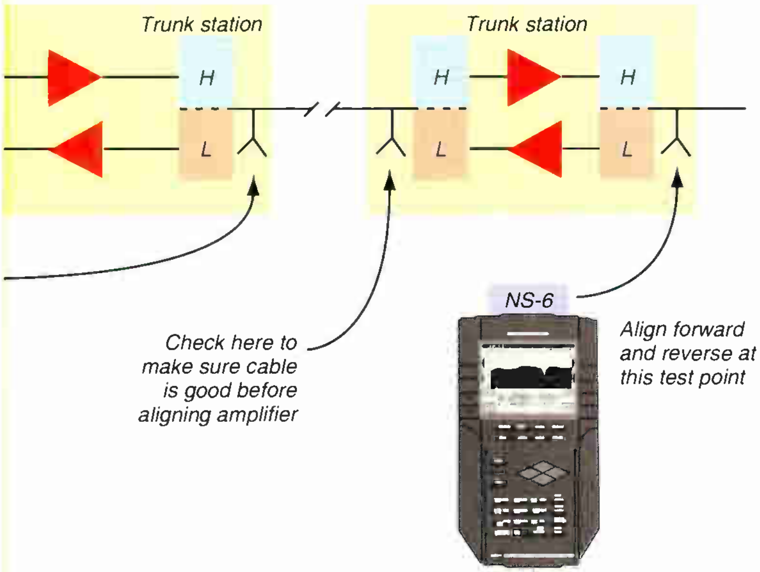
With the reverse sweep option, a transmitter is built into the handheld sweep receiver. The headend sweep transmitter is set up to receive the reverse sweep sent from the field. When a reverse sweep is activated from a field test point, the headend transmitter receives the telemetry

Figure 4: Single cable–split band network reverse sweep configuration with direc





ctional test points

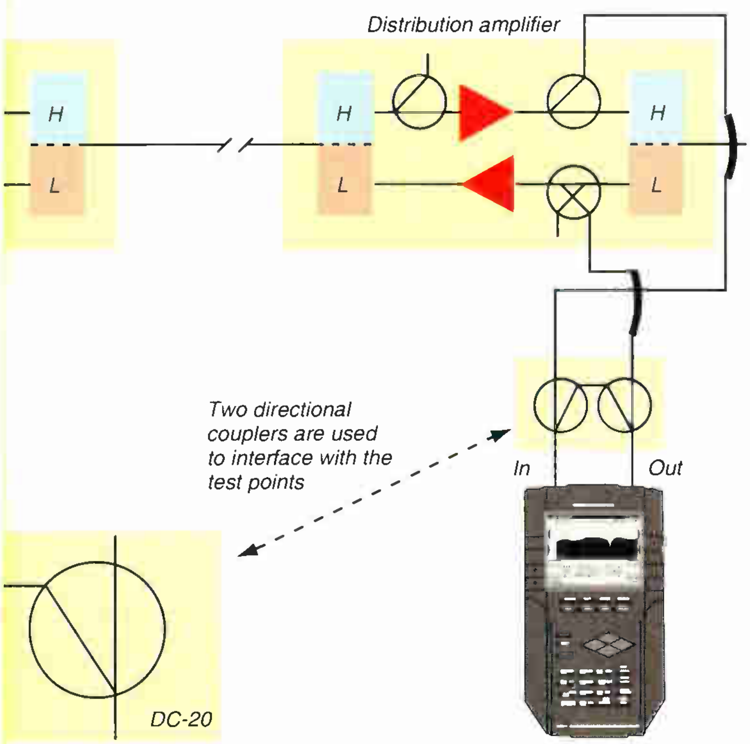


signal that indicates which receiver is sending the sweep. The headend transmitter measures the sweep, and sends the results, along with the serial number of the sending receiver, via its telemetry signal to the field. The field receiver with the tagged serial number then displays the sweep response as measured in the headend on its LCD.

Reverse sweep procedure

Sweeping the reverse path is a little different from sweeping the for-

tional test points



ward path. Because the system is designed with appropriate spacing for the forward high frequency range, the reverse path may not require amplification at each station. The lower frequencies aren't attenuated in cable as much as the higher frequencies. In sweeping the forward path, the amplifier is aligned such that its output is within certain limits (the amplifier compensates for the cable behind it). In sweeping the reverse path, however, the amplifier is aligned such that the response at the headend is within certain limits from this amplifier alignment point. So, in the reverse path the amplifier compensates for loss characteristics in the cable in front of it. This is why it's best to transmit the sweep from the amplifier test point and measure it in the headend. This ensures that the system is properly aligned to carry signals in the reverse path.

It's best to transmit the sweep from the amplifier test point and measure it in the headend

Interfacing with different network architectures

What follows are the equipment setup and test procedures in the headend.

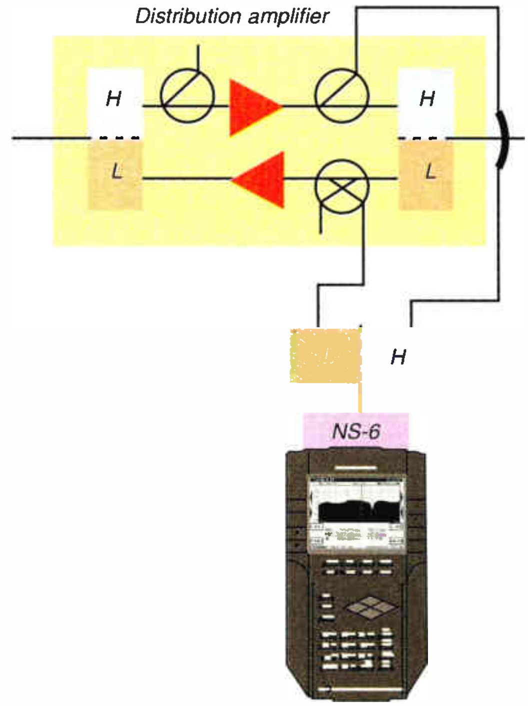
Single cable–split band network. The sweep transmitter is connected in the headend as shown in Figure 1. The connections are similar to those made for forward sweep, with the transmitter output connected to the combining network. The difference is on the input to the transmitter. The system signals, along with the transmitted signals, are tapped off and coupled together with the reverse signals by using a splitter. This enables the transmitter to receive both forward and reverse telemetry and sweep signals.

One headend connection scenario is shown in Figure 1. Provision must be made for a sample of the reverse signals to be summed with the sample of the forward path signals.

The headend scenario shown in Figure 2, while slightly different from that shown in Figure 1, maintains the key principle that the transmitter input must have a sample of both forward and reverse signal paths.

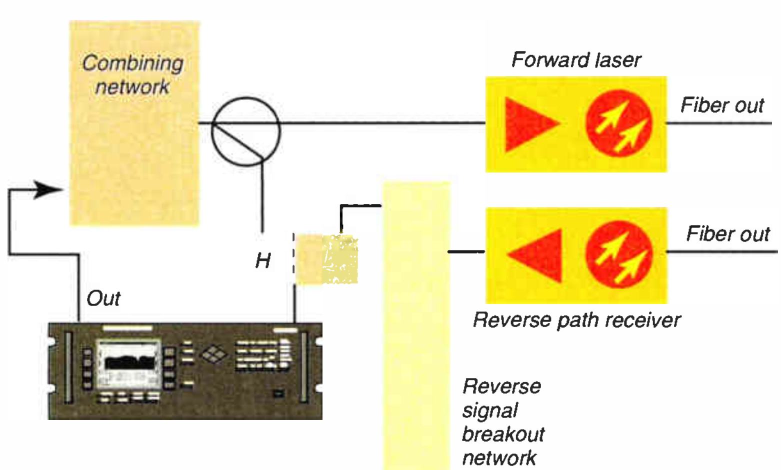
In the field, systems with bi-directional test points (forward and reverse signals both present on the same test point) use a summing network, provided with each reverse sweep option, to enable reception of forward telemetry and sweep, as well as inject reverse telemetry and sweep. This summing network simplifies the connection of the field receiver to the test point.

Figure 5: Directional test point scheme using diplex filter and NS-6 summing network



As in sweeping the forward path, a reference should be taken in the headend at a test point with a loss characteristic matching that of the field test points. A subsequent forward sweep test at the next amplifier input will show the cable loss, and the amplifier output will show how the amplifier compensates for that loss. A reverse sweep injected at the amplifier forward input will show the cable loss at the reverse frequencies, and a reverse sweep injected at the amplifier forward output will show how the amplifier compensates for the cable loss in front of it (between the amplifier and the headend).

Figure 6: Transmitter connections in headend for hybrid fiber/coax networks



Systems with directional test points are set up as shown in Figure 4. In this configuration, two directional couplers are used to provide a sample of the reverse sweep output to the input of the receiver. It is critical that the value of these directional couplers be at least 20 dB, and the one on the input side should be designed for at least the frequency range of the forward bandwidth of the network under test. (This coupler network should never be connected to the system without the receiver attached, or the resulting lack of isolation may cause signals from the forward path to bleed over to the reverse path.)

An alternate connection scheme for testing with directional test points is to use a diplex filter, as shown in Figure 5.

Another common architecture, which is only slightly different from those described above, prescribes the use of fiber optics to nodes. In these architectures, the installation of the transmitter in the headend is slightly modified, as shown in Figure 3. Notice that a diplex filter is used on the input of the transmitter. This provides optimal isolation between forward and reverse paths and minimal insertion loss. The connection at the node may be as shown in Figure 4. Notice that in this configuration the forward and reverse test points are separated, and two directional couplers must be used.

In all of these connection scenarios, either a summing network or two directional couplers are used to interface with the system test points. Care should be taken to use the same interface at each test point to ensure that the normalization process is canceling out any response variation caused by the interface. It is also important to remember not to make absolute level measurements through the summing network due to the insertion loss and frequency response characteristics of the interface.

The diagram shown in Figure 6 shows a connection scheme that was used at a beta test site. In this scenario, the system is fully loaded to 450 MHz, and the band is split as shown by the combining networks in the diagram. The sweep was inserted only on the 450 to 750 MHz combiner, as 750 MHz was the highest frequency to be tested at this time. The sweep could be inserted on the 750 to 1 GHz band as well, if proper filtering is used. Again, notice that provision is made to couple both forward and reverse signal samples to the sweep input.

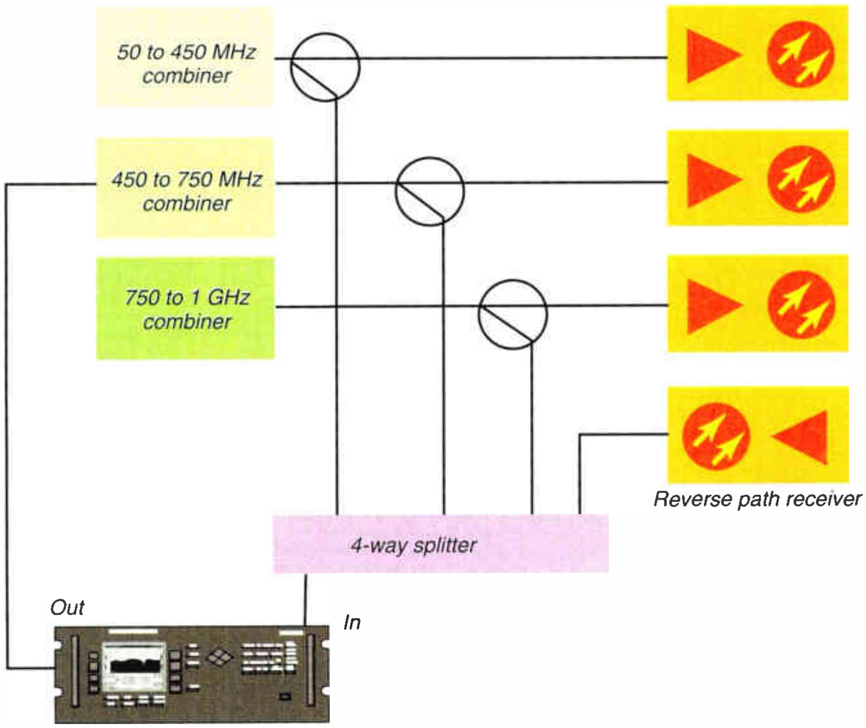
Dual cable network

Another possible, though rare, network configuration is the dual cable network, in which a full bandwidth is used for both forward and reverse–essentially two cable systems overlaying each other with signals carried in opposite directions. These networks are impossible to sweep simultaneously in both directions by one person. The problem is that the two systems use the same spectrum, making it impossible to distinguish between the two with one instrument. The recommended method for these systems is to first sweep the forward portion of the network, then move the transmitter out to the furthest extremity and sweep the reverse portion.

Summary

With all of the new services soon to be carried on the reverse path, it will be critical to ensure its optimum performance. A reverse sweep allows for fast, accurate frequency response measurements of the reverse path, without the need for multiple technicians or additional field equipment. Technicians can easily align the reverse path while performing their regular forward sweep maintenance. CED

Figure 7: Fiber node test point connections



WDM technology poised to enter fiber market

Gear ready to come out of lab

By Fred Dawson

Wavelength division multiplexing (WDM) is rapidly becoming a tool to be reckoned with in planning for network evolution, no matter what topologies engineers are implementing today.

While it's too soon to predict how pervasively high-density WDM at four, eight or more wavelengths per fiber will be used in either long-haul or local distribution applications, recent developments suggest compelling options are at hand which should be factored into industry thinking about the best approaches to expanding capacity of hybrid fiber/coax networks or to implementing star/star fiber networks in '96 and beyond. One sign of what lies ahead can be found in the fact that high-density WDM figures in virtually all of the latest government-backed advanced network projects linking high-tech facilities and institutions in various parts of the country.

From a cable TV industry perspective, WDM is emerging at an opportune moment. With on-line and LAN-extension services showing strong promise as operators prepare to enter the telephone business, even state-of-the-art systems could be short of upstream bandwidth in a very short timeframe, notes Wilt Hildenbrand, vice president of engineering and technology at Cablevision Systems Corp.

"This (technology) could save you from having to choose between drawing a whole lot of extra fiber you don't know you're going to need during the initial rebuild, or having to go back in and add it later," Hildenbrand says. "Fiber down to 500-home nodes gets you started and holds you awhile, but you want to have a path to migrate the system to a lower house count if demand goes up."

Is it cost-effective?

WDM, of course, is but one expansion strategy under consideration in the cable industry. The question is whether this newest scheme is less costly and more bandwidth efficient than other ideas, such as use of upstream block conversion to put separate upstream paths from segmented coaxial links in the serving area together onto return fiber at the node. And the analysis will have to factor in the issue of adding services in the downstream path as well, where WDM offers the advantage of being able to divide a serving area into four separate serving areas for targeting dedicated services without adding fiber.

Hildenbrand recently took a look at a demonstration of the capabilities of four-wavelength multiplexing in the HFC environment at the headquarters of Synchronous Communications in San Jose. "From what we saw, it looks like it will happen," he says. "The demonstration showed you can put four wavelengths together in the 1550 (nanometer) window without experiencing any interference."

The demo, which was put together at Cablevision's request, entailed multiplexing of lightwaves from four transmitters through a passive combiner onto a 40-kilometer fiber path. Two of

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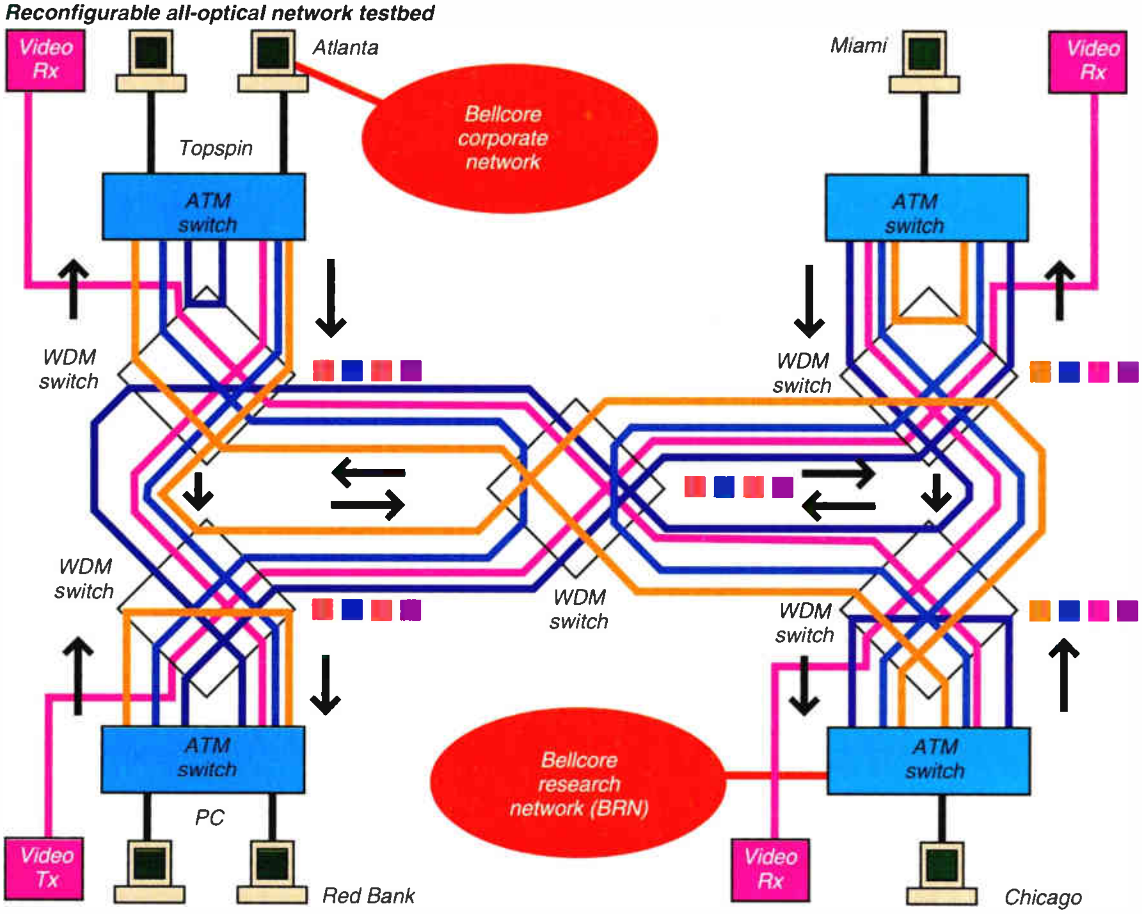

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the transmitters–externally modulated, optically amplified EMS-1550s supplied by Synchronous–employed amplitude modulation across 50 MHz to 750 MHz, while a third EMS operated digitally at 2.4 Gigabits per second. A fourth, tunable laser from Hewlett Packard provided an unmodulated signal to serve as a point of reference.

Wavelengths of the transmitters ranged between 1532.5 nm and 1558.8 nm, with about 8 nm of separation from one to the next. "We looked for analog and digital crosstalk, intermodulation in the high and low bands–you name it," says Vince Borelli, chairman and CEO of Synchronous. "The results were outstanding."

Synchronous and Scientific-Atlanta recently announced they would work together on future development of WDM technology as part of an agreement under which S-A becomes the primary distributor of optical amplifiers and optically amplified transmitters built by Synchronous. "We regard this technology as a key component in our efforts to give our customers a competitive edge in performance and costs," says Perry Tanner, vice president and general manager of the transmission systems division at S-A.

WDM and optical amplification are two key benefits of 1550 nm technology over transmission at 1310 nm. And there is a fundamental distance advantage at 1550, where, for any given light power, the signal will travel about 33 percent farther. But, until recently, these advantages were useless because 1550 signals spread out, or disperse, when they are transmitted over fiber that has been optimized for 1310 equipment, which is especially ruinous in the analog domain.

Industry engineers say Synchronous' technique for overcoming dispersion, combining optically linear modulators with special circuitry, has broken this barrier, to the point that many major MSOs, including Cox, Comcast, Time Warner and Tele-Communications Inc., have begun using the gear in some of their supertrunks, and a handful have begun deploying it in the distribution plant as well.

Cablevision Systems, with systemwide deployment in Yonkers, Long Island and elsewhere, has the longest track record with 1550. "It's working great," Hildenbrand says, noting that the MSO is serving approximately eight 500-home nodes per 40 milliwatt transmitter over 1310 nm fiber.

Lately, a number of entities have taken Synchronous on in the analog domain, offering a variety of dispersion compensation techniques with their erbium doped fiber amplifiers (EDFAs). Suppliers include Northern

Cable industry sneaking up on telcos

Cable industry consumption of optical fiber is growing so fast that 1995 just might be the year in which the MSOs actually deploy more fiber than the nation's telephone companies, according to research performed by Corning Inc. and made public during the Optical Fiber Communications conference in February.

According to figures supplied by Cliff Hund, manager of marketing and strategic planning at Corning, the North American market for fiber grew 27 percent last year to 7.4 million kilometers, fueled by competition and deregulation in many industries.

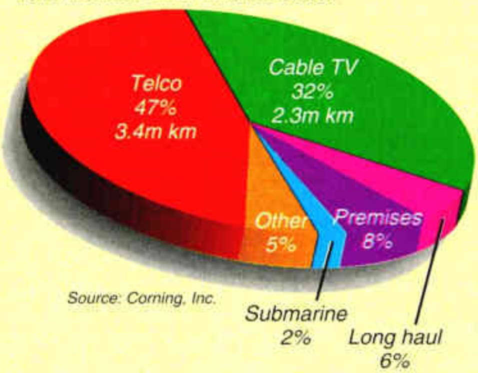
The telcos still weighed in as the largest market segment, accounting for 47 percent of fiber sales volume. The most active companies were U.S. independents, Canadian local exchange companies and competitive access providers. Among U.S. RBOCs, BellSouth was the growth leader in fiber deployment, followed by Bell Atlantic. However, growth continued at a sluggish 6 percent rate overall, primarily as a result of ongoing re-engineering efforts within the RBOCs. Hund said the completion of these efforts, as well as video dialtone approvals, should translate into greater growth for the telco market segment in 1995. "All the RBOCs are strong, and even though their stock prices may be depressed by competition, we're expecting the segment to grow by 25 percent in 1995," Hund said.

Meanwhile, the cable TV market doubled for the third year in a row to where it now accounts for 32 percent of the entire fiber market. Corning executives say the increased demand was driven by the desire of cable MSOs to enter the telephone market, an attempt to improve network reliability, more fiber to smaller nodes and larger fiber counts within those cables.

Hund said further industry consolidation and clustering of systems in major metro areas will continue to fuel demand for fiber throughout 1995. But will the industry's voracious appetite for fiber continue at this pace? The answer is unclear: "The interesting market dynamics make forecasting a real challenge," Hund wrote in his report. "The bigger companies are reaching their limits in terms of fiber deployment speed. We expect the greatest growth to come from the smaller companies. We're anticipating fiber consumption growth of 43 percent in 1995."

Beyond that, Corning officials said the demand for fiber has left the market "tight," meaning delivery times for product are creeping out. In response, Corning has again increased capacity at its plant in Wilmington, N.C. In addition, the company announced a price increase of up to 8 percent for its SMF-28 and Titan singlemode fiber. Corning officials say the price of fiber may have finally stabilized after several years of decline. –Roger Brown

1994 North American cabled optical fiber. Total market = 7.2 m kilometers.



Telecom, ATx (formerly Amoco Laser), Photon Systems and Litton Industries. "Competition is coming," Borelli says. "The market wants more suppliers."

"In the U.S. we're seeing (that) most applications of the EDFA are for supertrunking," says James Regan, product manager for Northern Telecom. "But already in Europe we are selling some EDFAs for use in cable systems on the subscriber side of the headend."

With EDFAs and EDFA-powered externally modulated transmitters opening a broad product base in cable TV, it remains to be seen whether vendors push the WDM window for cable operators. So far, says Greg Hardy, S-A's director of marketing for distribution and fiber optic networks, the lion's share of industry interest in 1550 technology is focused on supertrunking applications. In addition, he says, for new plant extensions or in situations where an operator connects a distant franchise area in need of a rebuild to a metro headend, some customers are preferring to stay with 1550 all the way to the individual fiber nodes in the distribution plant, rather than changing to 1310 at the hub for distribution over feeder.

"We're going to learn more about the possibilities as we work with Synchronous," Hardy says. "As our system engineering people better understand the technology, we may find ways to make broader use of 1550."

WDM in the digital domain

WDM has more momentum in digital telecommunications, of course, where interexchange and local exchange carriers have long duplexed 1310 and 1550 and are now beginning to multiplex four wavelengths in the 1550 window together to support OC-192 (10 Gbps) Sonet throughput. The trend, which will soon be challenged by a new generation of 10 Gbps DFBs from Hitachi and others, got underway a few months ago when Wiltel, MCI and BellSouth announced they were adding the technology to some of their links.

"WDM will enable us to continue to provide our customers with next-generation services on a faster, more economical basis," says Russ Ray, WilTel's vice president of engineering. He notes the firm is also using bidirectional optical amplifiers to boost the combined wavelengths in each direction, representing the first time these technologies have been put into operation together commercially.

But there's much more to WDM than a race to OC-192, or even to OC-768, where Hitachi is likely to go next with a 40 Gbps laser now in prototype, according to one company insider. The key to whether WDM is the wave of the future lies in whether the purported flexibility and low cost of increasingly passive optical networks prove out against competing technologies.

'But already in Europe, we are selling some EDFAs for use in cable systems'

The most ambitious application of advanced optical technology yet undertaken came to light in March with news that the Defense Department's Advanced Research Projects Agency was putting up $54 million in a consortium with Bell Atlantic, BellSouth, Pacific Telesis, Bellcore and AT&T to build a $100-million high-density multiwavelength network linking sites across the Washington, D.C.-New Jersey corridor, including other U.S.-backed advanced networks that are already up and running.

The goal is to come up with a design that sticks nationwide. "The consortium will move us toward an industry consensus among telecommunications network operators, equipment suppliers, operations software makers and standards forums on how to build a national-scale optical networking layer," says George Heilmeier, president of Bellcore. "We expect the (design) to serve as the underlying platform for establishing a flexible National Information Infrastructure that can grow to meet expanding communications needs."

ONTC project

A maturing project which represents a key step in designing the Washington-N.J. network is the "reconfigurable multiwavelength optical network" developed by the nine-member Optical Networks Technology Consortium (see graphic, page 74). This consortium's goal is to demonstrate a "complete, practical, integrated optoelectronic technology base for reconfigurable multiwavelength optical networks," says Gee-Kung Chang, an engineer at Bellcore, which is a member of the ONTC. "This technology is only one hard development cycle away from commercial application."

The consortium has been operating a four-wavelength system and is moving into the next and final phase of the project, where it will increase the number of wavelengths to eight, operating at 2.5 Gbps each, while reducing the channel spacing to 2 nm. The wavelengths are reused as often as needed on different paths of the network, while information is transferred to whichever wavelengths are available in the transmission path. Such a network, operating in a ring configuration, can be scaled to very large numbers of nodes with the use of a small number of independent wavelengths, Chang notes.

With IBM demonstrating a 20-wavelength multiplexer that has already entered commercial operation at two banking locations, eight wavelengths, per se, is not so big a deal. But it is the flexibility across multiple light paths that gives the technology an edge not provided by sheer throughput alone. For example, Chang says, a metropolitan backbone network employing this technology would cut the number of ATM/Sonet ports by about 40 percent.

One of the biggest hurdles to be overcome is gain variation in EDFAs

Devices in the pipeline

With commitments to advanced optical technology expanding, the optoelectronics community is well positioned to make the leap from lab-tested concepts to commercial production. For example, there is growing interest in the multiple wavelength capabilities of the tunable distributed Bragg reflector laser (DBR), which has been operating in labs for two years or more, notes Nicholas Frigo, project leader for a multiwavelength local loop distribution system called "RITE-net" at Bell Labs.

"The DBR we're using, which is made by (AT&T) Microelectronics, looks like a fully packaged product from off the shelf," Frigo says. "It wouldn't take much for them to move it into production"–a move Microelectronics is contemplating, according to informed sources.

The tunable DBR is an integrated optoelectronic device that uses planar grating, or electron-sensitive reflective grooves which alter reflection paths to determine which mode from a multimode output, such as a Fabry-Perot, lases at any instant. Thus, with a laser modulated at, say, OC-12, the incoming time multiplexed signal could be broken into separate OC-1 time division paths by "hopping" the light from one mode reflection to the next, so long as the hopping takes place at the clocked intervals corresponding to the slots assigned in the demultiplexing of the aggregate signal.

This method is in competition with one where several DFB or other diodes with narrow fixed wavelengths are integrated with a high density star coupler, allowing all the individual laser outputs to be combined for transmission over one or more fiber paths. Several manufacturers are working on such devices, which, so far, appear to be more difficult to fabricate than the tunable DBR, owing to the exactitude required in differentiating one diode wavelength from another.

Frigo's project draws on other potentially low-cost, easily produced devices as well, including a two-way, multipath router that can be used in the field to minimize the fiber count, and a silicon-based, low-power modulator which can add an upstream signal to the available lightpulse from the downstream laser, thereby eliminating the need for an upstream light source. In fact, Frigo says, with support from the operating community, the whole passive optical network (PON) system could be moved into production within two years, greatly reducing the costs and powering requirements typically associated with PONs.

"Most people think of multiple wavelength division multiplexing as an expensive proposition when it comes to using the technology in local loop applications," Frigo says. "But our idea is it can be done at very low cost.

"We cut fiber costs because we don't have to run a dedicated fiber to each ONU (optical network unit–the neighborhood drop-interconnection point) from the transmitter," Frigo explains. "What we're trying to do is to show that it makes sense to start thinking about this kind of network."

The flat gain problem

One of the biggest perceived hurdles to be overcome in dense WDM is gain variation in EDFAs, where different wavelengths are amplified at different power levels. IBM, which demonstrated its 20-wavelength multiplexing system at the OFC '95 conference, is limited to this number of wavelengths by the gain issue, says Paul Green Jr., manager of advanced optical networking at IBM Research.

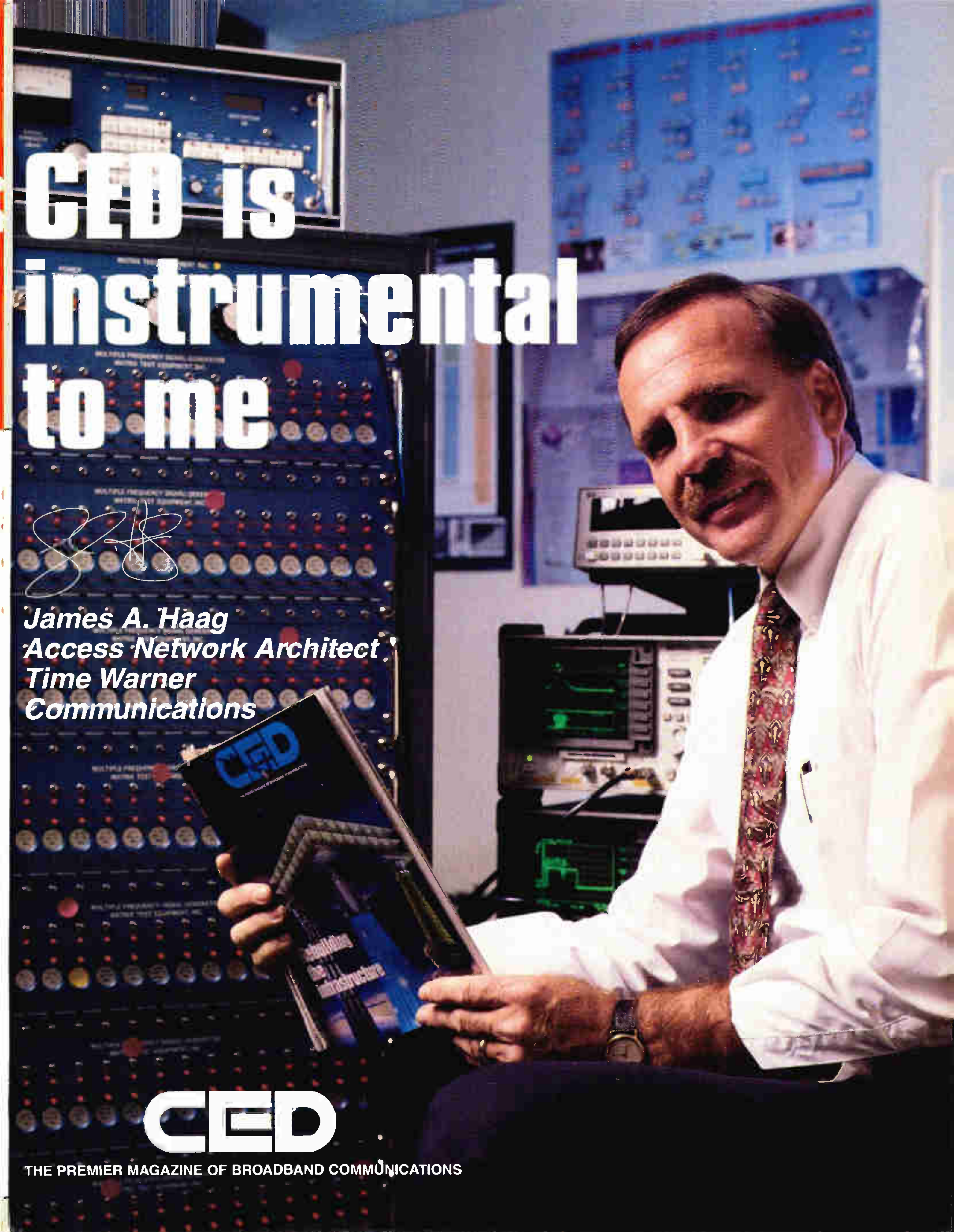
"To do 20 wavelengths requires that the amplification be flat across a much broader spectrum–19 nanometers versus 3 nanometers in today's optical amplifiers," Green says. "Getting to 100 or more wavelengths will require even more development work."

However, Green's statement appears to ignore what is going on in the development of EDFAs for analog transmission. For example, the Synchronous unit now widely in commercial operation is spec'd for flat gain across 30 nm, from 1530 to 1560.

"There's a disconnect in this field, where people have focused so long on the digital domain, they don't know what's going on in analog," Borelli says. "You can't operate in analog unless you have an extremely flat gain profile. We learned that a long time ago."

With a growing number of entities chasing 1550 technology applications in digital and analog services alike, the disconnect is not likely to last long. Asked whether the Bell Labs PON would work with analog signals, Frigo replies, "I don't see why not. We weren't thinking about analog, but we're using RF modulation in the downstream so we can add a baseband signal at lower power for the modulator to act on in the upstream path."

Such synergies could have a major bearing on the shape of things to come. At this point, the extent to which WDM becomes a viable tool in HFC and telco fiber networks appears to depend more on demand from the operating community than it does on pure research. CED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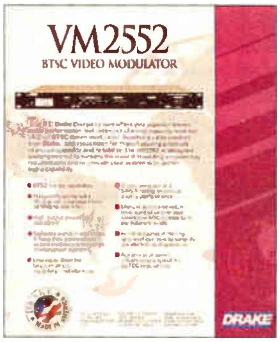

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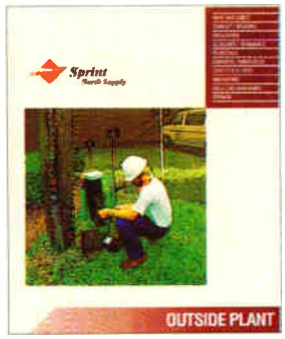

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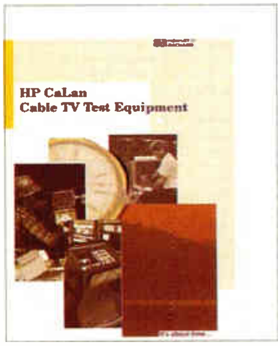

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Moore's Easy Access Fiber Node Enclosure

Moore's Diversified Products, Inc. Fiber Node Enclosure is designed for the CATV industry to house an Amplifier, Splice Enclosure and up to 300 feet of Fiber Optical Cable. Lockable doors, front and back easily remove for loading equipment and storing fiber. Universal steel rod mounting allows all Amplifier and Splice Enclosure brands to be installed using existing strand mounting brackets. Like all Moore products, you buy directly from the source insuring dependable delivery and no middle man cost. Call 1 (800) 769-1441.

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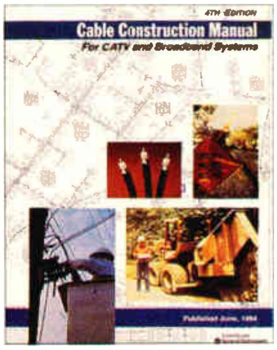
CommScope is now making available a revised and updated edition of its widely distributed and used Cable Construction Manual for CATV and Broadband Systems. The new manual includes sections on storage, testing and construction procedures for coaxial trunk and distribution cables in aerial and subsurface applications, fiber optic cables as well as safety procedures. For more information, call **CommScope/GI** (800) 982-1708.



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Ripley Company's Cablematic Division offers a complete catalog in cable preparation tools. The catalog displays tools for jacket and sheath stripping, simultaneous coring and stripping, hex and round full-cycle crimping, plus many specialty tools including fiberoptic tools and cable expanding kits. Using proper tools promotes system reliability and assures safe, fast, accurate cable preparation. Call now 1-800-528-8665 for your free catalog. **Ripley Company, Cablematic Division,** Phone (203) 635-2200, Fax (203) 635-3631

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Jensen Catalog Sets New Standard of Technical Support

Jensen Tools has introduced a new LAN support catalog that makes good on the company's claim to outstanding technical support. In addition to wire and cabling tools and tool kits from Jensen, it presents cables & connectors, testers, hubs and cards, network operating systems/software, cable management products, and test equipment from all the major manufacturers. Helpful selection charts, diagrams, technical data, and useful illustrations are distributed throughout. Call (800) 426-1194 for a free copy.

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Cable TV, MMDS & LAN Products Catalog on a Disk

Viewsonics Inc. new full color catalog in digital format has over 150 products listed, including their complete line of amplifiers, splitters, taps, multitaps, isolators, ground blocks, Lockinator™ Locking System, boxes, connectors and many more. Specifications for actives and passives are also included. Experience the 21st century today. Call and/or fax for your Viewsonics Virtual Catalog now. **Viewsonics Inc.**, (800) 645-7600, (407) 998-9594, Fax (407) 998-3712.

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The issue: Data communications

Cable networks can send data at speeds approaching 10 megabytes per second, easily outperforming even the fastest telephone-based modems. Equipment vendors say the market is ripe to be picked. But are cable operators excited about the market opportunity?

WIN $50 for responding*

The questions:

1. How familiar are you with the concept of the Internet?

❑ Somewhat ❑ Very ❑ Not at all

2. Are you presently subscribing to a commercial on-line service such as Prodigy or America Online?

❑ Yes ❑ No ❑ Don't know

3. Does your system have any interest in providing data services over the cable network?

❑ Yes ❑ No ❑ Don't know

4. Has your system tested or deployed RF "cable modems" to allow this access to occur?

❑ Yes ❑ No ❑ Don't know

5. Does the local telco offer ISDN services in your franchise area?

❑ Yes ❑ No ❑ Don't know

6. Has your system been approached by local government, schools or anyone else to offer high-speed data communications?

❑ Yes ❑ No ❑ Don't know

7. Has your system actively tried to market such services to anyone?

❑ Yes ❑ No ❑ Don't know

8. Do you think datacom provision is a good way to compete with the local telco?

❑ Yes ❑ No ❑ Don't know

9. Do you think your system is technically capable of sending high-speed data?

❑ Yes ❑ No ❑ Don't know

10. How much would your system be willing to pay for cable modems?

❑ Under $200 ❑ $200-$500 ❑ Over $500

Your comments:

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Alpha Technologies provides power to Nynex

BELLINGHAM, Wash.–Alpha Technologies has signed an agreement with Nynex to provide power products to its broadband network currently under construction in the New England area.

As part of the contract, Alpha will provide power supplies for Nynex's full service video, telephony and digital services network. Initially, the network will serve 330,000 households in eastern Massachusetts and 60,000 households in Warwick, R.I., and will have the capacity to carry hundreds of channels. The system will allow subscribers to receive both expanded cable television and traditional telephone service via a 750 MHz fiber optic network. Each power node is capable of serving as many as 500 homes.

The network management system will allow Nynex to remotely diagnose problems and manage its network without dispatching service trucks. Alpha's initial deliveries to Nynex for the project began in November of 1994 and will continue through 1996.

StarNet will use DigiCipher

HATBORO, Pa.–StarNet Inc. will use General Instrument's DigiCipher digital compression technology to compress multiple channels of programming onto a single satellite transponder. Additional transponder space will be used for StarNet's AdStar delivery service, which offers satellite delivery of digital video files for national and regional advertising at local cable systems. "We will start the service with DigiCipher I, then migrate to DigiCipher II when that technology becomes available," says Robert Bower, vice president of engineering and operations for StarNet.

BellSouth picks Pirelli's optical amplifiers

LEXINGTON, S.C.–Pirelli and BellSouth Corp. have signed a three-year, multi-million dollar contract for Pirelli to supply its new Wavelength Division Multiplexing (WDM) optical amplifier systems. BellSouth will begin deployment of the systems in its network within the first six months of 1995.

In Pirelli's system, network capacity is increased to 10 gigabits per second by optically multiplexing four OC-48 channels. It incorporates optical amplifiers in a "line" configuration, which allows signal amplification without conversion to electrical and back to optical form.

Continental unveils interactivity for education

BOSTON–Continental Cablevision recently demonstrated an interactive, multimedia network linking two schools in northern California. The project–made possible by the company's donation of a $135,000 fiber optic transmission system in Stockton, Calif.–was demonstrated to a group of public officials, educators and Stockton-area residents.

The system links Lincoln High School and Brookside Elementary School in the Lincoln Unified School District, plus San Joaquin County Schools Administrative Offices. It allows people at each location to communicate via voice, video and data between venues such as science classrooms, libraries, performing arts facilities and administrative offices.

A local area network and a wide area network have been created to enable each classroom to have access to the Internet, in addition to the interactive video capabilities.

DAVID Conference slated for September

PHILADELPHIA, Pa.–Microware Systems Corp. and Multichannel CommPerspectives have announced that the 1995 DAVID Developers Conference and Convergence '95 Interactive Television Conference and Exposition will be held September 25-28 at the San Jose Convention Center in San Jose, Calif.

The conferences will feature both seminars and exhibits culled from the interactive television industry.

DAVID (Digital Audio/Video Interactive Decoder) is a standard operating system environment for interactive television decoders that can be used in telephone, cable TV and wireless networks. The DAVID system supports both networked and local interactive applications, graphics and user interfaces.

Ameritech doles out video network contracts

CHICAGO–Ameritech has awarded contracts worth up to $475 million for components in its new two-way video communications network. Among these, the company has signed a five-year agreement with Scientific-Atlanta for analog and digital set-tops and remote controls. The agreement is valued around $400 million. Last May, Ameritech awarded S-A a contract to supply distribution electronics, and analog and digital headend systems.

Ameritech has also signed a five-year agreement with Digital Equipment Corp. for video servers. The value of that contract is as much as $40 million.

And the third agreement, which was signed with ADC Telecommunications Inc., is worth as much as $35 million for cabinets that will house equipment placed in neighborhoods.

In February, Ameritech began building the network, which is expected to be operational in some Midwestern communities by the end of this year. The company expects to reach 1 million new customers a year.

Antietam Cable to upgrade in Hagerstown

STATE COLLEGE, Pa.–Antietam Cable will purchase more than $2 million in AM fiber optic and RF equipment from C-COR for use in its 650-mile upgrade in Hagerstown, Md. The purchase includes C-COR's LinkNet AM fiber optic transmit and receive equipment, as well as 750 MHz FlexNet trunk, bridger and line extender amplifiers. Deliveries will begin in early spring and continue throughout 1995.

Australis Media chooses Conifer system

BURLINGTON, Iowa–Conifer Corp. has been selected by Australis Media Ltd. as its supplier of wireless cable receive systems for its Australian projects, including the cities of Sydney and Melbourne. Conifer has developed a special electronics receive package tailored to the frequency requirements of the Australian wireless market.

Wegener receives order from Networx

DULUTH, Ga.–Wegener Communications Inc. has received an order from Networx Corp. for more than 1,000 of its addressable Series DR95 SCPC digital audio receivers. Coupled with Wegener's Addressable Network Control System (ANCS) hardware and software, the receivers will be used to distribute three channels of stereo program audio throughout the United States

The addressable DR95 receivers use MPEG 2 digital encoding and feature mono, dual mono and stereo operation, with real-time diagnostics.

Wegener has also signed a multi-year, multi-million dollar contract with Foundation Telecommunications Inc. (FTI) to provide digital video and audio products for distance learning. Using the Wegener compressed digital video equipment, FTI will allow multiple SCPC (single channel per carrier) video channels to be transmitted simultaneously from sites around the country. In addition to video, network users will also transmit multiple languages, ancillary audio channels, data files and perform broadcast document transfers. Plans to expand the network on a global basis may be announced in the future.

FTI will offer satellite time, on a full-time and occasional use basis, for video, audio and data transmissions.

The products planned for the network include Wegener's addressable digital video product family, encompassing digital video encoders, decoders and SCPC IRDs. CED

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Revisiting the green scene

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

Dr. Patricia Dillon's article in the August 1994 *IEEE Spectrum* was the inspiration for "My View" in the October issue of *CED*. I predicted then that the disposal of obsolete electronic equipment is a problem that will not go away. I also hoped they would outlaw the plastic packs that force you to buy 10 pieces, when you need only one or two.

Now comes *Fortune* magazine, in its February 6, 1995 issue, with a piece by Alicia Hills Moore and Karen Nickel Anhalt entitled, "Manufacturing for Reuse." A joint venture of the Big Three automakers, the Vehicle Recycling Center in Highland Park, Mich. is a laboratory with the mission of teaching the Big Three to better design cars for easier dismantling. The United States already reuses three-fourths of most American cars, and is pushing to match BMW and Volkswagen, who are aiming for 95 percent. Generators, motors, alternators and other moving parts are refurbished and sold by auto parts recyclers. The metal parts are shredded and pulverized for use by steelmakers to make the ingots from which more car bodies are made.

Recycled chips better than new

In some cases, according to Moore and Anhalt, it has been found that recycled parts may actually be better than new ones, especially when electrons are the only moving parts. Fox Electronics in San Jose recycles memory and microprocessor chips. While "infant mortality" accounts for about five percent of new production, Fox found that only two percent of the recycled chips die young. Disassembly of old computers began several years ago, in order to salvage the gold and other precious metals used in circuit boards and connectors. But the chips were removed from the circuit boards and sold to toy and game manufacturers.

Design for Disassembly (DFD) is the new buzzword: using screws instead of glue; laying out modules for easy removal; reducing the number of components. Green Engineering Corp. of Pittsburgh has even produced a software program called ReStar to help manufacturers generate disassembly plans. The $19,600 program can even be downloaded on the Internet!

Computers are now apt to be obsolete within 12 months. According to Carnegie-Mellon University, "Seventy-million obsolete computers are sitting in the basements of various organizations and will eventually end up in the landfills, if they are not recycled." IBM, Hewlett-Packard, Digital Equipment Company and others are already introducing DFD designs.

The Kodak throwaway camera

The *Fortune* article tells an interesting story about the Kodak "throwaway" camera. Engineers got little encouragement in the 1980s when they came up with the idea of the "Fling" disposable camera–it bombed. They blamed it on what seemed to be Kodak's belief that, "God intended people to buy a roll of film and a camera, and use the film to load the camera." A new version was developed and renamed "Fun Saver" to take panoramic views. Environmentalists still complained, however, that hundreds of thousands of the returned cameras were ending up in already overloaded landfills.

By 1990, a Congressman's "Wastemaker of the Year" award to Kodak was a wake-up call. The throwaway camera then became a recyclable camera. Snaps replaced welds so that the case could be more easily taken apart. The customer would still return the camera and film to the photo finisher, who now would return it to the Kodak factory. A New York State-sponsored organization which employs handicapped people was hired to break them down: covers and lenses were removed; electronics and moving parts were tested and reused up to 10 times in new, disposable cameras; and plastic parts were ground up and made into new camera parts. Only 13 percent by weight was sent to the dump.

Legislation is coming

The authors also reported that the four-year-old Xerox green manufacturing program is paying off at the rate of about $500 million in annual cost savings. The cartridge assembly, for example, had to be torn apart by hand for disassembly. This was replaced with a design that anticipates recycling. Reusable parts were put in easily accessible places. Snaps replaced screws. Common parts were standardized for use in different products.

Xerox admits to some sales resistance to refurbished photocopiers. However, the Xerox corporate manager for environmental design is pleased that the Clinton administration issued an executive order in 1993 urging (but not requiring) federal agencies to buy green products such as refurbished photocopiers.

As *Fortune's* article says, "The green wave of German legislation is rolling across the Atlantic–and don't think Republican control of Congress can stop it. While chances of German-type product take-back legislation are nil in this Congress, it doesn't matter: The Germans have established a de facto global manufacturing standard. U.S. companies wishing to compete globally must start making products that will comply with the green dictates of the huge European market." Nevertheless, Chrysler's vice president for vehicle engineering says, "Frankly, I prefer the more natural, more cost-effective way of what happens in the U.S.," without subsidy or government involvement.

Manufacturers, apparently, are finding out that green designs can be cost-effective, and even more efficiently produced, just as cable TV has found that monitoring and eliminating signal leakage pollution often improves the product. CED

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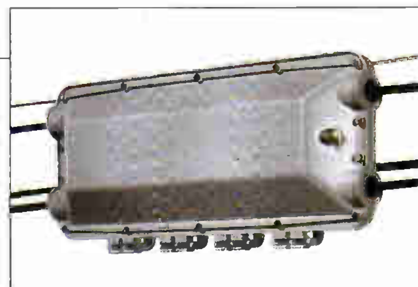

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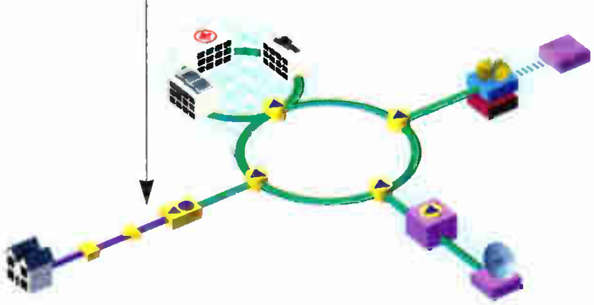

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